

European Marine Fish Market Dynamics, 1500 to 1800 CE

John Alphonsus Matthews

A thesis submitted to the University of Dublin, Trinity College, for the Degree of Doctor of
Philosophy

Department of History, University of Dublin, Trinity College

2021

Declaration and Online Access

I declare that this thesis has not been submitted as an exercise for a degree at this or any other university, and except where duly acknowledged, it is entirely my own work.

I agree to deposit this thesis in the University's open access institutional repository or allow the Library to do so on my behalf, subject to Irish Copyright Legislation and Trinity College Library conditions of use and acknowledgement.



John Alphonsus Matthews

Trinity College Dublin

November 2020

Summary

European population more than doubled during the early modern period between 1500 and 1790. A priori, the demographic rise depended on increased food supplies, but to what extent was food security dependable, and what were the impacts of natural and human-generated disasters and change? These are fundamental questions in economic history that have mostly been addressed by looking at the grain market. This thesis provides an in-depth study of the price dynamics of European fish markets during the period from 1500 to 1800 CE. Herring and cod were major products of the late medieval food market, and during the early modern period supplies were vastly increased, primarily by quantities of cod, fished from the Grand Banks off the shores of Newfoundland. The thesis asks to which extent the supplies of fish were delivered to consumers by an efficient market.

Methodologically, the analysis is largely based on a quantitative study of historical commodity price series. These prices have been derived from archival records studied by historians over almost the last two centuries. In this thesis, the dynamics of these price series are studied, in particular the extent to which they increase or decrease over the study period, and the level of price volatility (i.e., aggregate year-on-year change, regardless of it being an increase or decrease). To understand the context of these dynamics of price, they are compared to estimates of historical fish supplies, records of conflict, and climate reconstructions.

The results show that European marine fish markets, specifically for herring and cod, were well integrated at the outset of the study period, and at levels that were comparable to staple foods such as beef and wheat. This did not remain the case, however, and markets became less integrated during the 17th century, a period marked by elevated conflict levels and heightened environmental variability. Over the course of the 18th century, markets returned to levels of integration seen in the early 16th century. Available price information for the new and increasingly abundant cod arriving from Newfoundland generally begins late in the 16th century, and quickly displays similar levels of market integration to herring, though may have been slightly less integrated. Over the following century, cod prices maintained levels of integration that were similar to herring, even during the dramatic lowering of the level of integration that occurred across these food products and the likes

of wheat and beef. Thus, the integrated prices and increasing volumes (and lowering prices) show that the Newfoundland cod quickly found its place in the market.

From decade to decade, cod, herring, wheat, and beef often shared price variability trends. Thus, the markets for the different products and locations were well connected, even if the precise mechanism of these connections is not clear. Over the longer term, however, prices were diverging. Prices were decreasing for marine fish products relative to beef and wheat from the mid-1600s onwards. Thus, larger volumes of marine fish arriving to European markets were not only supplementing diets, but they were also becoming a lower priced source of nutrition (e.g., protein and calories). These “relative” price divergences were not uniform across all locations. The divergence was evident between northern and southern regions. Northern locations saw cod becoming progressively cheaper relative to beef, while this was not apparent in southern regions. Thus, price changes suggest that a more significant preference for cod products was emerging in the south, with beef becoming preferred in the north.

Conflict often occurred alongside changing prices. In particular, larger conflicts were accompanied by significant price changes. Most notable was the Thirty Years’ War (1618 to 1648), which occurred alongside a pivotal change in prices. During that time, large price increases that had occurred over the previous century ground to a halt and a period of price stagnation and even decline in some instances occurred and continued until the end of the century. In the background, climate dynamics were also at play, as evident by price changes occurring alongside ocean temperature variations, changing drought levels on land and explosive volcanic activity. Climate events often occurred with dramatic effect, for example, drought leading to harvest failures. Evidently, market integration and commodity price changes bore a relationship with conflict and climate, both of which can be thought of as factors “external” to the markets. In addition, there were interactions between these two factors, this further complicated the relationship with prices. During times of conflict and extreme climate conditions, larger price changes (often represented by higher price volatility) created conditions for marine fish products to supplement diets, thus contributing to the role of the fish market in increasing food security. In times of larger price volatility, the markets may also be less well integrated, adding to the difficulty in supplying products. To understand the extent conflict and climate influenced commodity

price changes, firstly the relationship between conflict and climate was untangled. Next, their relationship with price changes will be established, ultimately leading to an improved understanding of the complex interactions of conflict, climate, and commodity prices.

Acknowledgements

I would like to thank my supervisor, Professor Poul Holm, for providing me with the opportunity to undertake this project and for his guidance throughout. I would also like to thank the Trinity Centre of Environmental Humanities and to extend my thanks to all members and colleagues for their support over the years, in particular Patrick Hayes, as a fellow member of the NorFish project. I extend a very big thank you to Eve Rannamäe for her support and for patiently listening to me talking about my research. Finally, I would like to thank my parents, Anne and John Matthews.

This research was funded by the European Research Council (Grant Agreement No: 669461), The Oceans Past Platform (EU COST Action IS1403) and Cultural Heritage and the H2020 RISE project CONCHA (2018-2021).

Table of Contents

European Marine Fish Market Dynamics, 1500 to 1800 CE	i
Declaration and Online Access	ii
Summary.....	iii
Acknowledgements	vi
Table of Contents.....	vii
List of Figures	xiv
List of Tables	xix
List of Equations.....	xxi
List of Diagrams.....	xxii
1. Introduction	1
1.1. Research Questions	3
1.2. Setting the Scene: Europe and the Fish Markets.....	4
1.2.1. Market Locations and Trade	5
1.2.2. Prominence of Herring and Cod	8
1.3. Thesis Overview by Chapter	11
2. Price Sources and Methodology	14
2.1. Price Sources.....	14
2.1.1. Sources Selection Process.....	18
2.1.2. Historiography	18
2.1.3. Price Collections.....	21
2.1.4. Conclusion - The Character and Features of the Price Sources.....	21
2.2. Methodology.....	22
2.2.1. Comparability of Sources Across Regions and Products	24
2.2.2. Converting Data for Statistical Packages	28

2.2.3. The Database	30
2.2.4. Absolute Prices or Log Transformed Values	30
2.2.5. Temporal Coverage of the Price Series.....	32
2.2.6. Definitions - Indicators of Market Dynamics	36
2.3. Conclusions	39
3. Conversions and Common Price Unit	41
3.1. A Common Price Unit for Protein	43
3.2. Currency and Quantity Conversions by Location.....	47
3.3. Conclusions	47
4. Commodity Substitution and Market Levels	49
4.1. Commodity Substitution	50
4.1.1. Price Ratios and Market Volatility in Paris.....	51
4.1.2. Quantity Sources.....	62
4.1.3. Units of Quantity.....	63
4.1.4. Quantity and Price Case Studies: Cod and Herring.....	64
4.1.5. Conclusions	75
4.2. Market Levels.....	76
4.2.1. Amsterdam - The Exchange and Large Institutions	76
4.2.2. France - Bordeaux and Paris	82
4.2.3. Conclusions	86
4.3. Conclusions	87
5. Price Dynamics	89
5.1. Long-Term Price Changes.....	89
5.1.1. Herring	91
5.1.2. Cod	111
5.1.3. Conclusions	120

5.2. Market Integration and Medium-Term Price Changes.....	121
5.2.1. Herring Markets	124
5.2.2. Cod Markets.....	129
5.2.3. Comparison Between Northern and Southern Europe	132
5.2.4. French and Spanish Cod.....	136
5.2.5. Conclusions	138
5.3. Conclusions	139
6. Conflict	141
6.1. Measuring Conflict.....	142
6.2. Changing Nation States and Institutions	148
6.3. Herring	150
6.4. Cod	153
6.5. Beef	157
6.6. Wheat.....	160
6.7. Conclusions	162
7. Environment and Climate	164
7.1. Comparing Prices to Climate.....	165
7.2. Ocean Temperature	167
7.3. Drought and Land Temperature	172
7.4. Conclusions	184
8. Discussion.....	186
8.1. Comparison with Previous Research	186
8.2. Influence of Conflict and Climate on Prices.....	189
8.2.1. Influence of Climate on Conflict	189
8.2.2. Influence of Conflict and Climate on Prices Examined Separately.....	195
8.2.3. Combined Influence of Conflict and Climate.....	202

8.2.4. Relationship with Market Integration.....	206
8.3. Conclusions	209
9. Conclusions	211
A. Appendix. Overview of Each Price Collection.....	218
A.1. Rogers and Beveridge - Southern England	218
A.2. Hamilton - Spain - Madrid.....	222
A.3. Posthumus - The Netherlands (Amsterdam, Utrecht, and Leyden)	224
A.4. Elsas - Frankfurt and Munich	227
A.4.1. Frankfurt	228
A.4.2. Munich	230
A.5. Pelc and Furtak - Gdańsk	231
A.6. Hauser and Baulant - Paris.....	234
A.7. Pribram - Vienna	236
A.8. Van der Wee - Antwerp	237
A.9. Allen-Unger Database	238
A.10. Feliu - Barcelona	239
A.11. Bauernfeind - Nuremberg.....	242
A.12. Jansson, Palm and Soderberg - Stockholm.....	243
A.13. Allaire - Paris	245
A.13.1. From Transcription to Quantification	248
A.13.2. Transcription, Currency and Conversions.....	250
A.13.3. Comparison to Hauser's Price Series	251
B. Appendix - Currency and Quantity Conversions.....	253
B.1. Southern England and London.....	253
B.2. Spain - Hamilton.....	254
B.3. Netherlands - Amsterdam and Surrounding Regions.....	256

B.4. Germany - Frankfurt	259
B.5. Germany - Munich	261
B.6. Germany - Nuremberg.....	262
B.7. Poland - Gdańsk	264
B.8. Hauser and Baulant - Paris.....	264
B.9. Austria - Vienna	265
B.10. Belgium - Antwerp	266
B.11. Spain - Barcelona	266
B.12. Sweden - Stockholm and West Sweden	267
B.13. France - Paris	269
C. Appendix. Price Series Sources in further detail	270
C.1. Rogers and Beveridge for London	270
C.2. Hamilton - Spain	272
C.3. Posthumus - Amsterdam	273
C.4. Elsas - Frankfurt and Munich	274
C.4.1. Frankfurt	274
C.4.2. Munich	275
C.5. Pelc and Furtak - Gdańsk	276
C.6. Hauser and Baulant - Paris.....	277
C.7. Pribram - Vienna	278
C.8. Bauernfeind - Nuremberg.....	279
C.9. Jansson, Palm and Soderberg - Stockholm and West Sweden.....	279
C.10. Van der Wee - Antwerp	280
C.11. Feliu - Spain.....	280
D. Appendix. R Scripts	282
D.1. Collating the Input Files.....	282

D.2. Creation of Central Price Data Frame and Conversions	286
D.2.1. First Script: 02001. DF Create price.df.core	286
D.2.2. Second Script: 02002. Common Price and Quantity Unit	287
D.2.3. Third Script: 02003. Creates Main Dataframe.....	289
D.2.4. Forth Script: 02004. Extra measures	290
D.3. The Core Dataframe with all information Types	291
D.3.1. First Script: 03101. Dataframe for Quantities	291
D.3.2. Second Script: 05100. Dataframe for Conflict.....	291
D.3.3. Third Script: 05110. DF all factors xy.to.plot.melt.big.chart	293
D.4. The Core Graph for Prices with Climate and Conflict Backdrop.....	299
D.5. Conflict Analysis.....	303
D.5.1. Script Name: 05100. df Conflict (xy.to.plot.melt.big.chart.conflict)	304
D.6. OWDA Analysis	305
D.6.1. Script Name 05210. OWDA Set some Variables:.....	305
D.6.2. Script Name 05211. OWDA Grid Co-Ord list per region.....	306
D.6.3. Script Name 05212. OWDA Main Drought Atlas Analysis	308
D.6.4. Script Name 05213. OWDA Map check:.....	310
E. Appendix. Market Dynamics by Location	311
E.1. Paris.....	311
E.2. Spain - Barcelona and Madrid	314
E.3. London.....	316
E.4. Amsterdam.....	320
E.5. Gdańsk.....	322
E.6. Nuremberg	322
E.7. Frankfurt.....	324
E.8. Munich	325

E.9. Vienna	327
E.10. Stockholm	328
F. Appendix. Conflict Levels by Location.....	330
F.1. British Empire - Southern England.....	330
F.2. France - Paris.....	333
F.3. Habsburg Empire and The Holy Roman Empire.....	334
F.3.1. Austria - Vienna.....	335
F.3.2. The Netherlands - Amsterdam.....	336
F.3.3. Belgium - Antwerp	337
F.3.4. Germany - Munich, Frankfurt, and Nuremberg.....	338
F.3.5. Summary	340
F.4. Poland - Gdańsk	340
F.5. Spain - Barcelona, Madrid, and Valencia	341
F.5.1. Barcelona	341
F.5.2. Madrid.....	342
F.5.3. Valencia.....	343
F.5.4. Summary	344
F.6. Sweden - Stockholm.....	344
Bibliography	346
Websites	369
Digitised Sources.....	372
Grants.....	372

List of Figures

Figure 1.1. “The Great Fish Market”, painted by Jan Brueghel the Elder. Dating to the year 1603.....	2
Figure 1.2. The studied market locations.	6
Figure 1.3. In the 17th century, the French and English took more control at the Grand Banks	7
Figure 1.4 Example of North Sea Fishing grounds for herring in 1833.	9
Figure 1.5. St John’s sidewalk stone cod.....	10
Figure 2.1. The processing of price information through a number of stages.	28
Figure 2.2. A chart of the most complete cod and herring time series.	32
Figure 2.3. Commodity Price series for cod, herring, beef and pork.....	34
Figure 2.4. Commodity Price series for cod, herring, beef and pork from Allaire’s Paris report.	35
Figure 2.5. “His Majesty’s Fleet Blockading the Spanish Port called Cadiz”. Anonymous, late C18th.....	36
Figure 3.1. Dutch merchant manual from the 16th century.	42
Figure 3.2. The Hooping of Herring Barrels.	43
Figure 4.1. Cod prices in Paris for Newfoundland produce and for fresh produce.....	52
Figure 4.2. The chart displays raw price series for cod and herring in Paris.	53
Figure 4.3. The ratio of cod prices relative to herring at an annual resolution (yearly price values).	55
Figure 4.4. Coefficient of Variation by decade for cod and herring.	56
Figure 4.5. Coefficient of Variation applied to the ratio of cod and herring prices.	57
Figure 4.6. Denier prices for cod and beef in Paris.	58
Figure 4.7. The ratio of cod to beef (in red).....	59
Figure 4.8. Coefficients of Variation for cod and beef.....	60
Figure 4.9. The coefficient of variation (CV) of the ratio of cod and beef in Paris.	61
Figure 4.10. Cod quantity and price information for England.	66
Figure 4.11. Herring quantity and price information for England.	67
Figure 4.12. Dutch Herring catch quantities and prices.	72
Figure 4.13. French Cod catches from Newfoundland.	75

Figure 4.14. Dutch Herring prices at two market levels.	77
Figure 4.15. Ratio of herring prices in Amsterdam for herring at two market levels.	79
Figure 4.16. Dutch stockfish prices at two market levels.	80
Figure 4.17. Ratio of stockfish prices.	81
Figure 4.18. Ratio of stockfish compared to herring prices on wholesale markets in Amsterdam.	82
Figure 4.19. Prices for eggs sold in Paris.	84
Figure 4.20. Ratio of egg prices in Paris.	86
Figure 5.1. Southern England commodity prices over each 50-year period.	97
Figure 5.2. Wheat prices.	123
Figure 5.3. Wheat Coefficients of Variation (CV)s.	124
Figure 5.4. Herring prices in grams of silver per kilogram.	125
Figure 5.5. Coefficient of Variation for selected herring price series.	127
Figure 5.6. Cod prices in Southern England, Barcelona and Paris.	130
Figure 5.7. Coefficient of Variation (CV) for cod price series.	131
Figure 5.8. Prices in Stockholm for herring and Barcelona for bacalao.	133
Figure 5.9. CV of prices in Stockholm for herring and Barcelona for bacalao.	134
Figure 5.10. Bacalao from Barcelona and Gdańsk herring prices.	135
Figure 5.11. Decadal Coefficient of Variation values for case study.	136
Figure 5.12. Cod prices in Paris and Barcelona.	137
Figure 5.13. CV of cod prices in Paris and Barcelona.	137
Figure 6.1. The Battle of the Herrings. Journée des Harengs.	142
Figure 6.2. Conflict levels in Europe.	146
Figure 6.3. Total conflict levels for different territories in Europe.	147
Figure 6.4. Total conflict levels in Europe as represented by a grey scale to represent conflict levels.	148
Figure 6.5. A representation of cases of years when a country saw a change of ruling entity or change in company.	150
Figure 6.6. Herring prices (log transformed) and compared to conflict.	151
Figure 6.7. Cod Prices (log transformed) and compared to conflict levels.	155
Figure 6.8. Beef prices.	159
Figure 6.9. Wheat prices.	161

Figure 7.1. Atlantic Multidecadal Variability (AMV) for the study period of 1500 to 1800.	169
Figure 7.2. Cod and herring prices compared to AMV.	171
Figure 7.3. The Old World Drought Atlas (OWDA) Index.....	174
Figure 7.4. The OWDA index for each country.	175
Figure 7.5. Cod and Herring Prices compared to the OWDA.....	177
Figure 7.6. Prices in Paris compared to the OWDA index for France.	178
Figure 7.7. Prices in Amsterdam for cod and herring compared to the OWDA.....	180
Figure 7.8. Beef and Herring Prices in Gdańsk compared to the OWDA activity.	181
Figure 7.9. Commodity prices in Barcelona, Spain, for cod and herring.	182
Figure 7.10. Estimated European summer temperatures anomalies.....	183
Figure 8.1 SEA compared conflict to SST levels (based on AMV normalised by 10 years).	191
Figure 8.2 SEA comparing conflict to drought levels. Based on OWDA normalised by 10 years.	192
Figure 8.3 Cross-correlation of conflict levels per year against herring, cod, beef, and wheat logged prices.	197
Figure 8.4 Cross-correlation of drought levels against herring, cod, beef and wheat logged prices.	199
Figure 8.5 Cross-correlation of ocean activity against herring, cod, beef and wheat logged prices with conflict levels per year.	201
Figure A.1. Price series for Southern England based on the works of Rogers and Beveridge.	220
Figure A.2. Prices in Madrid based on Hamilton’s work.....	224
Figure A.3. Selection of Prices for the Netherlands from Posthumus.....	227
Figure A.4. Prices for Frankfurt, based on Elsas’s collections.....	230
Figure A.5. Prices for Munich, based on Elsas’s collections.....	231
Figure A.6. Prices in Gdańsk, from the work of Pelc and Furtak,	234
Figure A.7. Prices in Paris from the works for Baulant and Hauser.....	235
Figure A.8. Prices in Vienna for herring, beef and stockfish from Alfred Francis Pribram.	237
Figure A.9. Prices in Antwerp for herring.	238

Figure A.10. Prices in Barcelona from Gaspar Feliu’s collection.	241
Figure A.11. Prices in Nuremberg. (Rye and herring).	243
Figure A.12. Price paid in Stockholm, based on research by Arne Jansson and Johan Söderberg.....	244
Figure A.13. Example of the archival documents from Paris.	247
Figure A.14. Prices for cod, herring and beef.	248
Figure A.15. Table from NorFish Internal Report One.....	249
Figure A.16. An extract from previous table.....	249
Figure A.17. An extract from the final consolidated table.	250
Figure A.18. From the text just above.	251
Figure E.1. Paris animal protein sources; cod, herring, pork, beef and chicken.	312
Figure E.2. Coefficient of Variation by decade for Paris.	313
Figure E.3. Bacalao, pilchards and sheep meat products in Barcelona.....	315
Figure E.4. Coefficient of Variation for prices in Barcelona.....	316
Figure E.5. Price series for fish and beef in London. Converted to prices in grams of silver.	317
Figure E.6. Coefficient of Variation for fish and beef in London.	319
Figure E.7. Amsterdam prices.	321
Figure E.8. CV for Amsterdam prices.	321
Figure E.9. Gdańsk prices.	322
Figure E.10. Gdańsk price CVs.....	322
Figure E.11. Nuremberg prices.	323
Figure E.12. Nuremberg price CVs.	323
Figure E.13. Frankfurt prices.....	324
Figure E.14. Frankfurt price CVs.	325
Figure E.15. Munich prices.....	326
Figure E.16. Munich price CVs.	326
Figure E.17. Vienna prices.....	327
Figure E.18. Vienna price CVs.	328
Figure E.19. Price series for herring and oxen in Stockholm.....	329
Figure E.20. Coefficient of Variation for herring and oxen in Stockholm.....	329

Figure F.1. English prices (log transformed) for herring, stockfish, salted cod, wheat and beef.	331
Figure F.2. Prices in Paris (log transformed) and compared to conflict.	333
Figure F.3. Vienna prices (log transformed) and compared to conflict levels.....	336
Figure F.4. Prices in Amsterdam with conflict levels in grey.	337
Figure F.5. Prices in Antwerp for herring.	338
Figure F.6. Prices in Nuremberg, Munich and Frankfurt compared to conflict levels.....	339
Figure F.7. Prices in Nuremberg for herring, salt and rye.....	340
Figure F.8. Prices in Gdańsk for beef, herring and pork.	341
Figure F.9. Prices in Barcelona for bacalao, herring and mutton.	342
Figure F.10. Madrid prices compared to conflict levels.....	343
Figure F.11. Prices in Valencia compared to conflict levels.....	344
Figure F.12. Prices for Stockholm.	345

List of Tables

Table 5.1. Herring prices for 50-year periods.....	91
Table 5.2. Herring prices differences/changes between each 50-year period.	93
Table 5.3. Southern England prices with 50-year averages for fish products.....	94
Table 5.4. 50-Year average prices in Grams of Silver per Kilogram of produce in Amsterdam.	98
Table 5.5. 50-year averages for herring in Amsterdam and Southern England.	99
Table 5.6. 50-Year averages for herring in Paris and Amsterdam (referred to as “Dutch”).	102
Table 5.7. Paris prices. Sources: Allaire, Hauser and Baulant.....	103
Table 5.8. 50-year average prices in Grams of Silver per Kilogram of produce in Barcelona.	104
Table 5.9. 50-year averages for Amsterdam (referred to as “Dutch”) compared to Barcelona.	104
Table 5.10. Herring Prices for Non-wholesale pieces for Amsterdam, Frankfurt and Nuremberg.....	105
Table 5.11. Information for Frankfurt. Covers barley, beef, herring, mutton, rye, veal and wheat.	106
Table 5.12. Nuremberg prices in grams of silver per kilogram of produce. (Rye and herring).	106
Table 5.13. Gdańsk 50-year average prices of commodities.....	108
Table 5.14. Vienna prices in grams of silver per kilogram of produce. (Herring and stockfish).	108
Table 5.15. 50-Year averages for herring (both stromming and sill), pork and oxen in Stockholm.	109
Table 5.16. Herring prices for Amsterdam, Gdąnsk, Vienna and Stockholm.	110
Table 5.17. Cod prices with 50-year averages.	112
Table 5.18. An example of costs from boats to market for cod coming from Newfoundland.	113
Table 5.19. Stockfish prices for Amsterdam (i.e., Dutch), Munich, London and Vienna...	116
Table 5.20. Dutch stockfish cod and herring.	116
Table 5.21. Price in Munich for Stockfish (cod) and herring.	117

Table 5.22. Price in Vienna for Stockfish (cod) and herring.....	117
Table 5.23. Salted cod prices.	118
Table 5.24. Salted cod and herring in Southern England, Paris and Amsterdam.	118
Table 5.25. Green cod, Newfoundland cod and salted cod price in Paris.	119
Table 5.26. Minimum, maximum and mid-point prices over all 50-year averages and locations.	121
Table 6.1. Conflict Events for the Netherlands within the period from 1500 to 1800. (In some cases, there is a formatting issue, with dates appearing twice).....	144
Table 6.2. Examples of changes in ruling Empires and influential trading companies.....	149
Table 8.1. Views of previous scholars.	188
Table 8.2 Correlation matrix comparing conflict and environment.	194
Table 8.3. Correlation Matrix for logged herring prices, conflict levels and environment.	203
Table 8.4. Correlation Matrix for logged cod prices, conflict levels and environment.	204
Table 8.5. Correlation Matrix for logged beef prices, conflict levels and environmental activity.....	205
Table 8.6. Correlation Matrix for the CV of herring prices, conflict levels and environment.	207
Table 8.7. Correlation Matrix for the CV of cod prices, conflict levels and environment.	208
Table 8.8. Correlation Matrix for the CV of wheat prices, conflict levels and environment.	209
Table B.1. Swedish currency conversions.	268
Table B.2. Conversions for Sweden.....	268

List of Equations

Equation 2.1 Purchasing Power Parity.....	26
Equation 2.2. A price ratio formula for two commodities.	37
Equation 8.1. Conflict compared to climate.	193
Equation 8.2. LM Equation for herring.	202
Equation 8.3. LM Equation of cod.	204
Equation 8.4. Beef Adjusted R-squared: 0.9144.....	205
Equation 8.5. Model of CV compared to conflict and environment.	207
Equation 8.6. Moving CV compared to conflict.....	207
Equation 8.7. Moving price average compared to previous year, conflict and climate. ..	208

List of Diagrams

Diagram 5.1. Amsterdam Herring Trade from 1600 to 1649.101

Diagram 5.2. Example of possible European cod trade routes in period 1600-1649.....111

1. Introduction

The study period for this thesis is from 1500 to 1800 CE, this period is often referred to as the early modern period. This time was marked by European expansion to the Americas at its onset. Return voyages saw the introduction of new products to markets within Europe, amongst these, were abundant supplies of cod (*Gadus morhua*) fished from the Grand Banks off the coast of Newfoundland, a location in modern-day Canada.¹ Over time, the cod began arriving to European shores in increasingly large volumes over the entire study period, supplementing the already established east Atlantic fishing grounds and the already established European cod and herring (*Clupea harengus*) markets. The magnitude of the marine fishing industry in Europe was such that it produced tens of thousands of tonnes of fish at the beginning of the study period, and it grew significantly with the return of cod from the Grand Banks. Total annual cod landings in the Atlantic for European consumption increased almost ten-fold between 1520 and 1788, from over 81,000 to almost 774,000 metric tonnes.² At the same time, herring landings also increased, though more modestly, from annual averages of 100,000 metric tonnes between 1520 and 1600, to a peak in 1788 of more than 250,000. Thus, for at least some, marine fish, in particular Newfoundland cod, became a more important feature of food supplies, diets, and livelihoods (Figure 1.1).

¹ Charles Travis et al. "Inventing the Grand Banks: A Deep Chart: Humanities GIS, Cartesian, and Literary Perceptions of the North-West Atlantic Fishery ca 1500 - 1800," *Geo: Geography and Environment* 7, no. 1 (2020).

² Poul Holm et al. "A Revolution in Fish Supplies. The Scale of the Cod and Herring Fisheries, c. 1500 - 1800," (In preparation).



Figure 1.1. “The Great Fish Market”, painted by Jan Brueghel the Elder. Dating to the year 1603. Brueghel here presents an imaginary landscape that emphasizes the significance and importance of the sea and fish to everyday life.³

The arrival of the new supply of cod has been hypothesised to have occurred with effects comparable to modern-day globalisation.⁴ From the perspective of the current study, this relates to a hypothesis that commodity prices in different European locations may have become increasingly aligned or related. The relationship of prices across different locations can be measured by studying degrees of market integration (introduced in more detail in Section 2.2.6). Market integration is often indicated by price volatility, with less volatility indicating more integration. That is, a more integrated market can be expected to come with increased price stability. The issue of how contemporary integrated markets will fare under future supply shocks is increasingly on the research agenda of many disciplines today.⁵ Supply shocks will be studied in this thesis. In particular, the long term influence of the then growing new supply of cod from the Grand Banks beginning in the early 1500s,

³ “Great Fish Market.” Oil painting by Jan Brueghel the Elder in the Alte Pinakothek, Munich:

<https://www.wikidata.org/wiki/Q1548676>.

⁴ Poul Holm et al. “The North Atlantic Fish Revolution (ca. AD 1500),” *Quaternary Research* (2019).

⁵ Giovanni Federico. “Market Integration from Measurement to Economic Analysis: A Survey of the Recent Literature,” CEPR Discussion Paper No. DP12902 (2018). Available at SSRN:

<https://ssrn.com/abstract=3184207>; Michael J. Puma et al. “Assessing the Evolving Fragility of the Global Food System,” *Environmental Research Letters* 10 (2015).

and shocks from major conflicts and climate events. Another important parallel to today is food security for our modern societies. Returning to the early modern period and the influx of cod, this new supply would have increased food security, at least for a part of the society. In early modern Europe, important sources of nutrition were wheat, beef, and marine fish. With the arrival of the Newfoundland cod came an additional source of protein, which would have affected the already established markets in the eastern Atlantic. While wheat, for example, has been studied particularly well from the perspective of market integration, marine produce has gained less attention.

1.1. Research Questions

As already alluded to, from a modern-day perspective, questions arise about the outcome of the arrival of the new supply of cod. Thus, three core research questions are put forward. They relate to two market dynamics: market integration and commodity substitution. In brief, market integration is a measure of how connected prices are between locations, as well as price stability. Commodity substitution relates to the extent commodities were replacing one another.

The three questions are outlined below and have been subdivided into shorter and more specific component questions.

1) Did the levels of market integration during the period from 1500 to 1800 change meaningfully for cod and herring? In particular, how did these levels of integration compare relative to beef and wheat?

- Does available information allow measurement of market integration?
- Did the Newfoundland cod arrive with volatile cod prices earlier in the study period? Further, did the prices stabilise in time?
- Did already established markets in Europe for cod and herring become relatively more or less integrated?
- How did levels of cod and herring market integration compare to that of beef and wheat?

2) Did Newfoundland cod behave as a commodity substitute and an alternative, lower-priced source of nutrition in European markets? Specifically, did it supplement supplies of

already established commodity markets for herring, beef, wheat, and cod from northeast Atlantic fisheries?

- Did the arrival of the Newfoundland cod occur with decreasing prices for cod products? Either for the Newfoundland cod or the already established cod markets?
- Did cod products decrease in price relative to herring?
- Did cod or herring prices decrease relative to beef and wheat?

3) Did conflict and climate play a role in the degrees of market integration and commodity substitution established in questions 1 and 2? Conflict and climate are factors that can be considered in some way as “external” to the market. They will be studied to understand if they influenced market integration and price changes.

- Did conflict, in the form of warfare, influence the occurrence of market integration and commodity substitution?
- Similarly, did climate influence these market dynamics?
- To what extent can we understand the interaction of conflict, climate, and the market dynamics?

1.2. Setting the Scene: Europe and the Fish Markets

A recent publication by Holm *et al.*⁶ raises questions around the value of cod relative to rye in northern European locations from 1500 to 1800 CE. The publication highlights that with the decreasing price of cod relative to rye in Bergen, Norway, cod could have become an increasingly cheaper source of protein for some. Moreover, they proposed a concept of the Fish Revolution and hypothesised that the arrival of the large quantities of cod from Newfoundland may have had far-reaching consequences in European nations, including globalisation effects.⁷ Such effects would have included markets that developed closer relationships between regions, that is, they would have become more integrated to one another. Another effect would have been a more stable and secure food supply due to a diversification of commodities that provided increased food supplies and also mitigated

⁶ Holm, “The North Atlantic Fish Revolution,” 8.

⁷ *Ibid*, 1.

against the loss of supply that could occur for reasons such as conflicts that halted trade or droughts that caused crops failure.

To set the scene for the analysis, the market locations and changing values of food commodities are briefly discussed. The early modern food markets did not feature the modern levels of uniformity of process, measurement, and currency. The markets were, however, in constant development. From around the 1470s or 1480s up to as late as the 1650s, a long-term trend of price inflation occurred, referred to as the Price Revolution.⁸ In the late-16th and most of the 17th century, a General Crisis has been hypothesised to have occurred. In that time, the price inflation that was a defining feature of the Price Revolution came to an end. The General Crisis was marked by elevated levels of conflict, it also occurred alongside changing climate conditions such as the Little Ice Age.⁹

1.2.1. Market Locations and Trade

The Oxford English Dictionary defines a market as:

“A meeting or gathering together of people for the purchase and sale of provisions or livestock, publicly displayed, at a fixed time and place; the occasion or time of this. Also: the people gathered at such a meeting.”¹⁰

Thus, markets depend on both time and space. As such, they can change over time and occur in different locations. Also, what was sold at the markets will have changed. Over the study period, different countries fished from the Grand Banks with different degrees of control and interest. The Spanish and Portuguese were amongst the first to bring back cod from the Grand Banks and were the major fishers there up to the mid-16th century, while England and France became the more dominant fishers after that.¹¹ Market integration will be studied to understand to what extent the markets were connected, and if this increased over the course of the study period. In this thesis, the studied market locations are the

⁸ David Hackett Fischer. *The Great Wave: Price Revolutions and the Rhythm of History* (New York: Oxford University Press, 1996), 69.

⁹ Geoffrey Parker, and Lesley M. Smith, eds. *The General Crisis of the Seventeenth Century* (London and New York: Psychology Press, 1997).

¹⁰ “market, n.” OED Online. Oxford University Press. <https://www-oed-com.elib.tcd.ie/view/Entry/114178?rskey=amBTKJ&result=1&isAdvanced=false>. (Accessed October 13 2020).

¹¹ William H. Lear. “History of Fisheries in the Northwest Atlantic: The 500-Year Perspective,” *Journal of Northwest Atlantic Fishery Science* 23 (1998).

cities, rather than the surrounding regions or countryside (Figure 1.2). This is largely due to most price information being available for these population centres.

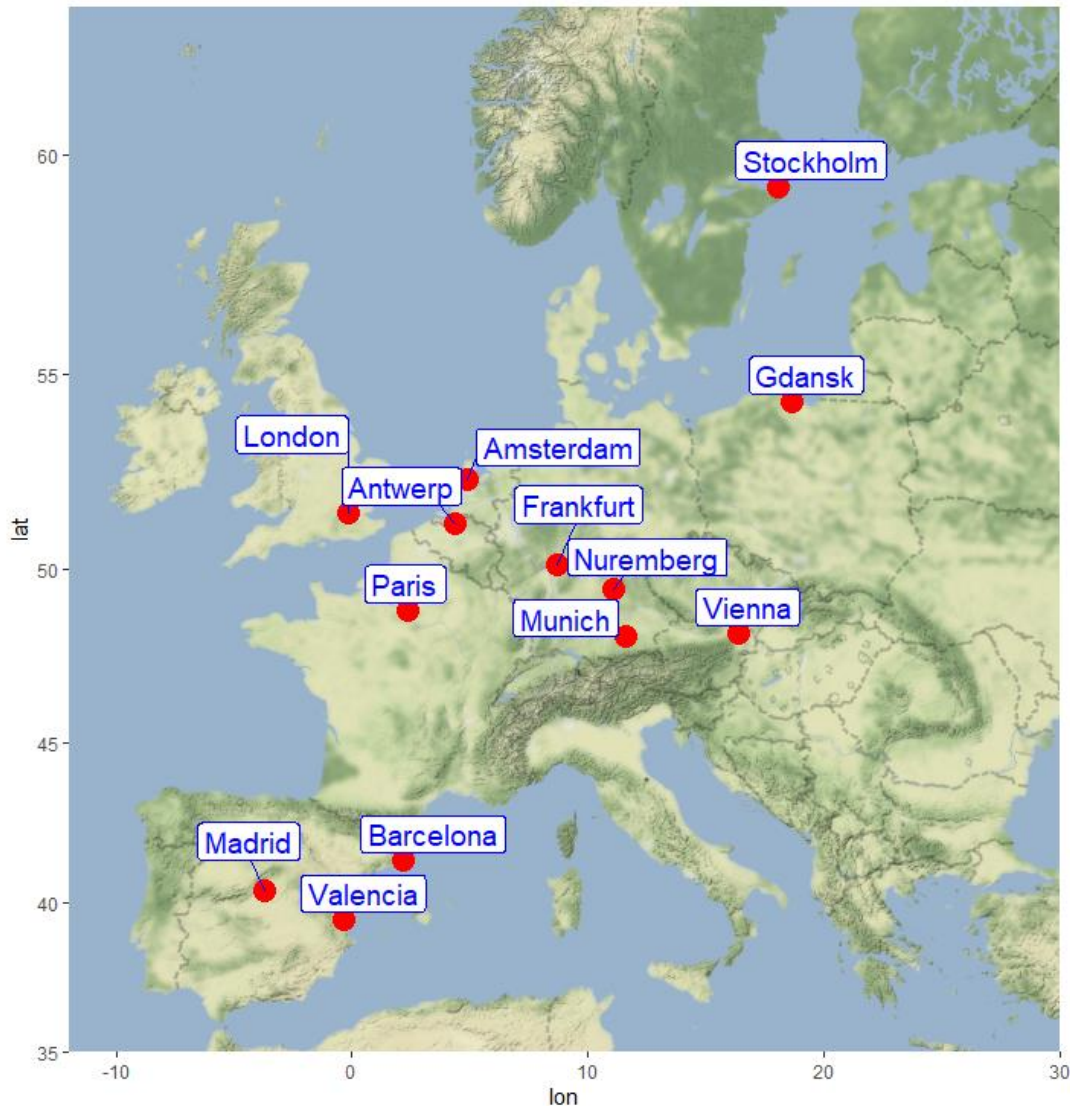


Figure 1.2. The studied market locations. Madrid, Valencia and Barcelona in Spain, Paris in France, Frankfurt, Nuremberg and Munich in Germany, Vienna in Austria, Gdańsk in Poland, London in England, Amsterdam in the Netherlands, and Stockholm in Sweden.

Dynamics will be studied for locations across Europe. These are England, The Netherlands, Germany, Austria, France, Poland, Spain, and Sweden. As an example of one influence on prices, those paid for cod and herring were influenced by the changing control of different fishing grounds. The Spanish and Portuguese were prominent fishers at the Grand Banks in the first half of the 16th century, before the French and English took more control. The map below is an example of French cartography from the early 17th Century, it portrays North America including the Grand Banks (Figure 1.3). In Northern and Central Europe, some

locations were involved in Hanseatic trade. For example, during the 16th century, stockfish was transported along the Rhine to a central point of Frankfurt before being further traded and transported to locations such as Nuremberg.¹² Further northeast, Gdańsk is located in the north of mainland Europe and on the coast of the Baltic Sea. The fish here arrived on vessels from a variety of home ports, such as Copenhagen and those of the Netherlands.¹³ Returning to Western Europe, Amsterdam was a very significant player in herring fishing and trading. Also, the Dutch fleets had a strong link to other locations for grain and timber, for example with Gdańsk.¹⁴



Figure 1.3. In the 17th century, the French and English took more control at the Grand Banks. In this map, the Grand Banks are visible off the coast of “Terres Noeefves” (i.e., Newfoundland) and south of “Terre de Laboradon” (i.e., Labrador). (Excerpted from an illuminated map of the Atlantic by Pierre de Vaulx, 1613¹⁵).

In Northeast Europe, two different herring products were sold in Stockholm: the North Sea herring and the East Baltic herring.¹⁶ At times, trade to and from Sweden was limited by

¹² Arved Nedkvitne. *The German Hansa and Bergen 1100-1600* (Köln: Böhlau, 2014), 234.

¹³ Karl-Erik Frandsen. “The Scale and Politics of Danzig’s Salted Herring Trade in the Late Sixteenth Century,” *International Journal of Maritime History* 16, no. 2 (2004): 153, Figure 4.

¹⁴ Jonathan Irvine Israel and R. J. W. Evans. *The Dutch Republic: Its Rise, Greatness, and Fall, 1477-1806*. vol. 321. (Oxford: Clarendon Press, 1995), 117.

¹⁵ Sarah Toulouse. “Marine Cartography and Navigation in Renaissance France,” in *The History of Cartography*, vol. 3, ed. David Woodward (Chicago: University of Chicago Press, 2007). URL: <https://www.wdl.org/en/item/15482/>.

¹⁶ Arne Jansson, Lennart Palm, and Johan Söderberg. *Dagligt Bröd I Onda Tider: Priser Och Löner I Stockholm Och Västsverige 1500-1770* (Gothenburg: Inst. för Lokalhistorisk Forskning, 1991).

the Danes, who controlled Øresund (commonly known as “The Sound” in English). It was an important connection between the Baltic and North seas and for long periods of time controlled by the Danish who imposed a tax known as the “Sound Toll” on ships passing through.¹⁷

1.2.2. Prominence of Herring and Cod

Cod and herring products were important food commodities prior to and during the early modern period in Europe.¹⁸ They have been studied from a number of perspectives, from their bones in archaeological studies to the archival records of quantities and prices. Previous studies have primarily focussed on the medieval period and on production rather than consumption.¹⁹ Before exploring the price information, both fish merit a brief discussion.

Herring

Herring spawning and fishing grounds were in the North, Norwegian, and Baltic seas. For example, following the study period, from 1856 to 1863, Bo Poulsen has described fishing activity as focused on the North Sea, close to the East coast of Britain and the Shetlands (Figure 1.4).²⁰ Fishing patterns were highly seasonal. The Dutch herring fishing season began on the 24th of June each year and continued to the end of the year, and this remained largely in case from 1582 to 1857.²¹

Fishing methods were standardised in many instances. For example, the Dutch followed a standardised production process that included drift nets, custom-built “factory-like” herring busses, and barrels the fish were ultimately transported and sold in.²² The herring production for markets was dominated by “uniform” and reliable produce from the Dutch

¹⁷ Erik Gøbel. “The Sound Toll Registers Online Project, 1497–1857,” *International Journal of Maritime History* 22, no. 2 (2010).

¹⁸ David C. Orton and James H. Barrett, eds. *Cod and Herring: the Archaeology and History of Medieval Sea Fishing* (Oxford: Oxbow Books, 2016), 1.

¹⁹ *Ibid*, 6.

²⁰ Bo Poulsen. *Dutch herring: An environmental history, c. 1600-1860. vol. 3.* (Amsterdam University Press, 2008), 197.

²¹ *Ibid*, 44.

²² *Ibid*, 111.

during the 17th century, although it declined throughout the 17th and 18th centuries, with Norwegian and Scottish production becoming more common.²³



Figure 1.4 Example of North Sea Fishing grounds for herring in 1833.²⁴

Cod

Cod fished from around Iceland and Norway was consumed in many European countries by the 1500s. Cod from the Northwest Atlantic became another product consumed in

²³ Ibid, 70.

²⁴ Ole Theodor Olsen. "Herring (Clupia Harengus), 1883. Pictorial map, 46 cm x 36 cm," David Rumsey Map Collection. <https://www.davidrumsey.com/luna/servlet/s/3wx7n1>. Accessed June 20 2020.

Europe, following the discovery of the Newfoundland Grand Banks. These products were different combinations of salted, unsalted, wet, and dried cod. These different markets occurred due to differing production processes, transportation, and dietary preferences. Production and sale of cod remained important in Newfoundland up to recent times. As a testament to this importance, the image below (Figure 1.5) displays a stone cod built into a modern sidewalk in St. Johns in Newfoundland.



Figure 1.5. St John's sidewalk stone cod.²⁵

From the northeast Atlantic, cod was mostly a dried product known as “stockfish”. It was not the only cod product coming from the northeast Atlantic as the English were returning a salted cod product for their local markets. The English salted the produce to make the transport faster, not wanting to wait for the longer process of the fish drying on land, as was the case for stockfish dried on the shores of Iceland and Norway. Thus, in those instances it might not be clear what fish historical sources are referring to. As for the Grand

²⁵ “The Mighty Cod.” The World's Fair. <https://worldsfare.wordpress.com/2008/12/12/the-mighty-cod/>. Accessed November 24 2020.

Banks, bacalao was a dried and lightly salted product commonly sold at Iberian markets,²⁶ while the French preferred a salted but not dried product, known as “green cod”.

1.3. Thesis Overview by Chapter

The thesis is structured into eight chapters. Following the introduction, Chapter 2 introduces the price sources and the methods used to analyse them. Many of the sources come from secondary literature that are collections of prices, compiled and tabulated from archival primary sources. Marine fish prices, usually herring and cod, are of particular focus for this analysis. The methodology outlines the process of analysing information for the thesis, including the design of a database to house quantitative information. The indicators of market dynamics are defined. Ratios were applied for commodity substitution. The Coefficient of Variation (CV) was used for market integration.

Comparisons between locations require standardised units of price. Thus, conversion of the commodities prices from local currencies and weights to a common price unit is covered in Chapter 3. The common unit is grams of silver per kilogram of produce. The variety of units becomes apparent, highlighting these markets had not yet reached the levels of standardisation and uniformity that is often taken for granted in modern times.

Commodity substitution and “market levels” are analysed in Chapter 4, in particular focusing on quantities of fish and how they relate to price behaviour. The estimation of fish catch quantities is based on studies by previous scholars. The analysis in this thesis focuses on relative changes and trends in quantity series, rather than the absolute values caught in any given year. The last section of the chapter considers the “market levels”, which explains the dynamics of supply and demand between the market levels by discussing supply chains. The market levels refer to different points in the fish supply chains, for which prices are examined, comprising either “wholesale” prices or those paid by consumers. The wholesale prices represent an early stage in the supply chain, such as prices paid for barrels of fish sold shortly after arriving at port. Consumer prices represent prices at the other end of the supply chain, i.e., those paid by large consumers such as hospitals and religious institutions.

²⁶ Peter E. Pope. *Fish into Wine: The Newfoundland Plantation in the Seventeenth Century* (Chapel Hill: University of North Carolina Press, 2004), 14.

Chapter 5 focuses on the price dynamics. Price differences between locations are studied over the long term, focusing on 50-year price averages. This is to give an overview of the market across all included locations and the full study period. To study market integration on a shorter and medium-term, price movements are studied at decadal resolution, including their levels of variability. Beef and wheat prices are also studied to understand how their prices compared to these alternative food sources.

Conflict is the focus of Chapter 6. A chronology of conflict events is introduced and analysed to understand if conflict drove price changes or vice versa. This includes a quantitative approach that is developed from the chronology of conflict events. A grading system is applied to the events to understand the magnitude of conflict per year. The chronology of conflict events is also sub-divided into regional indices, to understand how different regions behaved. The indices are compared against the price information. Major conflicts are studied in more detail. The Thirty Years' War (1618 to 1648) is a particular focus, as it was a devastating event in European history.

Chapter 7 focuses on climate. The connection between climate and society is an active area of research. This section studies environmental proxies and their relationship with commodity prices. The main sources of environmental information are long time series of information. In particular, time series that represent ocean variability, and climate on land are included.

The 8th chapter comprises two sections. The first section analyses the results from previous scholars and compares them to those developed in this thesis. This includes a discussion of what was unique or distinct about fish products compared to the likes of wheat and beef. The second section of the chapter then applies advanced numerical models to commodity prices with the objective of further understanding how conflict and climate interacted with them. The thesis is concluded in Chapter 9, bringing together the analysis from each of the preceding chapters.

There are six appendices. Appendix A is a detailed analysis of the commodity prices by location. Appendix B studies the currencies and quantities that prices were recorded in. It further outlines how prices were converted to a common unit of grams of silver per kilogram of produce. Appendix C gives an overview of the price series information for each location, specifically laying out in detail where the prices can be found in the secondary

sources and details such as their temporal converge and level of completeness. Appendix D includes code from the R scripts. Appendix E provides an extensive analysis of price dynamics at each location, while Appendix F gives further information on the level of conflict at each location.

2. Price Sources and Methodology

Commodity price series are the core source materials for this thesis. They will be studied to indicate various market dynamics, and to understand to what extent these changed through the study period. This analysis makes new use of information already published by price historians over the last two centuries, and where possible, incorporates completely new data. To this end, systematically the different sources have been analysed with the objective of understanding their features and how they represent, or relate to, market prices.

The methodology and research framework will also be outlined. This methodology is influenced by the Annales school of thought, which also shaped the development of the price literature from the 1930s onwards. In broad terms, the Annales school was instrumental in the development of the study of long-term trends in demographic and economic processes.²⁷ The analysis in later chapters is moulded by quantitative and statistical techniques and includes modern computational techniques. These techniques will largely be facilitated through application of the R statistical package.

2.1. Price Sources

The price series that are introduced below have been researched and developed over the last two hundred years, with a peak interest in the mid-20th century. They have been extracted from archival sources throughout Europe. Each series was developed with a methodology, these differed between authors, but tend to become increasingly standardised as the area of research developed. The price series are a type of time-series, thus they variously employ intervals such as days, weeks, months, years, five-year averages, and decadal averages. This thesis focuses on yearly intervals and longer, as the research is concerned with inter-annual variability rather than seasonal variability of the prices. The individual series cover the entire study period of 1500 to 1800 to different degrees. The overall coverage from the different series is sufficient as to not significantly impede the analysis.

²⁷ Michael Harsgor. "Total history: the Annales School," *Journal of Contemporary History* 13, no. 1 (1978), 3.

It is necessary to understand the purpose and motivation for the creation and storage of the original documents. Also, for the purpose of creating a price series and to analyse them, the sources must be reliable, thus it is important to establish if motivation existed for accurate record keeping. In 2000, Heather MacNeil discussed in general how to assess the reliability of historical sources and why it is important to assess this, including understanding of the motives of the authors, the purpose of the text and the context they were written in.²⁸ The concept of “positivism” has been a cause for debate, as Philippe Carrard described in relation to Braudel’s work. As Carrard notes, there was debate about the applications of the positivist methods in historical studies.²⁹

As a more specific example of the process behind the development and survival of archival records, Nicolaas Posthumus notes that in the case of Amsterdam, certain institutions (usually hospitals, municipal, and religious) performed the following three actions: they bought commodities, they kept a record of the paid prices in registers, and finally, they preserved these registers.³⁰ As the registers were kept for regular audits, it was in the record-keepers’ interest to have them reliable and accurate. As was the case for Amsterdam, and other locations, this reliability has subsequently been assessed by the scholars when working with the primary archival sources. If the authors decide the records contain biases or if the absolute prices are found to be significantly different compared to other similar commodities, they should in essence be excluded or come with an indicator or guide that states the limitations of the information. For a more recent discussion of the original motivations for keeping these records, Alexandra Walsham describes how this evolved over recent centuries.³¹ Scholars have studied original documents and trends in price series to understand the “character” of the prices. In broad terms, this refers to what the price represents. For example, documented prices can represent recommended list prices set by a municipal authority for a variety of reasons, in such a scenario they may not have been the actual prices that were paid in the marketplace. Such lists of recommended

²⁸ Heather MacNeil. “Trusting Records as Historical Evidence: Modern Historical Methods,” in *Trusting Records: Legal, Historical and Diplomatic Perspectives* (Dordrecht, London & Boston: Kluwer Academic Publishers, 2000), 57-85.

²⁹ Philippe Carrard. “Figuring France: The Numbers and Tropes of Fernand Braudel,” *Diacritics* 18, No. 3, (1988), 6.

³⁰ Nicolaas Wilhelmus Posthumus. *Inquiry into the History of Prices in Holland*. vol. 2 (Leiden: EJ Brill, 1964).

³¹ Alexandra Walsham. *The Social History of the Archive: Record-Keeping in Early Modern Europe, Past & Present Supplement 11*, vol. 230. (Oxford: Oxford University Press, 2016).

prices will not display the same degree of price variation as market prices, as market prices most likely fluctuate around the recommended prices. Thus, list prices can provide a different type of information, more indicative of medium to long term changes (i.e., around five years and longer, for example). This, for example, could be indicative of medium to long-term inflation trends, easier to interpret than the more volatile, or “noisy” market prices. It is possible that such a list price was set by a government authority to account for inflation. The temporal frequency that the documented price series occur in can differ, reflecting daily, weekly, monthly, or annual transactions. Depending on this resolution, cyclical trends in the prices may be discernible. For example, for information available on a monthly or quarterly basis, seasonal trends could be studied. Higher resolution series allow a closer inspection of short-term (e.g., inter-annual or finer) variability.

Prices differ depending on what stage of a supply chain they represent. Comparing the price series at different stages in the supply chains can explain the more complex inner workings and dynamics of the fish markets. The prices studied in this thesis usually represent wholesale markets, which are lower priced and earlier stages in a supply chain, or stages such as hospitals or wealthier members of society, who will pay higher prices that represent the final stages in a supply chain. These two ends of a supply chain will display different changes in the prices, beyond simply wholesale being cheaper than that later stages in the market. Some of this difference occurs because there are different pressures on supply and demand between stages. Also, the motivations of those involved in transactions will differ. For example, the actions of buying or selling have different motivations that, in turn, can lead to contrasting price behaviours. As Posthumus observes, the prices for institutions, such as hospitals and religious institutions, represent a final point of sale, as they are not sold on again. Thus, profit from selling produce is not a factor in their transactions.³²

Closely related to the supply chain is the ability to establish prices paid by different groups in society, for example if they represent the elite or large institutions such as hospitals. It is possible these were totally different supply chains, starting from different wholesales markets, for example. Or perhaps they had branched off from the same markets. Still, the wholesale prices should be cheaper, while the prices for the elite and the likes of hospitals and wealthier members of society are higher. What is missing from this picture are the

³² Posthumus. *Inquiry into the History of Prices in Holland*. vol. 2.

prices paid for the less well-off and poor, as there is little to no information available to analyse.

The sources represent the value of a commodity in a market. These values have been measured in local currencies and quantities, specific to the time and place. Measurements vary, with containers and barrels differing over locations and between commodities. The currencies differ also, with many different coins and metal bases. This is quite different from the levels of uniformity we take for granted in modern times. Currency is itself also a commodity, thus its value raises questions as well. For example, currency could represent something different for the poor or the wealthy. Currency based on gold and silver were money that only the wealthier parts of society had access to. Regarding the less wealthy in society, Braudel refers to money of the poor being known as “black money”, which were small change coins with less gold or silver but with a high proportion of copper.³³ Because the price series available are based on gold and silver, prices studied in this thesis do not represent the less well off, and thus, that part of the market is not visible. Instead, the study focuses on wholesale prices and those from the hospitals, religious institutions, wealthy nobles, and municipal sources.

This thesis studies locations with different currencies, and there is a need to describe each of them and how they related to one another. Exchange rates for currencies did exist, thus many coins and currencies can be equated, by converting them to a common unit of currency. To develop these conversions, one of the first considerations are complexities in local currencies arising from more than one unit of measurement. This is similar to the modern unit of a “Euro” that can be subdivided and also measured in the unit of “cents”, though the conversions were more complex in the past in some instances. One example was the Livre Tournois (LT) in France; it was equivalent to (or worth) 20 sols. Also, some units of currency, such as the LT, were not always available as a coin, but were “notional”, that is they are visible in accounting records. More specifically, not all denominations of a currency existed in a physical form, there were real and notional currencies. Certain denominations were not represented as a physical coin, but instead being a monetary unit

³³ Fernand Braudel, and Frank Spooner. “Prices in Europe from 1450 to 1750,” in *The Cambridge Economic History of Europe 4* (Cambridge: Cambridge University Press, 1967), 377.

used for accounting purposes only. Braudel refers to these as “Moneys of Account”.³⁴ Thus, for purposes of conversions, prices are first converted to one unit of a local currency (such as Denier in the case of France), before converting them all to a common unit for all currencies.

2.1.1. Sources Selection Process

In addition to choosing sources based on their quality and the relevance of the commodities they represent, sources were selected for their temporal and spatial coverage, and their coverage of different price levels in the markets (i.e., different points in the supply chain). The most important, or central, commodities are cod and herring. Meats and grains are also important because they allow a study of commodity substitution. Cod and herring were especially important and prominent fish products during the study period,³⁵ thus large amounts of price information relating to them has been preserved in archives. Herring price information has been widely researched in Europe. This is also the case for cod, though to a lesser extent. It is possible that a greater availability of herring prices arose because it was a cheaper, more abundant and established product in European markets of the time, and indeed was traded throughout Europe for centuries prior to the 1500s. Cod, though, is a more complicated study in some regards than herring. It is quite likely that much for the herring was a more uniform product. For cod, the archival materials comprise prices for different products, returning from both the Northeast and Northwest Atlantic. Also, the Northeast Atlantic cod market was well established while the North-West Atlantic was new to Europeans.

The locations that the price series cover, not just for cod and herring, provide a diverse spatial spread of much of Europe. This breadth of coverage allows an examination of whether the observed price dynamics were common or different between locations, and ultimately whether they influenced each other due to an integrating market.

2.1.2. Historiography

³⁴ Fernand Braudel, and Frank Spooner. “Prices in Europe from 1450 to 1750,” in *The Cambridge economic history of Europe* 4 (1967), 378.

³⁵ Poul Holm. “Commercial Sea Fisheries in the Baltic Region c. ad 1000-1600,” in *Cod and Herring the Archaeology and History of Medieval Sea Fishing*, eds. James Barrett and David Orton (Oxford: Oxbow, 2016).

As Robert Allen and Richard Unger have stated, by the start of World War I, the majority of European nations were producing masses of data.³⁶ This was a key period in economic history when economic and social historians began extensively collecting and tabulating numerical information. In fact, both the drive for data and developments in the discipline of statistics grew hand in hand, with statisticians such as Ronald Fisher, Karl Pearson, and William Sealy Gosset at the forefront, to name a few. For example, Pearson presented the Chi-squared test in 1900. Gosset developed the Student t-test, 1908, published under pseudonym while working for the Guinness Storehouse in Dublin, Fisher published on ANOVA in 1925.

During this period of activity amongst price historians there were conferences held, discussing European price histories. As Arthur Cole and Ruth Cranda discussed in 1964, the conferences stopped in 1933, as there had been funding issues and some works were never completed or developed to the level initially hoped for.³⁷ Perhaps this was linked to problems in Europe in that time that eventually culminated in World War II. Scholarship on European price histories did not fully cease, however, ultimately leading to extensive collections of tabulated price information for a geographically dispersed set of locations throughout Europe.

In an earlier period of the collection of price information, during the 19th century, information was collected without the improved methodological standards that came in the 20th century. This caused problems as it was not always clear what the information was representing, rendering the comparison between products and locations difficult. In 1929, the International scientific committee on price history was created by William Beveridge and Edwin Francis Gay.³⁸ They shared a common interest in the collection of long and homogeneous price series that were collected with accuracy and reliability. Ultimately this all resulted, either directly or indirectly, in a collection of important price histories. Many of the works produced during this peak of activity in the collection of price materials

³⁶ Robert Allen, and Richard Unger. "The Allen-Unger Global Commodity Prices Database: Social and Economic History," *Research Data Journal for the Humanities and Social Sciences* 1 (2019): 1-10.

³⁷ Arthur Cole, and Ruth Crandall. "The International Scientific Committee on Price History," *The Journal of Economic History* 24, no. 3 (1964), 385.

³⁸ *Ibid*, 381.

are discussed in this chapter, from Beveridge, Hamilton, Posthumus, Elsas, Pelc, Furtak, Hauser, Baulant, Pribram, and Van Der Wee.

Nicolaas Wilhelmus Posthumus was a Dutch social and economic historian,³⁹ who also founded the International Institute of Social History (IISG) in 1935. From 1940, the Committee (or Council) of Economic Research was established, it continued the work on price history.⁴⁰ Over two decades later, in 1967, Braudel was involved in the opening of the International Institute of Economic History. At this time, Braudel discussed the state of the art, summarising much of what had happened up to the 1960s in this area of research after it had become pretty much dormant in the previous two decades.⁴¹ He discussed some of the discoveries that came from analysing the price series for Europe between 1450 and 1750. He further referred to what could be seen in the prices with respect to significant and influential events such as the 30 Years' War (1618 to 1648), which resulted in price decreases throughout Europe, the extent of which varied between regions.⁴² Thus showing an awareness of the influence of conflict during that period. He also discussed the strengths and some of the problems with price analysis, which this thesis also explores, such as the many different units prevailing in different locations and how they changed over time.

Even though the collection of price information became increasingly dormant following the 1960s, a resurgence occurred from the 1990s, with scholars such as Gaspar Feliu producing price series for the Catalonia region in Spain (published in 1991), while Allen and Unger developed a growing digital database incorporating price information from as many regions as they could obtain globally.⁴³ The database is publicly available, and part of a larger collection of price information that is available as part of the IISG's website.⁴⁴ This database was applied to analyse and develop historical concepts such as the "Great Divergence", which is hypothesised to be an increase in dominance of Western Europe and the New

³⁹ Biografisch Woordenboek van het Socialisme en de Arbeidersbeweging in Nederland (BWSA), "Biography of Posthumus, Nicolaas Wilhelmus," <https://socialhistory.org/bwsa/biografie/posthumus>. Accessed August 8 2020.

⁴⁰ Arthur Cole. "The Committee on Research in Economic History: A Historical Sketch," *The Journal of Economic History* 30, no. 4 (1970): 723-741.

⁴¹ Fernand Braudel, and Frank Spooner. "Prices in Europe from 1450 to 1750," *The Cambridge Economic History of Europe 4* (Cambridge: Cambridge University Press, 1967).

⁴² *Ibid*, 399.

⁴³ Robert Allen, and Richard Unger. "The Allen-Unger Global Commodity Prices Database: Social and Economic History," *Research Data Journal for the Humanities and Social Sciences* 1 (2019): 1-10.

⁴⁴ The International Institute of Social History, "The IISH List of Datafiles of Historical Prices and Wages," <http://www.iisg.nl/hpw/>. Accessed August 8 2020.

World when compared to China.⁴⁵ As an example of recent developments, the NorFish project has developed a limited set of new price series for France, specifically Paris and Bordeaux, based on archival research by Bernard Allaire.⁴⁶

2.1.3. Price Collections

The available price series collections focus on many commodities, reflecting those that were important enough to be documented by the institutions at the time for their own internal purposes, or mandated as part of obligations to the state or other authorities. The individual collections are unique in some respects, but ultimately share sufficient common ground to be compared. The Allen-Unger Global Commodity database assembles and stores the price information from many individual collections and is employed in this thesis to study price dynamics for London, Amsterdam, Frankfurt, Munich, Gdańsk, Paris and Vienna.⁴⁷ Further sources are called upon to examine Nuremberg and Stockholm, and supply additional information for Paris, Bordeaux, and Barcelona. When available, multiple sources were studied for a given location or product to check for the validity of the prices given. Multiple sources also provide perspectives from different supply chain stages or customers, allowing identification of differences that further explain the research questions. (Appendix 1 provides further detail on where precisely to find each of the price series from the respective volumes, including page numbers.) A more extensive overview of the price series can be found in Appendix A.

2.1.4. Conclusion - The Character and Features of the Price Sources

The price series are derived from different types of sources (see Appendix A. for further detail). In some instances, they are nominal prices, i.e., stated list prices agreed by the likes of municipal authorities. In other instances, they are the at point of sale on the markets, while in other cases they are based on contracts agreed for purchase for wealthy nobles. For this reason, it will be important to bear in mind that the type of source is influential

⁴⁵ Robert Allen. "The Great Divergence: Wages and Prices in Europe from the Middle Ages to the First World War," *Explorations in Economic History* 38 (1998).

⁴⁶ Bernard Allaire. "Internal Norfish Report One: Fish and Commodity Prices in Food Supply Contracts in Paris (1538-1756)," Unpublished (2017); Bernard Allaire. "Internal Norfish Report Two: Landing, Price and Packaging in Bordeaux Fish Trade 1530s-1580s," Unpublished (2017).

⁴⁷ The International Institute of Social History. "The IISH List of Datafiles of Historical Prices and Wages - Europe," <http://www.iisg.nl/hpw/data.php#europe>. Accessed August 8 2020.

when comparing products and locations. Further, this could be a reason for different price behaviours between locations.

Price series, especially set prices lists, can mask short term variability. This is because they do not show actual transactions on the markets. Thus, they are more suitable for the study of medium and long-term trends.

An influence of seasonality in the prices series is possible in some instances. When possible, and enough information was available, authors removed seasonal trends and biases from the annual series. For example, Feliu, Elsas, Pelc and Furtak took monthly or annual prices each year and averaged them to remove the seasonal bias.

The archival documents provide the price information in local currencies and quantities. Thus, many of the price collections discussed in this chapter are presented in local currencies, but some have also been converted to a gold or silver standard by the relevant compilers. A uniform unit of conversion to grams of silver per kilogram of produce is further examined in Chapter 3.

2.2. Methodology

The methodology for the thesis included data transformations and conversions, with the objective of facilitating the analyses in later chapters. The conversion stages were summarised in the first section of this chapter (Section 2.1), with the introduction of commodity price information. That is, temporal price series collated by price historians that they developed from archival documents.⁴⁸ To store information, the commodity price series were transformed into a suitable and standardised numerical format. The standard was developed over the course of this PhD research. The NorFish datasets for Paris (see Section 2.1.3 - Allaire), were analysed first to develop the template for data storage for the thesis. That was achieved by translating the spreadsheet generated by Allaire to a standard suitable for this thesis, a standard that could be applied to all datasets included in the analysis. There are many benefits that come from the standardisation of the information. It leads to a clearer understanding of what prices represent, what sources the price series were developed from, what type of prices they are (such as recommended prices or actual

⁴⁸ The price historians have translated “qualitative” information from the primary sources, i.e., archival documents, to generate the “quantitative” price series.

market transaction prices). Knowing these features of the available price series allows more convincing comparisons and other analyses. The standardisation leads to a uniformity of the stored price series, which simplifies and improves the process of uploading the information into statistical packages, primarily R. This earlier stage in the process, the collection and standardisation of prices, was developed in Microsoft Excel and the resultant data stored in comma-separated files (CSVs).⁴⁹ Methods were coded in R to upload the CSV files, and to analyse the information, processing it through a number of stages.⁵⁰ The final results of this process are the tables and graphics presented throughout this thesis. The R coding is stored in files commonly referred to as “scripts” and they can be found in Appendix 2.

To allow comparison of the price information from different locations and commodities, scripts were developed, as part of the R process, that converted information to a common price unit of grams of silver per kilogram of produce. In some cases, the prices are summarised by grouping them into periods such as 50-year periods. This allows a focus on medium to long term changes and limits problems associated with missing data. These groupings are presented with summary statistics such as simple averages, the Coefficient of Variation (CV - defined later in this section), and minimum and maximum values. To explain the interaction of price series with other factors, additional time series and events are incorporated in the R model, as will be introduced throughout the thesis.

Finally, absolute price values are log-transformed in some instances. This is a standard practice in modern economics and econometrics. For example, Regina Grafe includes the log-transformed version of prices in grams of silver for Bacalao from North America arriving in Spain. Also, Victoria Bateman used logged transformed wheat prices before applying a “Vector Error Correction Model (VECM)” to quantify properties of market integration, (The

⁴⁹ “CSV” files are a straightforward and well-known alphanumeric information storage format. It is readable in multiple statistical packages and computer operating systems and is hence a preferred archival format for numerical data.

⁵⁰ This process included the first step of developing code to read all the input files from a centralised folder into a data structure within R. I refer to the centralised folder as a “library” of files and they are all in csv format. The R code (or script in other terms) runs through several steps to combine all the files. When they are combined in R, it is saved into two large csv files; the first file is the main one with a column for each price series while the second file (referred to as a “Header” file) includes information on each of the price series. The second file is also standardised and is effectively metadata. Data integrity is assessed in this process, for example the upload will fail if the csv contains unexpected information, such as text appearing where numeric information is expected.

VECM is a linear regression model that is used to model degrees of market integration based on commodity prices).⁵¹ The log-transformed prices come with benefits such as better suitability for linear regression models (i.e., in meeting the statistical assumptions underlying them), as well as a more intuitive presentation of inflation trends through linear models. Intuitively, log-transformed prices are closely related to the ratio of prices, they can be thought of as similar to the percentage difference between prices.

2.2.1. Comparability of Sources Across Regions and Products

A common unit of measurement is not alone sufficient to facilitate a credible comparison of price series. Prices should be of a similar character, meaning, for example, that they should be collected for similar institutions and describe prices at the same “position” in a market. The collection methodology employed by the scholars developing each price series should also ideally be similar. Many of the price historians discussed earlier did develop their work with a common (or near-common) methodology behind it, but there were divergences in approaches.

Prices in original archival documents can be considered a type of “raw” information, presented in local currencies and weights, such information is less processed. Price series derived from this information can be analysed individually, to discern change over time, for example. A benefit of analysing less processed information is that it is a less biased starting point, with fewer changes introduced by the likes of the price historians studying them. On the other hand, because the different commodities come in a myriad of sizes, weights, and currencies, this introduces questions concerning the validity of inter-series comparisons. To this end, two important considerations are metrology and conversion rates. Common weight units and currencies are not always certainly known, and best-effort assumptions have been made to facilitate comparisons while keeping the assumptions modest.

⁵¹ Regina Grafe. *Distant Tyranny: Markets, Power, and Backwardness in Spain, 1650-1800* (Princeton University Press, 2011), 160; Victoria Bateman. *Markets and growth in early modern Europe* (Routledge, 2015), 86.

Purchasing Power Parity and The Law of One Price

To give a theoretical framing as to why a uniform price measure is meaningful and useful, the informal concept of the “Big Mac Index” acts as a modern example.⁵² This food product is made to the same specifications in most locations and it is available globally, thus making it quite uniform and homogeneous. However, the cultural context will not necessarily have been the same for herring in each location, thus questions of the role of herring in different locations can be raised. Though for the purpose of this example, these questions are not the focus. The price can vary between locations, however. In this index, the value of 1 is given to the price in the US. A value is then given for each country, based on the price of a Big Mac in another country. This is based on the percentage difference. For example, if another country has an index value of 1.2 (or 120% in other terms), this indicates it is 20% more expensive than the US.

As an example, Dutch herring produced in Europe during the study is an earlier example of a relatively homogeneous commodity. To create a price index for a product, similar to that of the Big Mac Index, the prices need to be comparable, or more precisely, measured in the same units. This would indicate if the product, for example a Big Mac or herring, is more or less expensive in given locations. A decision would need to be made for this index as to what would be the location that represents the central value (in the Big Max example, this was the US). No central value has been developed for this thesis. Instead of the development of a complete index, this analysis limits comparisons to ratios between locations. This then allows us to ask why the price differs between certain locations.

The concepts of the Purchasing Power Parity (PPP)⁵³ measure and the Law of One Price (LOOP)⁵⁴ are valuable for comparing the prices in different locations. The PPP is a ratio, as shown in Equation 2.1 below. It is applied to quantify the relative value of goods between two locations. If the two prices are in different currencies, this ratio is comparable to a currency exchange rate. For example, a ratio of herring prices is measured in French Denier in one location and English Pounds is a PPP measure. As an example, if a herring cost 50

⁵² The Economist. “Burgernomics: The Big Mac index. Our interactive currency comparison tool,” <https://www.economist.com/news/2020/07/15/the-big-mac-index>. Accessed 11 August 2020.

⁵³ Lawrence Officer. “The purchasing-power-parity theory of exchange rates: A review article,” *Staff Papers* 23, no. 1 (1976): 1-60.

⁵⁴ Charles Kindleberger. *Economic Laws and Economic History* (Cambridge University Press, 1997), 67-92.

denier in France and 1 pound in England, it could be suggested that a reasonable exchange rate for Denier to Pound is 50 to 1.

A formula for PPP:

$$PPP = P_a / P_b$$

Equation 2.1 Purchasing Power Parity.

This PPP is often used in economics and econometrics.⁵⁵ This method of analysing commodity price ratios is applied in this thesis. These ratios are limited to two currencies at most by their definition. Later chapters study more than two products, often based on different currencies and quantities, therefore there is a requirement to convert all commodities to an absolute or common unit to allow comparisons. Thus, all commodities are converted to prices measured in grams of silver per kilogram of produce to give this common unit. This allows the simultaneous study of the relative value of products such as cod and herring in all locations and facilitates analyses of the evolution of their relative value over time.

When prices are presented in a common unit, it raises questions of the law of one price (LOOP). The LOOP suggests that prices in different locations tend to move towards parity (i.e., the same price for the same amount of product), if all barriers and trade restrictions are removed.⁵⁶ This would happen in an integrated market under certain conditions, such as no transport costs for moving a product between locations. This can be thought of as follows; if a product becomes cheaper in one location, then purchasers will buy from that location instead as there are no barriers to impede this. This is a hypothetical scenario though, in many instances distance will separate locations, thus creating transportation costs. Prices do not reach this “parity” (i.e., the same prices) in different locations in later chapters, and this would be expected for reasons such as transport costs. The LOOP is worth bearing in mind as it does explain why prices tend to become closer to parity, though, when markets are experiencing higher levels of integration.

⁵⁵ Alan Taylor. “Potential Pitfalls for the Purchasing-Power-Parity Puzzle? Sampling and Specification Biases in Mean-Reversion Tests of the Law of One Price,” *Econometrica* 69, no. 2 (2001), 473-498. (This publication discusses pitfalls in research on Purchasing Power Parity and the Law of One Price.)

⁵⁶ Dragan Miljkovic. “The Law of One Price in International Trade: A Critical Review,” *Applied Economic Perspectives and Policy* 21, no. 1 (1999).

A Common Price Unit

In a number of available price series collections, the conversion to a common unit of grams of silver per kilogram of produce has already been performed. In some instances, this conversion was completed in the Allen-Unger commodity database. For the remaining series, the conversions have been undertaken in this thesis. But all series included in this thesis were checked to be certain about and to understand the basis of the conversion calculations. There are two core parts to the conversion to a standard unit. One is conversions of local currencies to their grams of silver equivalent and the other is the conversion of the commodity amounts to an equivalence of kilograms of produce.

There has been some debate about what equating all currencies to a common value of silver achieves. Feliu, as an example, discussed the long controversy surrounding the practice, acknowledging its limitation but ultimately arguing in support of the conversions.⁵⁷ The core reason for this is any common unit will be subjective to an extent. For example, gold and silver do not maintain the same relative value to one another over time. Thus, after conversion to a common price unit such as gold or silver, price fluctuations and long term trends will vary to an extent, depending on which unit is chosen. These limitations do hold. Either gold or silver could be chosen, but silver was the base metal for many of the currencies during the study period, which suggests it may be a more suitable choice to convert prices to. Also, in support of converting to grams of pure silver, it is uniform in every region (specifically pure silver is uniform, not the coins that contain silver, as they could contain impurities). Thus, this uniformity makes it a good common base for historical prices. Though Braudel and Spooner do accept that ultimately there is no one perfect single unit to convert everything to.⁵⁸

Another benefit of the common silver unit is it deals with problems working with a confusing collection of coin types.⁵⁹ For example, a large change in a silver-based price could be explained by a rebasing of silver coin, and a delay in information and reactions of

⁵⁷ Gaspar Feliu. *Precios Y Salarios En La Cataluña Moderna. Estudios de Historia Económica* (Madrid: Banco de España, 1991) Vol. I, 16.

⁵⁸ Fernand Braudel, and Frank Spooner. "Prices in Europe from 1450 to 1750," in *The Cambridge economic history of Europe 4* (1967), 381.

⁵⁹ Abbott Payson Usher. "The General Course of Wheat Prices in France: 1350-1788," *The Review of Economic Statistics* (1930).

buyers and sellers to this change in the value of a coin.⁶⁰ This is one of the reasons price history authors tend to also include comparison by index, thus ignoring this problem with silver.⁶¹ This thesis predominantly studies prices converted to the silver standard though, as inter-regional analyses are necessary. When a change in the pure silver metal content in coins occurred, conversions are adjusted to account for this.

2.2.2. Converting Data for Statistical Packages

In many instances, research for this thesis began by studying already digitised sources, in particular, the Allen-Unger database, these sources can be referred to as “base tables”. The digitised sources came in different formats in some instances. In some instances, the information was digitised for this thesis, working from secondary literature. The process for translating and standardising the information for analysis is outlined below in Figure 2.1. The first steps have been applied in the first part of this chapter, which introduced the price series collections and how they were derived from archival documents. That is, experts explored local archives and selected information that meet their research criteria. Most of these price historians adhered to common criteria to ensure a similar methodology to enable comparability of their collections.

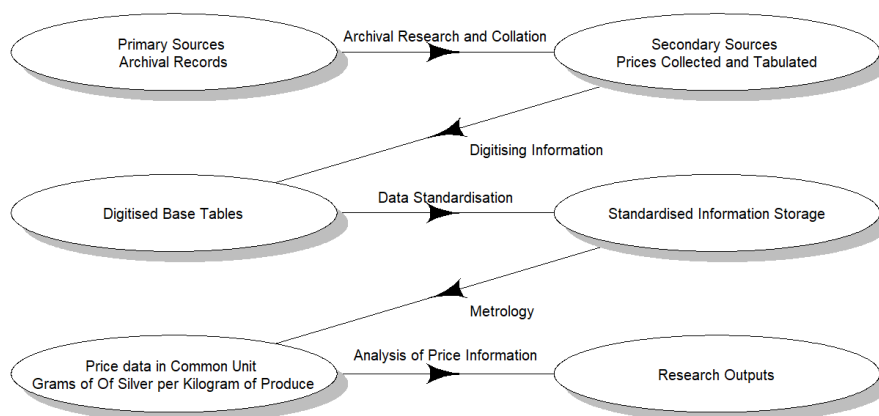


Figure 2.1. The processing of price information through a number of stages. The bubbles represent types of information, while the lines and arrows are process steps that transform the informant to the next stage. The

⁶⁰ Ibid, 168.

⁶¹ Posthumus. 2 Vols. Both volumes of Posthumus’ work include further information on price indices.

first type of information are archival sources, and the final type are the research outputs. The thesis generally begins research at the stage of the digitised base tables. In some instances, research for the thesis commenced at the secondary sources before proceeding to digitise them.

The tables described in Figure 2.1 above require additional formatting for compatibility with statistical packages. The selected price information is translated from the base tables to a single spreadsheet in CSV format and it has been standardised over the course of the research for this thesis. R is the statistical package most commonly employed in this thesis, due to its computational efficiency and powerful visualization and econometric analysis abilities. A selection of open-source packages, developed to extend the suite of statistical and graphical abilities of R, have also been used.⁶² The conversion to CSV files (i.e., comma-separated values) and its uploading into R is “lossless”, meaning no chosen data is altered or removed from the base table prices. The database of CSV files can be referred to as a “library”. This database, or library, is uploaded into R. Once within R, a large amount of exploratory analysis was undertaken. Ultimately, the information was transformed through a number of formats in R, such as “long” and “short” tables. The final result is a table that contains the exact same information that was uploaded to R but adjusted to a final format that is suitable for the analysis in this thesis. At this stage, the information is still in original currency units and quantities. Thus, after uploading conversions for currency and quantities, the information is converted to the standard of grams of silver per kilogram of produce.

The entire process of computing and transforming information was designed using an “audit trail”, making it possible to quickly review the progress from the base tables up to the final analysis. More specifically, each step of the data analysis and study can be traced back to the previous steps. For example, if a price is shown in the spreadsheets or report, it is possible to quickly see this datum as it appears in the previous step and keep going back steps to see either the tables in the primary or secondary documentary sources they came from.

⁶² As an example, the “ggplot2” package was important in this to produce graphs: Hadley Wickham. “ggplot2,” *Wiley Interdisciplinary Reviews: Computational Statistics* 3, no. 2 (2011).

2.2.3. The Database

That database developed for this thesis can, as previously mentioned, be referred to as a library. It is a collection of CSV files with a standard based on a common list of data fields or columns. They are loaded into R, then sorted and appended to one another in a “long” table. Long in this sense means vertical, with each table inserted below the last one. This simplicity of structure means a more complex relational database structure was not needed. It is the case, however, that this structure could easily be incorporated into such a database. This single file format allows for a variety of measures and calculations to be performed uniformly over the different series, thus leading to clear information that lacks ambiguity. Furthermore, it allows the production of summaries of the information. Another file has been created to complement the core datafile, it includes a summary of each price series; this type of file is commonly referred to as a “metadata” file.

The script applied to upload and combine the library of CSV files can be found in Appendix 2, under the name “Collating the Input Files”. This file includes a number of steps, such as creating programming loops, to progressively work through each file. It also includes operations to reformat the data, such as transpositions of data, and appending each new file to the end of the last.

2.2.4. Absolute Prices or Log Transformed Values

It is preferable to work with data that has gone through less stages of processing by other authors, especially when beginning an analysis, as less assumptions and possible biases have been made or introduced. In some instances, however, a conversion from the raw or absolute prices to logarithmic (also referred to as simply “log”) transformed prices is useful. The log transform process does not lose any information, because it can be reversed by applying an exponential transformation. The standard practice of the log transformation aids the study of relative change, such as percentages and ratios, rather than the absolute change. The first equation below is a hypothetical example or model, which is followed by a numerical example. The price in year i is represented as p_i . c is the starting value, commonly referred to as the “initial value”, i.e., it is the first year in a price series. Finally, a relates to the rate of inflation.

$$p_i = ca^{i-1}$$

To give a worked numeral example, if inflation occurred at 2% per year, and the starting price was 3g/Ag, then the price in year five would be as follows:⁶³

$$p_5 = 3gAg * (1.02)^4 = 3.25gAg$$

By applying log transformations to both sides, the above equation changes from one that was based on multiplication to another that is based on addition, as shown below.

$$\log_{10} p_i = (i - 1) * \log a + \log c$$

This is now in the form of a “simple” linear regression (i.e., equations such as $y_i = x_i + c$). Simple, in this sense, refers to the equation being a linear regression in a basic form without many variables and more complicated assumptions.

The following example includes prices in French Denier, and the log-transformed version of these prices (Figure 2.2) and is a comparative study of two products from Paris.⁶⁴ Weights have been converted to a kilogram of produce for both. The top chart represents the absolute prices, while the lower chart is a logged version of the same information (i.e., a log transformation has been applied). The logged version adjusts disproportionately large or small changes that create misleading visuals. In this example, the transform reduces the dominance of the herring price in 1592 and 1650, making it more comparable against the fresh cod (red).

⁶³ A log transform also needs a base, in the above example, ten is chosen. Any base can be applied, as long as it is the same base applied to all information.

⁶⁴ Allaire, “NorFish Report 1”. The two products can be found in Allaire’s first internal Norfish report, “Fresh Cod” (in red) and “100 Fresh Herring” (in blue), where 100 in this case referred to a quantity of 100 herring.

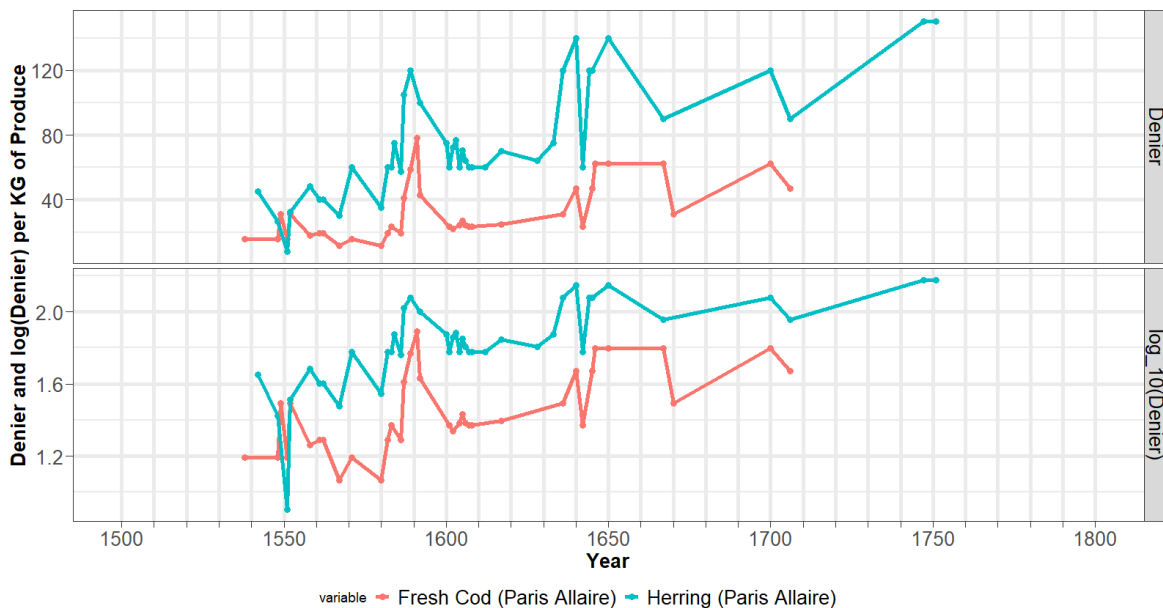


Figure 2.2. A chart of the most complete cod and herring time series. From Allaire’s first internal NorFish report.

2.2.5. Temporal Coverage of the Price Series

A key characteristic of each price-series is their temporal coverage, i.e., the time period they cover. This is not simply the range from earliest to latest year, but also the level of completeness of the series is within that range and the extent to which annual values might be missing. It is preferable to perform analysis without estimating missing values, but in some instances, it is useful to estimate them.

Missing Data - To Interpolate or Not

As shown in the above figures, gaps exist in some of the presently available price series. Even though the coverage within the combination of all the price series introduced earlier in this chapter is good for the entire research period, not all series have a value for each year. Missing data represents a common challenge in historical economic analyses, and there are many methods available to estimate missing values and interpolate these estimates into the gaps in the data.⁶⁵ These techniques are referred to as “imputations” and “interpolations” (or “extrapolations” if estimating beyond the temporal range for the

⁶⁵ Siem Jan Koopman, and Lennart Hoogerheide. “Analysis of Historical Time Series with Messy Features: The Case of Commodity Prices in Babylonia,” in *A History of Market Performance: From Ancient Babylonia to the Modern World*, eds. Robartus J van der Spek, Bas van Leeuwen, and Jan Luiten van Zanden (London: Routledge, 2015), 45-67.

data). Statistical packages developed for R are available to apply many of these techniques.⁶⁶ Imputation techniques tend to fall in the realm of statistical analysis, thus come with probabilities and confidence intervals to quantify uncertainty or confidence in the estimates they provide. Interpolations and extrapolations tend to be more on the side of pure mathematics, with mathematical formulae and curves to estimate missing information. Imputation methods were tested for this thesis, but instead interpolation techniques were applied, usually in the form of curves known as “splines”. Perhaps in another analysis, the imputation techniques could be applied. Though such an analysis should first build a set of statistical hypotheses and test them to understand the level of accuracy of any imputations that are applied. The interpolation methods were instead applied to keep assumptions at a minimum, introducing less complexity and bias to the information.

A commonly applied method is linear interpolation. This is effectively equivalent to drawing a straight line between two points to estimate missing values between them (Figure 2.3 below). Another method, one that allows some curvature, rather than a straight line, are cubic spline interpolations. This approach can be implemented in the R package “ImputeTS”⁶⁷ (see Figure 2.4). While developing this research, a variety of simple to complex interpolation methods were studied and tested to estimate missing values (or gaps), and some of these are discussed in the following section. The conclusion is that it is preferable to work with the raw data in later chapters where possible, rather than introducing unnecessary biases that come from the interpolations. Thus, interpolations are used sparingly, except for a limited number of examples that are specified as they occur. In a number of cases, scholars who collected and collated the time series of prices have made a decision to estimate years with missing values, though this is not common and in general, it is stated by the authors when they have been included. For example, Bauernfeind’s prices, such as herring in Nuremberg contain interpolated values.⁶⁸

⁶⁶ Stef van Buuren, and Karin Groothuis-Oudshoorn. “Mice: Multivariate Imputation by Chained Equations in R,” *Journal of Statistical Software* (2010).

⁶⁷ Steffen Moritz and Thomas Bartz-Beielstein. “imputeTS: Time Series Missing Value Imputation in R,” *The R Journal* 9, no. 1 (2017).

⁶⁸ Walter Bauernfeind. *Materielle Grundstrukturen Im Spätmittelalter Und Der Frühen Neuzeit: Preisentwicklung Und Agrarkonjunktur Am Nürnberger Getreidemarkt Von 1339 Bis 1670* (Neustadt/Aisch, BRD: Schmidt, 1993), 78.

Linearly interpolated prices (Figure 2.3) for four commodities, namely cod, herring, beef and pork, colour coded as per the figure legend are shown below. The lines indicate the trend between years where archival data is available. These lines are linear interpolations that cross missing years and occur between the observed data. By forcing the interpolated values to adhere to a strict linear progression, these linear interpolations are less likely to produce realistic interpolations, particularly where gaps between existing data points are large.

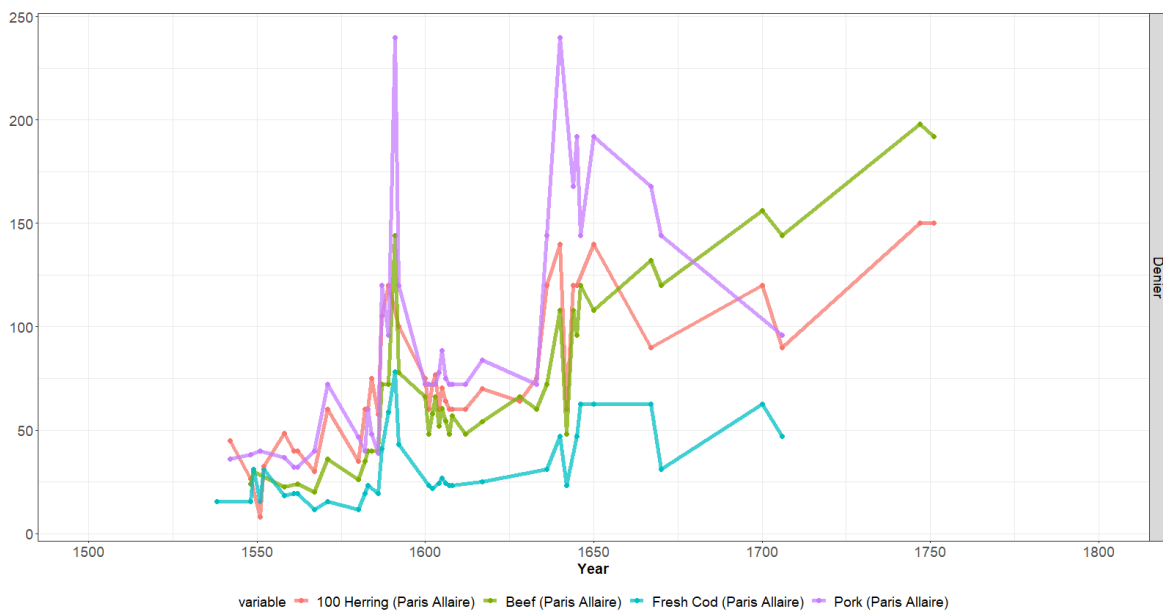


Figure 2.3. Commodity Price series for cod, herring, beef, and pork. From Allaire’s Paris report. Missing years are estimates with linear (straight-line) interpolations.

Smoothing splines allow for more complex trends than linear estimation. Unlike linear estimates, such splines estimate the rate of change throughout the entire data series.⁶⁹ These splines allow for curvature, rather than jagged in examples such as the linear interpolations. This ultimately reflects the possibility of an evolving, non-linear rate of change at both the beginning and end of the gaps. Figure 2.4, below, applies this spline interpolation to the same four price series.

⁶⁹ Carl de Boor. *A Practical Guide to Splines* (Springer, Revised Edition, 2001).

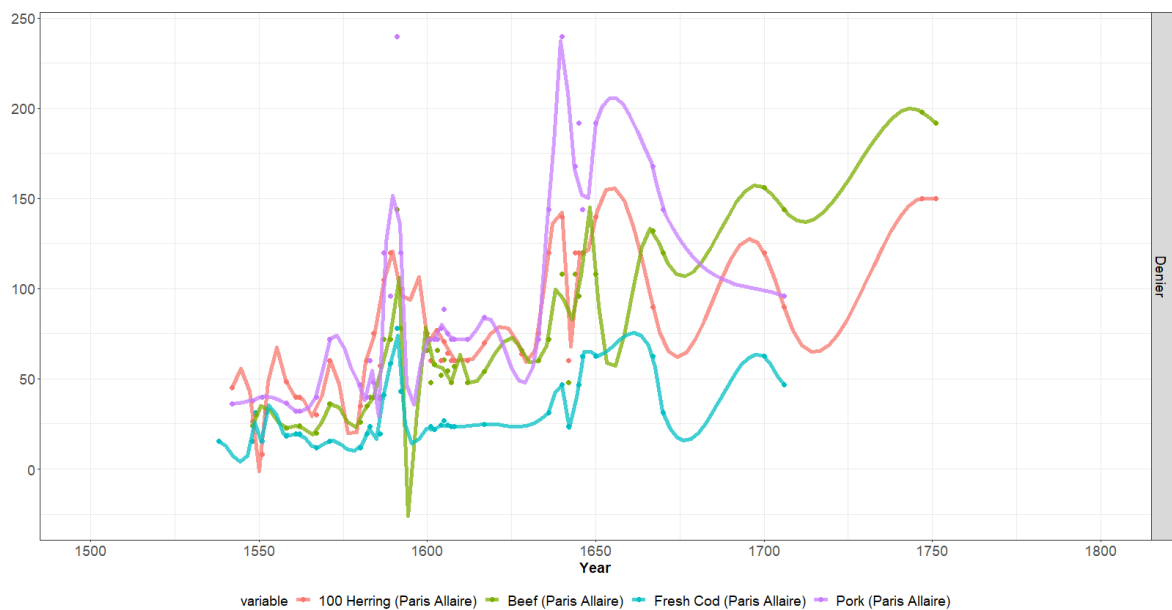


Figure 2.4. Commodity Price series for cod, herring, beef, and pork from Allaire’s Paris report. Missing years are estimated with smoothing splines interpolations.

The four series presented in Figure 2.4 exhibit short and long-run trends in common, fluctuating similarly at times. One prominent feature is the long-term tendency towards higher prices, though the progression towards these higher prices is certainly not uniform or constant, with some step changes that see prices abruptly jump and then vary around a higher state until a further jump occurs. One notable short-lived feature is the spike in all series in 1592, occurring following a key moment during the French Wars of Religion from 1559 to 1598, with the siege of Paris in 1590.⁷⁰ This multi-commodity price spike provides an important illustration of the effects of sieges, or indeed naval blockades (Figure 2.5), on markets via a constriction of supply. It is possible to infer all of this from either the linear interpolated version of the information and the non-interpolated version, thus the interpolations are not strictly necessary to draw such conclusions.

⁷⁰ Robert Jean Knecht. *The French Wars of Religion 1559-1598* (Routledge, 2014).



Figure 2.5. “His Majesty’s Fleet Blockading the Spanish Port called Cadiz”. Anonymous, late C18th. As noted by Cindy McCreery, “an amateur artist such as a naval officer most likely painted this watercolour of British warships blocking the entrance of Cádiz in Spain.”⁷¹ Naval blockades became an increasingly common tool of economic warfare during the eighteenth century.⁷² Copyright National Maritime Museum, Greenwich, London. Licence: CC BY-NC-ND.

2.2.6. Definitions - Indicators of Market Dynamics

To examine market dynamics in later chapters, three core quantitative indicators are defined. Commodity substitution is indicated by relative price changes between commodities, ratios are useful for this. Market integration is discussed by studying price volatility, which is observed by calculating the Coefficient of Variation (CV) of price series on a decadal scale.

⁷¹ Cindy McCreery. *Ports of the World: Prints from the National Maritime Museum, Greenwich c.1700-1870* (London: Philip Wilson Publishers, 1999), 77.

⁷² *Ibid*, 77.

Commodity Substitution - Price Ratios

Commodity substitution (often referred to as product or goods substitution) occurs when one product is replaced by another that is perceived to fulfil similar requirements.⁷³ Understanding how commodity substitution influences trade networks and prices, is an important topic in the study of the economy from the ancient period onward. For example, it has been examined for its role in preventing subsistence crises, whereby one food commodity may temporarily compensate for a shortfall in another during times of disruption.⁷⁴

One way of recognising commodity substitution is by observing the prices of several commodities changing in tandem (potentially in response to one another). This can be seen to begin through visual inspection of plotted data for any shared variability, as per the example in Figure 2.4 earlier. Price alone tells only a portion of the story, however (as prices may increase even in the absence of any change to underlying supplies, i.e., demand-side changes). When quantities are available too, this can help further indicate if changes in supply and/or demand were occurring. For example, if two commodities A and B can substitute one another, an increase in the price of one (perhaps reflecting a constriction of supply) should cause an increase in demand for the other. This could lead to a subsequent price increase in this commodity, which could be observed as lagging the price increase in the first commodity. To undertake such an analysis, the ratio of the prices for the two commodities allows a comparison between them, as represented by Equation 2.2, below. If the prices are already in the same currency (and unit), two different commodities can be compared. The evolution of price ratios over time will indicate if one commodity was preferred, or was substituting, for the other.

$$Ratio_{a,b} (R_{a,b}) = \frac{P_a}{P_b}$$

Equation 2.2. A price ratio formula for two commodities.

This can be used to aid a discussion of commodity substitution.

⁷³ Mengshi Lu, Simin Huang, and Zuo-Jun Max Shen. "Product Substitution and Dual Sourcing Under Random Supply Failures," *Transportation Research Part B: Methodological* 45, no. 8 (2011).

⁷⁴ Ibid, 1264; Donald Jones. *Economic Theory and the Ancient Mediterranean* (John Wiley & Sons, 2014).

This section draws parallels to the earlier introduction to Purchasing Power Parity and the Law of One Price. Here, P_a represents the price of commodity a and P_b represents the price of commodity b . By comparing two commodities by a ratio for each year, certain price fluctuations that influence both will be removed or “cancelled out”, for example any common inflation is removed. The ratio represents directly how the prices fluctuated relative to one another, specifically showing when they behave differently. When the ratio remains the same, it indicates the commodities may have been experiencing stable levels of supply and demand, relative to one another. When the ratio changes, it indicates the price change for one commodity is larger than the other, thus suggesting one commodity is more inclined to substitute the other. For this thesis, these ratios are applied to raw prices, or the prices upon conversion to grams of silver per kilogram of produce. If the price ratios begin to change between two commodities, this indicates one commodity may have been actively substituting the other, or that one commodity was becoming a lower-priced alternative to the other.

Market Integration - Price Variability

The Coefficient of Variation (CV) is an indicator of volatility or integration in a market. Higher values indicate a market that is more volatile or shocked, thus less integrated, while lower values indicate stability and integration. A more integrated market will often display less volatile (or in other terms, more stable) prices. This price stability can occur as a result of a more integrated market yielding less dramatic price changes than a market that is more scattered or disjointed (i.e., a less integrated or disintegrated market). As all prices are positive numbers (a negative price doesn't make sense), the lowest possible value for the CV is zero. To expand on the meaning of the CV, when it is calculated for a price series for a single commodity, a value of zero would suggest complete stability in the prices, that is they are not changing. On the other hand, if the CV is very high, it indicates the prices are very volatile and changing quite a large amount.

$$\text{Coefficient of Variation (CV)} = \frac{\sigma}{\mu}$$

The top value in the equation, σ , is the standard deviation. This is a standard summary statistic that represents the dispersion, or variability, of the data. The standard deviation alone is influenced by the currency unit that is used. It will change depending on the

currency unit applied. For example, if prices are in English Pounds, the standard deviation will be a value that is also measured in English Pounds. This cannot be compared easily to a commodity measured in French Denier, for example. Though prices have already been converted to a common silver-based unit for this thesis, removing this problem. Another problem with the standard deviation can occur if prices are inflating over time, the standard deviation will in part increase due to this inflation, and this is not necessarily closely related to the degree of integration of a market. For this reason, the standard deviation, σ , is divided by the average, μ , to remove bias introduced by the price unit, removing much of the influence of inflation. A group of values is needed to study the CV. Decades are a popular choice (in providing a sufficient sample size to calculate a meaningful CV value, while the resulting series of decadal CV values still captures reasonably fine-grained change through time, rather than averaging it out) and this grouping is applied throughout chapter four.

In the case of two commodities, if price series are available, a third time series can be created based on the ratio of the prices for each year. The CV can also be applied to this series of ratios. In this instance, the CV will measure the degree of price volatility the two commodities experience relative to each other. In this instance, a value of 0 would indicate the two commodities maintained the same relative value. For example, if both series were increasing by the same inflation rate each year, they would maintain the same ratio value and thus the CV would be zero, thus implying a high level of integration between the two products, (in some instances, integration between products is referred to as “co-integration”).

2.3. Conclusions

Price series analysed throughout this thesis are complex and varied. Often, though, they can be compared. Such quantitative series were compiled by previous scholars, and in many cases, they had common research objectives. The results of their studies led to an understanding of how prices between different regions can be compared. The analysis in this chapter illustrates the diversity of the price source, with price information coming from many locations, for different commodities, and a multitude of archives. Crucially, the overview also highlighted similarities between the sources. For example, prices tend to represent two market types: wholesale and consumer prices. These consumer prices tend

to be for larger institutions, rather than individual households. What remains is to convert these prices to a common price unit, to lead to a clear understanding of the relative values of commodities between locations.

Methodological components used in the thesis required an introduction, to provide further motivation for the following chapters. Much of this methodology is based on quantitative analysis, with a focus on prices at its core. Large amounts of information needed to be stored in a standardised digital repository, and the process for doing so was described. The R statistics package was the main computer system used to build and analyse this repository, including all comparisons to quantity, conflict, climate information. R was also used to develop almost all graphs, tables and diagrams that are presented over the course of the thesis.

3. Conversions and Common Price Unit

There is a need for common units of currency and quantity of produce. In their absence, it is not possible to accurately understand the relative value of prices between each location. Further still, in the absence of common units, comparing different commodities can also be limited. The commonly studied unit of grams of silver per kilogram of produce has been applied to all price series included in this thesis. It requires two sets of conversions; one is for currency and the other for the quantities of a commodity sold. The units of currency and quantity employed during the study period were varied and less standardised than in modern Europe. The variety of units of currency was complicated. Figure 3.1 below gives some examples from a 16th century merchant's manual, showing the many coexisting denominations likely to be encountered while trading. Such sources now provide modern scholars with the foundation for conversion between weights and values.

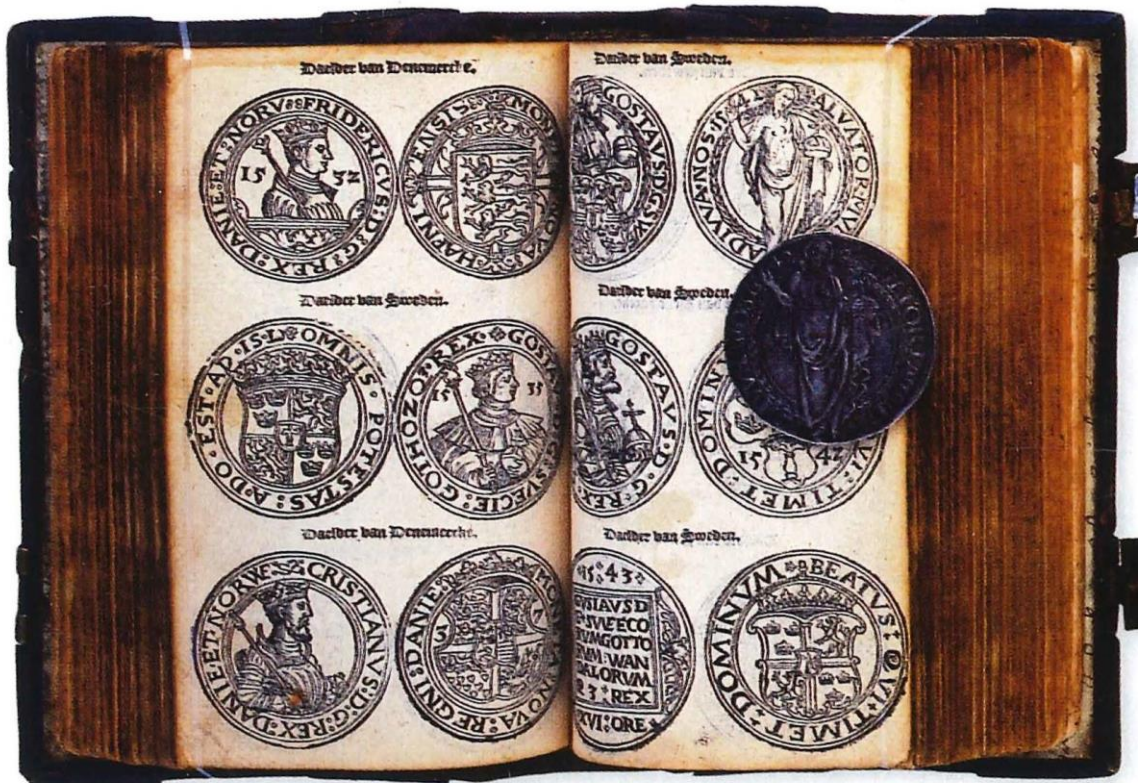


Figure 3.1. Dutch merchant manual from the 16th century. The manual offers contemporaries a guide to the multiple coexisting denominations likely to have been encountered during the course of trade. Such sources provide modern scholars with the foundation for conversion between weights and values.⁷⁵

Existing study in the field of historical metrology and numismatics provides a guide to the rigorous treatment of historical quantitative information. Metrology is concerned with the study of measurement,⁷⁶ while numismatics includes the study of coins. When these studies are combined, they allow conversions between different historical metrics for price and weight. A conversion from the complicated varied units of the markets of the time to an equivalence of grams of silver is common in the analysis of price history, and Braudel gives several reasons for this; firstly, better information was available and secondly, silver, more so than gold, is considered more indicative of economic activity.⁷⁷

The development of a Consumer Price Index (CPI) is another method that can be employed to understand the relative value of commodities. A CPI index relies on a “basket of goods”. Such a basket of goods should be chosen to represent on average what a household may have consumed. Robert Allen developed such indices for locations throughout Europe.⁷⁸ These indices are derived from a weighted average of prices for collections of household goods. The indices are often based on silver prices. These CPIs can be compared to fish prices, (which are not included in Allen’s indices). Such a comparison would indicate the relative value of fish “on average” to a basket of goods, rather than specific comparisons to products such as wheat. The approach is important, but for the purpose of this thesis it would remove the more subtle comparisons of how the individual products, i.e., wheat and beef, compared to fish prices. These comparisons against wheat and beef are important to the thesis’ research questions.

For volume and weight, original units included different barrels, lasts, containers and so on. Figure 3.2 displays the hooping of herring barrels in Amsterdam, which was part of the process of creating barrels. Fortunately, many of the series analysed in this thesis have

⁷⁵ Image is taken from Adam Hart-Davis. *History: The Definitive Visual Guide from the Dawn of Civilization to the Present Day* (London: Dorling Kindersley Limited, 2007), 267.

⁷⁶ Dominic Rathbone. “Earnings and Costs: Living Standards and the Roman Economy (First to Third Centuries AD),” in *Quantifying the Roman Economy: Methods and Problems*, eds. Alan Bowman and Andrew Wilson (Cambridge: Cambridge University Press, 2009), 299-316, 301.

⁷⁷ Fernand Braudel, and Frank Spooner, “Prices in Europe from 1450 to 1750,” 381.

⁷⁸ Robert Allen. “The Great Divergence in European Wages and Prices from the Middle Ages to the First World War,” *Explorations in Economic History* 38, no. 4 (2001).

already been converted to a silver equivalence of grams of silver. For the purposes of this thesis, the necessary conversion data was drawn from the literature introduced earlier in this chapter.



Figure 3.2. The Hooping of Herring Barrels. Engraving by Adolf van der Laan based on a drawing by Sieuwert van der Meulen, published by Pieter Schenk in Amsterdam, dated 1720-1730.⁷⁹

3.1. A Common Price Unit for Protein

Before continuing with the conversions to the common price unit of grams of silver per kilogram of produce, it is worth noting that a common price unit does not need to be based on grams of silver and a kilogram of produce. There are alternatives and different standards suitable for varying purposes. Whichever is chosen, it should be based on a unit of measure

⁷⁹ "The Hooping of Herring Barrels." Engraving by Adolf van der Laan based on a drawing by Sieuwert van der Meulen, published by Pieter Schenk in Amsterdam, dated 1720-1730.
<https://www.maritiemdigitaal.nl/index.cfm?event=search.getdetail&id=106017468>.

that remains uniform for the study period. For example, if a commodity was sold in pounds of 0.454g, and that pound did not change in weight over the study period, that unit could be applied throughout instead of a kilogram. The precise value of a kilogram was not the focus for those buying and selling produce on the markets at the time, in fact the kilogram was only defined in 1795.⁸⁰ There was a drive for uniformity of measures over time, Beveridge writes of information in the Magna Carta from 1225, with Henry III proclaiming there will be one measure throughout his entire kingdom for each for wine, ale and corn. Beveridge also notes that by 1820, this had still not been achieved.⁸¹ In the case of currency, silver is often studied as a common unit of measurement, but gold is also used in some instances, such as the price collections from Walter Bauernfeind, while Pelc and Furtak include both silver and gold prices, (introduced in Section 2.1.3)⁸². The choice of currency raises debate because each will exhibit a degree of behaviour that was distinct to it, which can lead to different trends in a price series. Even if gold and silver are uniform commodities themselves, their relative value did change over time, as evident by fluctuations in bimetallic price ratios. From around 1500 to 1650, Hamilton suggests in Spain this ratio increased from around 10:1 to 15:1.⁸³ Pribram provides values for the entire period from 1500 to 1800, and the values are similar to Hamilton's values for the first half of the period and tend to vary close to 15:1 for the latter half.⁸⁴

Another alternative measure is the nutritional content of the food; for example, the price per kilogram of protein that a product contained. Nutritional content was not understood between 1500 and 1800 to the extent that it is today. There was an awareness, though, of the influence of different foods on health, even if perceptions were not always correct. For example, at one time salted provisions on naval voyages were believed to contribute to

⁸⁰ Jan Gyllenbok. *Encyclopaedia of Historical Metrology, Weights, and Measures* (Cham: Birkhäuser, 2018), 1:16-7.

⁸¹ William Beveridge. *Prices and Wages in England from the 12th to the 19th Century* (London: Frank Cass & Co, 1966), 1:xxix.

⁸² Bauernfeind, (1993); Julian Pelc. *Ceny W Gdańsku W Xvi I Xvii Wieku* (skł. gł. Kasa im. Mianowskiego-Institut Popierania Polskiej Twórczości Naukowej, 1937); Tadeusz Furtak. *Ceny W Gdańsku W Latach 1701-1815* (Skł. gł.: Kasa im. J. Mianowskiego, 1935).

⁸³ Earl Hamilton. *American Treasure and the Price Revolution in Spain, 1501-1650* (Cambridge: Harvard University Press, 1934), 71.

⁸⁴ Pribram Alfred Francis et al. *Materialien zur Geschichte der Preise und Löhne in Österreich* (Vienna: Carl Ueberreuters Verlag, 1938), 46.

scurvy.⁸⁵ Modern measurements state that cod meat contains 18% protein while herring meat is 23%. For other meats, the equivalent percentages stand slightly higher, with beef at 26% and chicken is around 25% and pork at 27%.⁸⁶ It is impossible to be certain of the protein percentages of the products sold during the study period. These modern percentages are for flesh, rather than an entire fish, or a full animal carcass with bone and possibly offal. As there is uncertainty about precisely what type of product was sold in some locations from 1500 to 1800, particularly in the case of fish produce, it is difficult to state precisely what percentage of protein was available in each product. Allen's study of the "Great Divergence" does give costs per gram of silver for a kilogram of protein for different products, such as meat, butter, cheese, and eggs.⁸⁷ Unfortunately, fish are not distinguished in this example.

The different products, such as meat, fish, and eggs, contain varying proportions of protein. The following is a hypothetical scenario that could reflect the level of protein in fish and terrestrial meat, and further indicate if one or the other was a more expensive source of protein. If a fish product contained roughly 20% protein, while other meats were around 25%, this could be applied to the conversion of prices that are already in a common unit of a price per kilogram of produce to find the costs per kilogram of protein. More specifically, the following type of formula could be applied:

$$\text{price of a kilogram of fish protein} = \text{price of kilogram of fish} / 0.20$$

$$\text{price of a kilogram of meat protein} = \text{price of kilogram of meat} / 0.25$$

For example, beginning by assuming 20% of the product is protein, then dividing the cost for herring by 20% will give a price per kilogram of protein. Thus, it could be the case that meat was to a degree more expensive than fish. Upon conversion to the price per kilogram of protein, if the price per gram of silver per kilogram of protein is similar for two products,

⁸⁵ Patrick Hayes et al. "European Naval Diets in the Sixteenth Century: A Quantitative Method for Comparative and Nutritional Analysis," *Historical Methods: A Journal of Quantitative and Interdisciplinary History* 52, no. 4 (2019), 205.

⁸⁶ Values taken from the US Department of Agriculture (USDA) (<https://www.usda.gov/>).

Herring: <https://fdc.nal.usda.gov/fdc-app.html#/food-details/782531/nutrients>

Beef: <https://fdc.nal.usda.gov/fdc-app.html#/food-details/174032/nutrients>;

Chicken: https://www.fsis.usda.gov/shared/PDF/Chicken_Turkey_Nutrition_Facts.pdf

Pork: <https://fdc.nal.usda.gov/fdc-app.html#/food-details/167820/nutrients>

⁸⁷ Robert Allen. "The Great Divergence in European Wages and Prices from the Middle Ages to the First World War," *Explorations in Economic History* 38, no. 4 (2001), 431.

it would suggest that buyers were willing to pay a premium for a product because in return they received more protein. These examples are hypothetical, and there are limits to our knowledge of precisely the types of cod and herring produce sold in the different locations, such as the degree to which they were processed, salted, and dried, gutted, etc.

In many instances, terrestrial meats carried a price premium compared to fish based on grams of silver per kilogram of produce, as shown in Chapter 4. On the other hand, bacalao would have been very high in protein, as it was a dried fish product. With the water removed, the relative percentage of protein would have been higher per kilogram of produce than terrestrial meat. Though it is difficult to state precisely what this percentage increased to. Thus, per kilogram, bacalao as a dense source of protein could represent better value for money. This will be studied in chapters 3 and 4.

Studying the price per gram of protein alone is a simplification, as it disregards any value that might be associated with other nutrients in a product. It is also reasonable to believe that consumers during the study period had comparatively little awareness of the protein they were consuming. To some extent, they may have been aware of the benefits of eating certain foods, but not to the level of modern-day understanding. An example of lack of understanding of nutrition is the previously mentioned association of scurvy with salted rations of food on naval voyages.⁸⁸ Thus, the precise nutritional content of food was not a motivational factor in consumption of fish. Laurier Turgeon discussed the perception of Newfoundland cod arriving as a new product to Parisian markets. He argues that much of what drove consumption was a desire to consume produce from the New World, with a degree of status attached to this.⁸⁹ Nutrition was not a factor discussed by Turgeon. The understanding of nutrition had not developed during the early modern period to the levels are a familiar with today. In fact, our modern understanding of nutrition was largely due to advances in the 20th century.⁹⁰ Thus, commodity substitution strategies would not have been based on our modern understanding of the nutritional content of what was being consumed. Nonetheless, the evidence of early modern famine manuals, in which

⁸⁸ Hayes, *Naval Diets*, 205.

⁸⁹ Laurier Turgeon. "Codfish, Consumption, and Colonization: The Creation of the French Atlantic World During the Sixteenth Century," in *Bridging the Early Modern Atlantic World: People, Products, and Practices on the Move* (Ashgate, Aldershot UK, 2009).

⁹⁰ Dariush Mozaffarian, Irwin Rosenberg, and Ricardo Uauy. "History of Modern Nutrition Science - Implications for Current Research, Dietary Guidelines, and Food Policy," *Bmj* 361 (2018).

alternatives to common staples were specified for consumption during times of shortage (and, hence, price spikes), suggests at least a minimal operational knowledge of (or interest in) substitutable food categories motivated by price.⁹¹

3.2. Currency and Quantity Conversions by Location

This section provides information on the conversions applied to the price series in each of the sources introduced earlier in the chapter. Many of these sources have been collated previously in the Allen-Unger database worked with. This chapter studied conversions for all sources. For this, a selection of prices and price series were traced backwards from the database to the secondary sources they were derived from. Conversions were changed from those applied in the Allen-Unger database in a small number of instances. This was also completed for all other sources already discussed. In the case of Stockholm, a more extensive analysis of conversion was completed in this chapter. The detailed analysis of each location has been included in Appendix B. Undertaking this regional exercise brought to light the need to recalculate a small number of conversions. For example, the calculations in the Allen-Unger database assume for Frankfurt that a herring weighed approximately 0.75kg. This is an unrealistically large value, thus the estimate has been adjusted to a lower estimate of 0.12kg for this thesis. This value was applied by scholars such as Bauernfeind for Nuremberg, thus providing reassurance about the better accuracy of this estimate.⁹²

3.3. Conclusions

Common units of price have been established for the locations that will be studied in the following chapters. They are based either on computations provided in the secondary source literature or have been computed for this thesis. It can be difficult to establish how a unit of measurement converts to a modern standard, however, it is possible to estimate units to a high degree of accuracy. There are two main sets of conversions for the common

⁹¹ Sir Hugh Plat. *Sundrie Nevv and Artificiall Remedies against Famine*. Peter Short, dwelling on Breadstreet hill, at the signe of the Starre, 1596.

http://famineanddearth.exeter.ac.uk/displayhtml.html?id=fp_00165_en_sundrienewandartificiallremedies.

⁹² Walter Bauernfeind, *Materielle Grundstrukturen Im Spätmittelalter Und Der Frühen Neuzeit: Preisentwicklung Und Agrarkonjunktur Am Nürnberger Getreidemarkt Von 1339 Bis 1670* (Neustadt/Aisch, BRD: Schmidt, 1993), 321.

price unit: the currency and the quantity of the product in question. There has been debate about what unit of price per quantity of product is a suitable standard, e.g., by Braudel and Posthumus.⁹³ Infinitely many options are possible. However, *grams of silver per kilogram of prices* have been applied, and scholars have argued in its favour. Its strengths include the uniformity of pure silver, being the same in all locations. For the quantity of a commodity, the kilogram is the standard measure of quantity, aligning to modern standards. Thus, with these conversions in place for both the quantity of the commodity and the common currency in grams of silver, comparisons are possible for all commodities and locations.

⁹³ Fernand Braudel, and Frank Spooner, (1967), 381; N.W. Posthumus. *Inquiry into the history of prices in Holland*, vol. 1 (Leiden, 1964). Wholesale prices. For example, see page VIII, which discusses different prices indices and how they are not the only options, but are preferred.

4. Commodity Substitution and Market Levels

The extent to which marine produce supplemented and substituted beef and wheat is possible to understand by analysing prices, quantities, and market levels. Comparing the prices of different products indicates to what extent they were positioned to supplement or substituting one another as part of diets. When both price and quantities of produce information are available, comparing them explains more. As such, the first section of the chapter introduces commodity price case studies. This is followed by a comparison of prices to quantity information. The Catch Per Unit Effort (CPUE) is briefly studied to understand the degree markets were influenced by human and environmental behaviour. Indications of the level of market integration (i.e., a measure of how connected the markets are and defined in Section 2.2.6) are also introduced.

Market levels, the topic of Section 4.2, were a feature of markets during the study period. They are indicated by different price levels, i.e., a price stratification for commodities at differing points in supply chains.⁹⁴ To this end, commodity prices are compared for wholesale and consumer markets. One of these price levels is prices paid at an early procurement stage that is represented by wholesale markets, and the latter is prices paid at later and final stages by large institutions purchasing produce for consumption. Analysing these different price levels, and their behaviours, reveals the extent price dynamics differed between levels. These price dynamics indicate differing pressures that occurred at each level and indicate the state of supply chains. When price levels displayed larger differences between one another, this indicates there may have been stress on markets that resulted in commodities becoming increasingly expensive to move along supply chains. Conversely, lower price differences indicate increased stability and less expense to move along these chains.

⁹⁴ Metin Cosgel. "The Socio-Economics of Consumption," in *The Elger Companion to Social Economics*, eds. John Davis and Wilfred Dolfsma (Cheltenham: Edward Elgar Publishing, 2008), 121-136, 126. This includes a discussion of prices in free markets compared to command economies.

4.1. Commodity Substitution

Comparing the respective prices of commodities that can substitute one another explains if one was lower valued. If this is measured over time, it explains if one was becoming “progressively” lower in value or if it became more expensive. By also studying the quantities of commodities available for consumption, the extent one product might have supplemented or replaced another can be explained. To this end, and to take advantage of recently developed price series, prices for Paris are studied first as a case study. Following this, quantities of fish and prices are compared, concentrating on prominent locations that come with the advantage of both quantity and price information. These locations are Southern England, Amsterdam, and Paris. The culmination of these regional analyses demonstrates the degree to which commodity substitution occurred and varied between locations.

To analyse the interaction of prices and quantities, a range of approaches are adopted below. The first involves inspecting cod, herring, and beef products by comparing price series for pairs of commodities, by the calculation of price ratios in each available year. This is designed to expose to what extent the relative value of commodities changed over the course of the study period. Further, examining when the relative value between commodities shifted over time will explain which commodity acted as a lower-priced option and if this level of lower price changed. To supplement this analysis, coefficients of variation (CVs) are computed for each price series and their ratios. The CVs illustrate the volatility that each price series experienced in any given period. These will be used to understand both similar and different price behaviour between commodities. The CVs will be studied in more detail in Chapter 5 to understand levels of “market integration”. The Catch Per Unit Effort (CPUE) will be described for Dutch herring, based on work from Bo Poulsen.⁹⁵ In a strict sense, CPUE measure indicates the “catchability” (rather than abundance) of fish in the oceans. Higher CPUE values do, however, indicate more fish are available to be fished and vice versa (for a given level of technology).

⁹⁵ Poulsen, *Dutch Herring*, 130.

4.1.1. Price Ratios and Market Volatility in Paris

The following builds on recently conducted archival research that generated new commodity price series for Paris.⁹⁶ The analysis covers price series for cod, herring, and beef. In particular, the relationships between the price series are examined. The analysis is achieved by first studying each price series, then analysing price ratios to understand the relative value of pairs of commodities to one another.⁹⁷ Further, CVs are calculated, based on decadal time-periods, to reveal when commodity prices were most volatile. Further, the CV derived for price-ratio series indicates the level of shared price volatility of pairs of commodities. Smoothed curves, known as “splines”, are included to give a clearer view of the medium to longer-term changes. The study of Paris in this section will demonstrate relative changes in marine fish product prices, which in turn may have occurred due to the arrival of Newfoundland produce.

Relative price changes between two commodities that can substitute one another signal which was the lower valued commodity,⁹⁸ and thus the level they were changing value relative to one another as a source of nutrition. When these comparisons are considered alongside the hypothesis that increased quantities of marine fish produce were arriving in Paris from the Grand Banks, this is further telling of the magnitude of any substitution that occurred. With this in mind, the following establishes the dynamics of cod, herring, and beef prices. First, cod and herring are examined to understand the extent prices changed while large quantities of cod supplement herring supply in Europe. Second, cod and beef are studied to reveal if cod replaced or supplement supplies of this terrestrial meat product.

Fresh Cod and Newfoundland Prices

Fresh cod in Paris was not the same product as the Newfoundland cod. Less information is available for the Newfoundland cod, as prices became available only at the start of the 17th century. At the start of the century, there are indications that Newfoundland cod came with a price premium compared to the Fresh produce, though this is difficult to state with

⁹⁶ Allaire, “Internal Norfish Report One.”

⁹⁷ Ronald Findlay, and Kevin H. O’Rourke. *Power and Plenty: Trade, War, and the World Economy in the Second Millennium* (Princeton University Press, 2009), 115. Figure 3.4. Relative commodity price trend for England 1300-1500 for (a) woollen cloth to wool price ratio and (b) wine and port to wheat price ratio. Source: data graciously provided by Greg Clark.

⁹⁸ Donald W. Jones. *Economic Theory and the Ancient Mediterranean* (John Wiley & Sons, 2014), 60.

confidence due to the limited information (Figure 4.1 below). If it was the case, however, this may have been due to it being perceived as a new and different product. Over the following years, the Newfoundland cod was slightly cheaper than the fresh cod produce, but not a very large premium. Prices follow similar trends in both cod series. For this reason, and the longer availability of price information, the fresh cod is studied for price comparisons to herring. That is, the fresh cod prices are studied as a replacement for the less complete Newfoundland cod series. Thus, assuming both cod products maintained this similar relationship during the study period, a more extensive analysis of the relationship between Newfoundland cod and herring is possible.⁹⁹

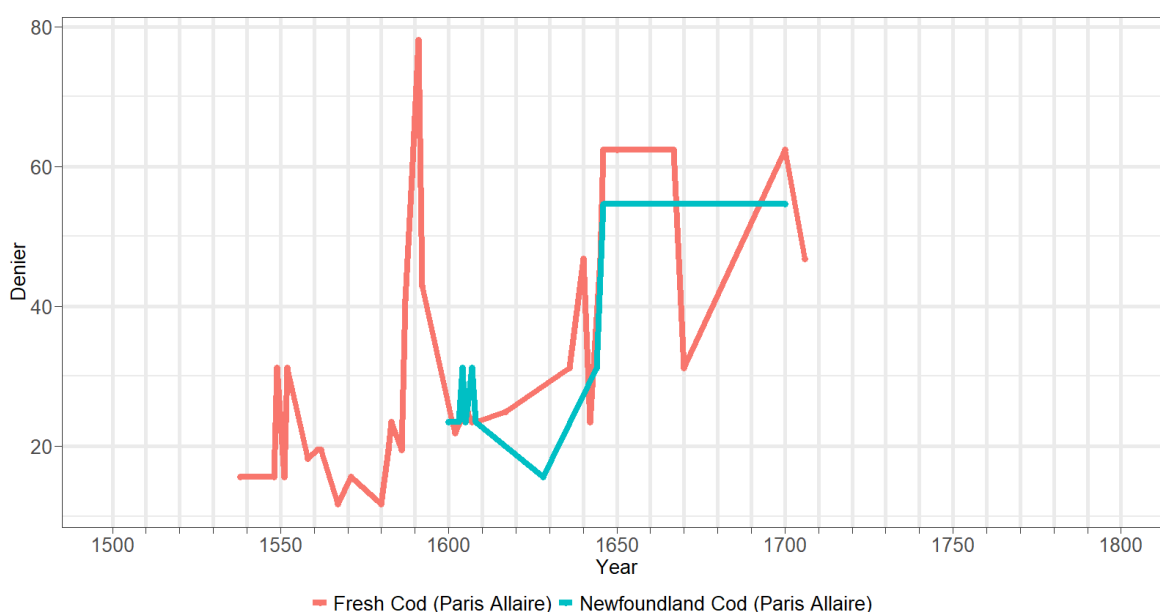


Figure 4.1. Cod prices in Paris for Newfoundland produce and for fresh produce.

Comparison of Fresh Cod and Herring

During the 1500s, cod became more abundant in French markets, arriving in large quantities, driven by imports from Newfoundland.¹⁰⁰ Figure 4.2 (below) depicts the prices for both cod (in red) and herring (in blue). The “Fresh Cod” is referred to by Allaire as either a wet and salty product (often known as “green cod”).¹⁰¹ The precise origin of this cod is unclear and may have been either Newfoundland or Northeast Atlantic fishing grounds. They are presented with a common unit of a price in denier (a local unit of currency) per

⁹⁹ The Newfoundland cod may have been a denser source of nutrition because it is a salted and dried product. This distinction makes no difference, however, to this analysis.

¹⁰⁰ Holm, “A Revolution in Fish Supplies. 1500 to 1800 CE,” (unpublished).

¹⁰¹ Allaire, “Internal Norfish Report One,” 11.

kilogram of produce. Original data points are highlighted by dots, while the lighter coloured lines are linear interpolations to indicate trends between missing years. We see that the herring values are consistently higher than cod values. This suggests herring was the more expensive product per kilogram of produce for almost the entire study period, being approximately twice as expensive for much of the time. As will be seen in Chapter 5, it was not the case that herring was higher priced than cod in all regions. Even though we can observe many missing values, the consistency with which herring exceeds the price of cod for those years that we do have data (barring one exception centred around 1550 CE) gives us confidence in this conclusion, at least.

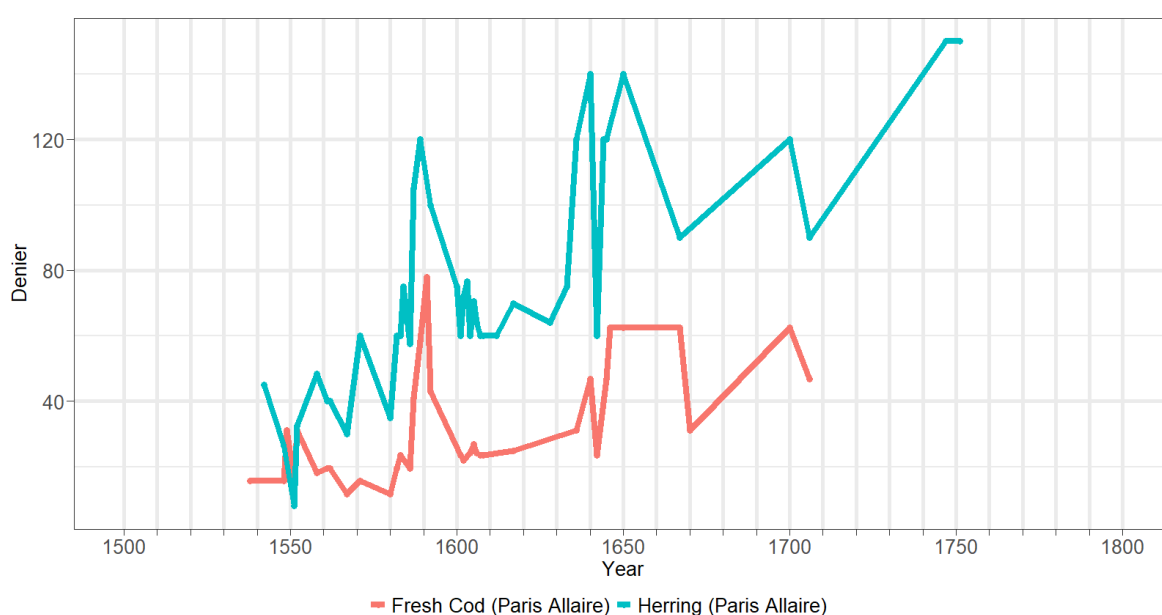


Figure 4.2. The chart displays raw price series for cod and herring in Paris.

Both products tend to follow similar price trends. The most notable feature over the course of the period the prices span is a gradual increase in price. Up until the early to mid-1600s, this was expected against a background of general price inflation that came with the Price Revolution. For the period that followed i.e., from the mid-1600s, the evidence is limited but the prices continued to inflate. That was unusual compared to many other locations, which experienced price stagnation or decline, though this will be discussed further from Chapter 5 onwards). The trends for both series present a dramatic picture of volatility on the short to medium-term (particularly where the data is dense enough to resolve this), with sudden price spikes and price drops. Examples of large price increases occurred in the 1590s and 1650s.

The next step is to develop a ratio of both series in order to better understand how they behaved relative to one another over time. Figure 4.3 (below) thus displays the price ratio for cod versus herring. The red dots represent the ratio based on actual information. The red line is a straight-line interpolation to fill the gaps between the available data points and assist with trend identification. The ratio shown in this figure has been presented in an annual resolution, and the volatility of the observed movements can make it difficult to discern genuine longer-term change. One simple method of counteracting some of the challenges of interpreting data with missing values is to apply a “smoothing spline”, this has also been duly supplied in the blue line. These splines represent a trade-off, with a loss of temporal resolution compensated for by a greater ease in discerning longer-term trends. As for what the price ratio represents, a decreasing price ratio of cod to herring suggests that cod is becoming relatively cheaper, while increasing indicates it is becoming relatively more expensive. A ratio value of one indicates that the prices are the same for both (in other terms this is called price parity). A value of two would suggest cod was twice the price of herring, while a value of 0.5 would suggest the opposite, with herring twice the price of cod.

Looking now at the ratio data, it is very notable in Figure 4.3 that cod became more expensive than herring, at almost twice the price, around 1550. Overall, though, when the large increase during the 1550s is excluded, the long-term price ratio was quite stable (as indicated by the blue trend line) with herring being more expensive than cod. The price ratio ranged around 0.25 to 0.75. During the 1630s, the ratio began to increase. Thus, even though cod remained lower priced than herring, this gap became less. Between the 1660s and first decade of the 1700s, however, the ratio began decreasing again. If this trend continued into the 17th century, cod would have continued to become even lower priced relative to herring.

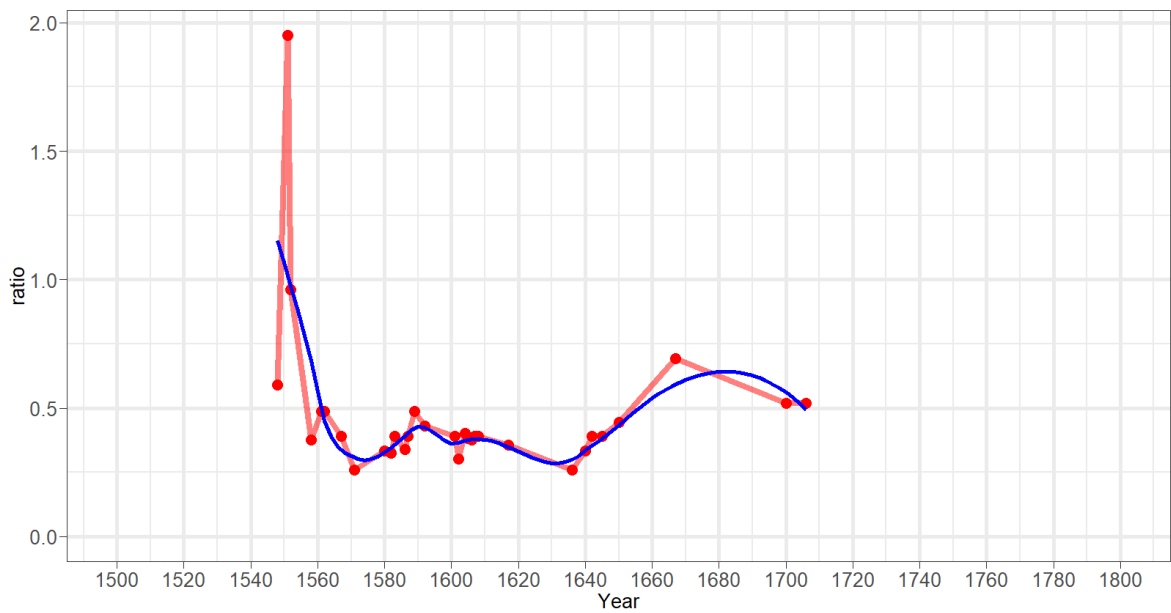


Figure 4.3. The ratio of cod prices relative to herring at an annual resolution (yearly price values). Higher values represent more expensive cod, relative to herring. Red dots represent available price information from archival research (Section 2.1.3 - Allaire). Values for the ratio are only possible to calculate when a value is available for both cod and herring in a given year. A trend line (smoothing spline) has been added in blue to show the medium to long term trends.

As previously stated, the Coefficient of Variation (CV) measures the level of volatility prices display as they change over time. Higher values indicate a more volatile market, one that is likely to be less integrated, and vice versa. The calculation of the CV for each commodity requires a set of values, and decadal groupings are deemed suitable as they allow for the study of medium-term change. (Market integration and the CV were introduced in Section 2.2.6). The decadal level provides a reasonable sample size from which to calculate the CV, while still capturing a good deal of high-frequency (shorter-term) variation (as compared to 50-year or 100-year groupings that would clearly preclude the identification of trends over shorter periods).¹⁰²

Examining the CV in Figure 4.4, below, we observe high instability in several of the opening decades, in particular in 1550 and 1580, interspersed with decades exhibiting greater stability (1560 and 1600). The 1600s demonstrate a noticeably higher degree of price stability. Even if trending upward to a peak in the 1640s, this is much more gradual than in the preceding century. Thereafter volatility eases off to an extent up to around 1700.

¹⁰² Interpolated values have not been included when calculating the CVs as their smoothing effect could cause an artificial lowering of CV values.

Overall, though, the level of volatility of cod and herring prices was very much shared. Price volatility in the early 1600s was low, relative to the previous century, suggesting increased stability in both markets at that time. It should, however, also be noted that the smaller number of values presently available for the second century of coverage could fail to capture the true levels of volatility experienced during that time. As for some of the larger price spikes, those in the 1580s and the 1650s are in keeping with the period when Newfoundland cod would have been abundant, these occurred during periods of conflict, and this will be further explored in Chapter 6.

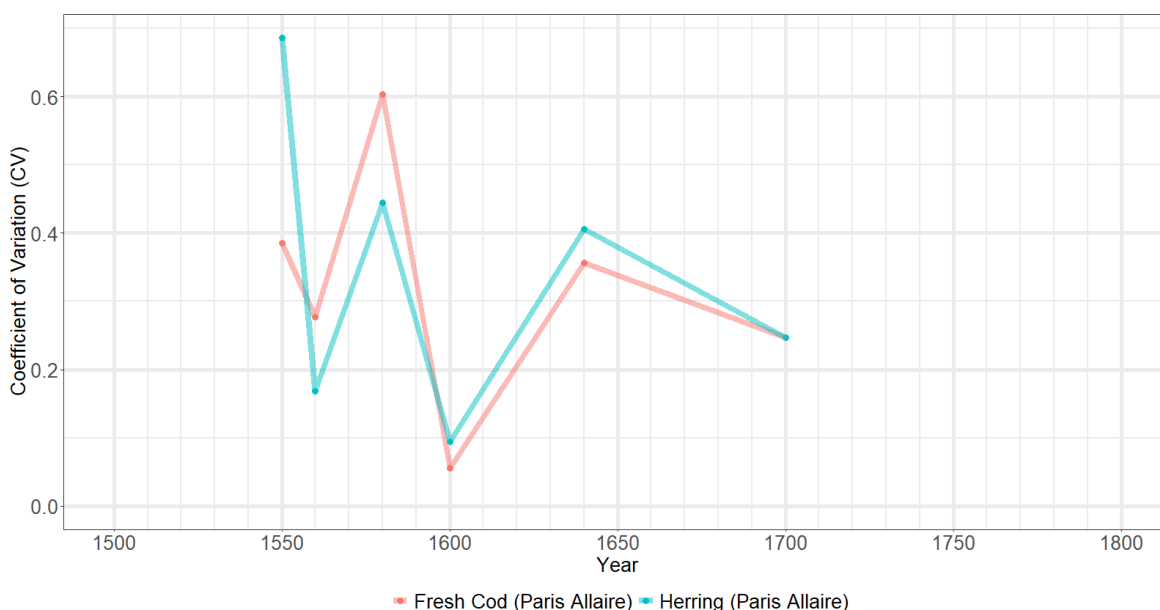


Figure 4.4. Coefficient of Variation by decade for cod and herring. Indicating increasing market integration through time.

Figure 4.5 (below) presents a combination of both the ratio and CV measures. They are CV values for the price ratios, and they remove price movements that were the same in both series. Thus, these CVs allow an examination of the volatility of the differences between price series. The results reveal a trend that is not apparent in the CVs for the individual series. Overall, there is a gradual decrease of volatility, but this is by no means smooth, with shorter-term reversals. We begin with very high values in the 1550s, most likely driven by a year of unusually elevated prices shown in Figure 4.2 earlier. Thus, regardless of the many variables potentially influencing the individual prices and increasing their volatility (as per Figure 4.4, above), when compared directly in this manner and based on the price information that is available, was decreasing between 1550 and 1700 (Figure 4.5 below). This increase in stability is consistent with products increasingly substituting for one

another, as their prices become progressively tied to one another. With cod supplies increasing in many regions in Europe, this increasingly stable price relationship with herring suggests it was replacing and supplementing herring supplies, at least in Paris. This is consistent with Laurier Turgeon’s discussion of cod being more widely consumed in France than herring from the 16th century onward.¹⁰³

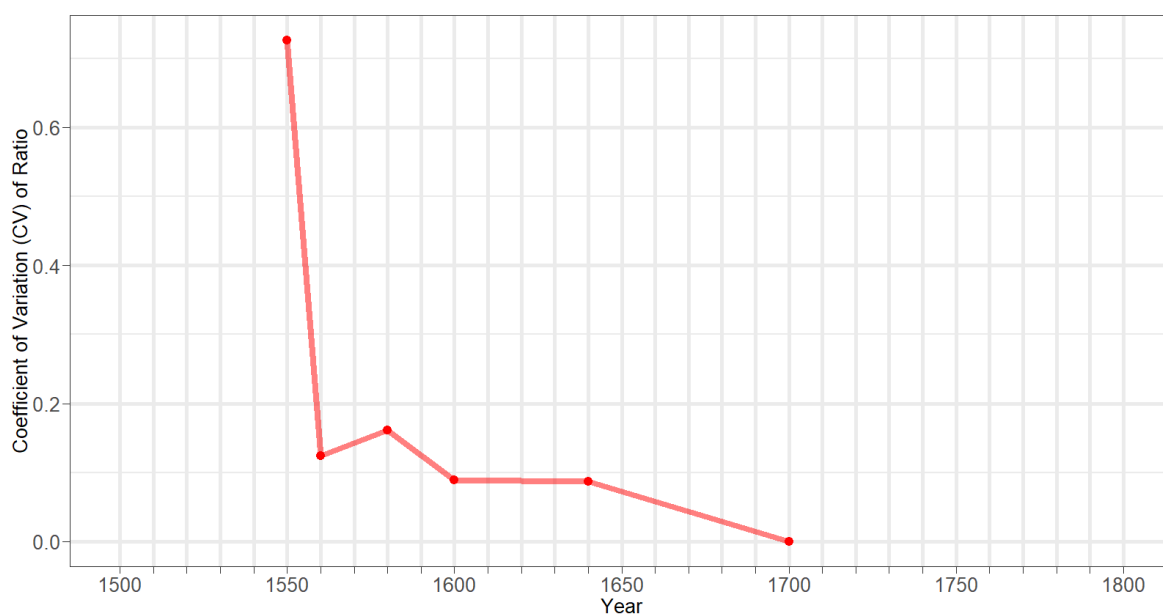


Figure 4.5. Coefficient of Variation applied to the ratio of cod and herring prices.

Comparison of Beef and Cod

Terrestrial meats and fish produce served as important sources of nutrition for the human diet, including nutrients such as protein. Beef is a terrestrial meat commodity with the ability to provide dietary protein, thus beef and cod could substitute for one another. Another reason for choosing this beef price series is it has a similar level of completeness to that of the cod series it is being compared with. The same series of cod prices from the last example is again used.

This case study seeks to understand if large amounts of cod from Newfoundland entering the French market become an increasingly lower priced alternative to beef. Further, understanding the degrees of price volatility the price displayed, and shared, explains if and when these markets followed a similar price trend. Lower CV values for the ratio indicate

¹⁰³ Laurier Turgeon. “Codfish, consumption, and colonization: the creation of the French Atlantic world during the sixteenth century,” in *Bridging the Early Modern Atlantic World: People, Products, and Practices on the Move* (Ashgate, Aldershot, UK, 2009), 38.

higher price stability between both markets, which in turn can be used to hypothesise to what extent they may have been substituting one another. Fresh cod and beef prices are compared below (Figure 4.6). As was the case for cod compared to beef, the dots represent archival price data, and a number of gaps are evident. Straight-line interpolations are therefore again included as an indicator of price trends for the missing years. Looking at the longer-term trends for cod and beef, two different stories are apparent. Beef prices (in blue) show a much steeper level of inflation that continues over the long term than cod (in red). Further, cod prices plateau from the 1640s onward, while beef continues its long-term trend of increasing prices. Aside from this long-term divergence, the two series notably share similar trends, on the sort to medium-term.

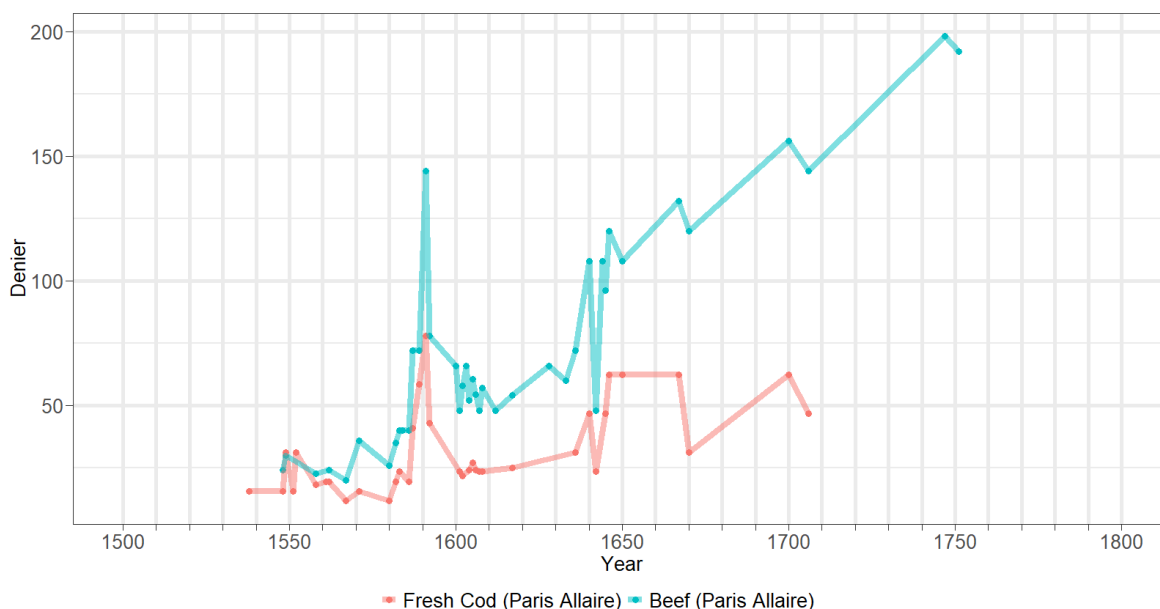


Figure 4.6. Denier prices for cod and beef in Paris.

The ratio of cod prices relative to beef have been calculated and are shown below (Figure 4.7). This is limited to years that a price value is available in both series, otherwise the ratio cannot be computed. A blue (smoothing spline) trend line is included to indicate longer-term trends and lessen the influence of large dominating values and missing data, (similar to what was included for the previous case study). Higher ratio values indicate higher prices for cod, while lower values indicate higher beef prices.

Cod prices are available from the 1540s, with almost the same price as beef per kilogram, (a ratio of 1 on the chart indicates price parity). Over time, the long-term trend shows cod becoming progressively cheaper compared to beef. This shift occurs until the first decade

of the 1700s, when the price information stops. This resulted in a drastically different relative value by the early 1700s, at around 0.3. In other words, cod became about one third the price of beef per kilogram, having started the period closer to price parity. This decreasing ratio demonstrating cod became progressively cheaper relative to beef.

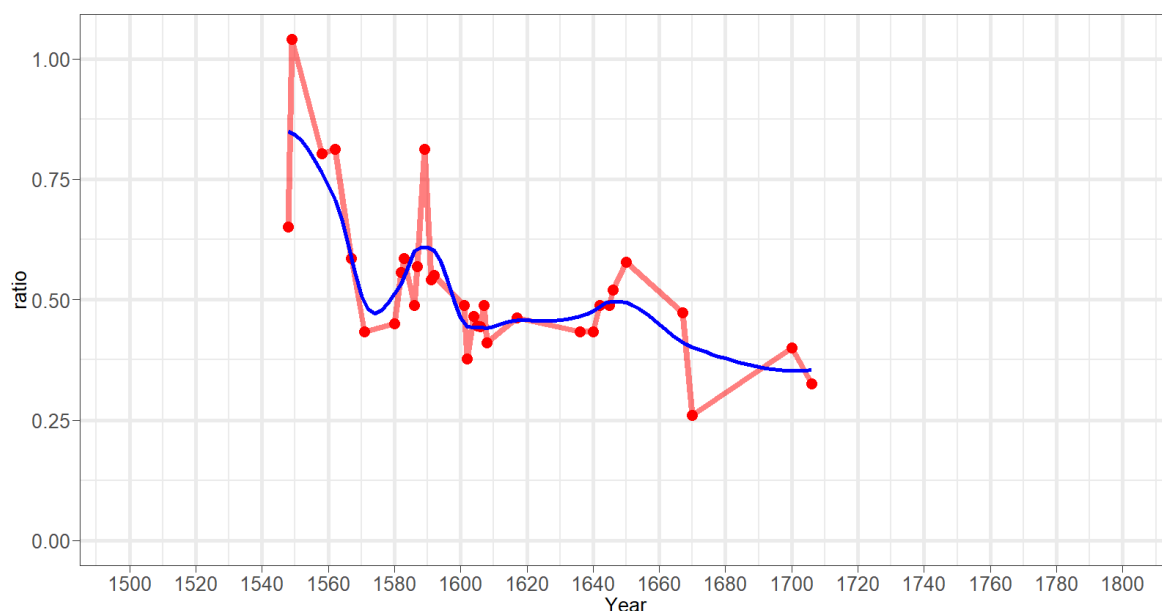


Figure 4.7. The ratio of cod to beef (in red).¹⁰⁴ The trendline (in blue) indicates longer-term trends.

The Coefficients of Variation (CVs) are presented in Figure 4.8. Both display periods of relatively high and low levels of integration for the period price information is available. Cod values were more extreme than beef. CV values hit a low in the first decade of the 1600s for both beef and cod. For both products, they had increased again by the 1640s, though fell again by the first decade of the 1700s. Over the long term, based on the information available, there is a trend toward less volatility for both products.

¹⁰⁴ The spike is driven by a very low price for beef. It is anomalously high and further investigation of the source material is required to ensure the credibility of this value.

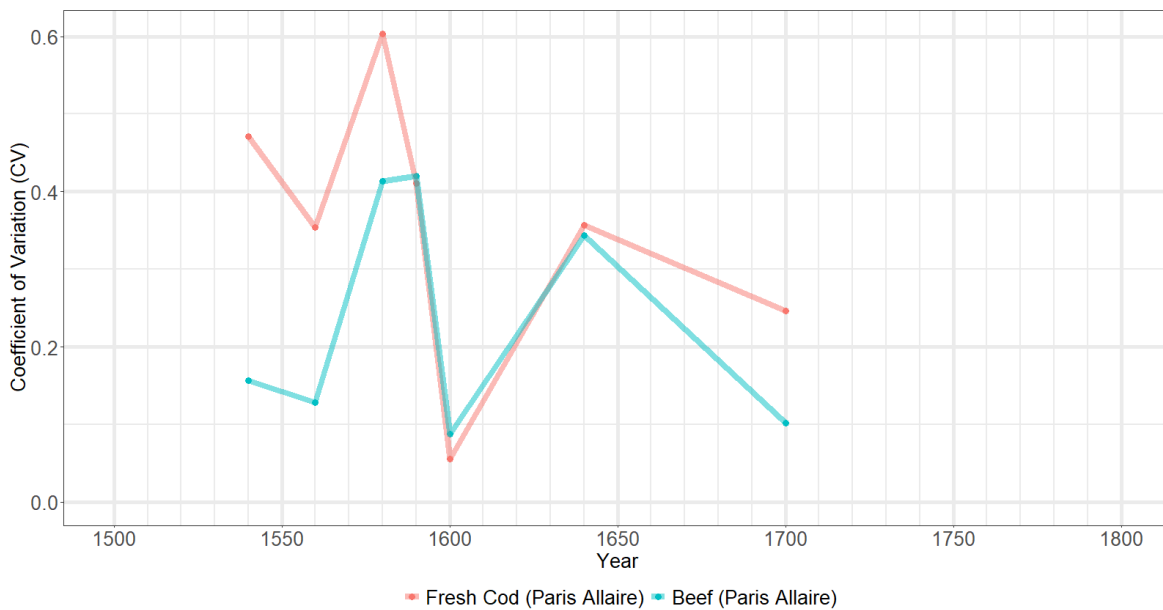


Figure 4.8. Coefficients of Variation for cod and beef.

The CV is applied to the ratio series to allow a direct indication of price behaviour that differed between beef and cod (Figure 4.9 below). The prominent peak in volatility at the beginning of the period that the data covers in the 1540s was driven by large price changes that occurred in that decade for both products. Overall, however, the values exhibit a declining variability (indicating higher levels of stability) up to the 1590s. Thus, the Siege of Paris in 1592 was marked by a level of relative stability between the prices paid for beef and cod. This further indicates they may have become more integrated and indeed increased the likelihood that commodity substitution occurred. Prices subsequently became more disintegrated in the following century. More specifically, from the start of the 1600s onwards, price volatility increases for almost every decade there is information available for up to 1700.

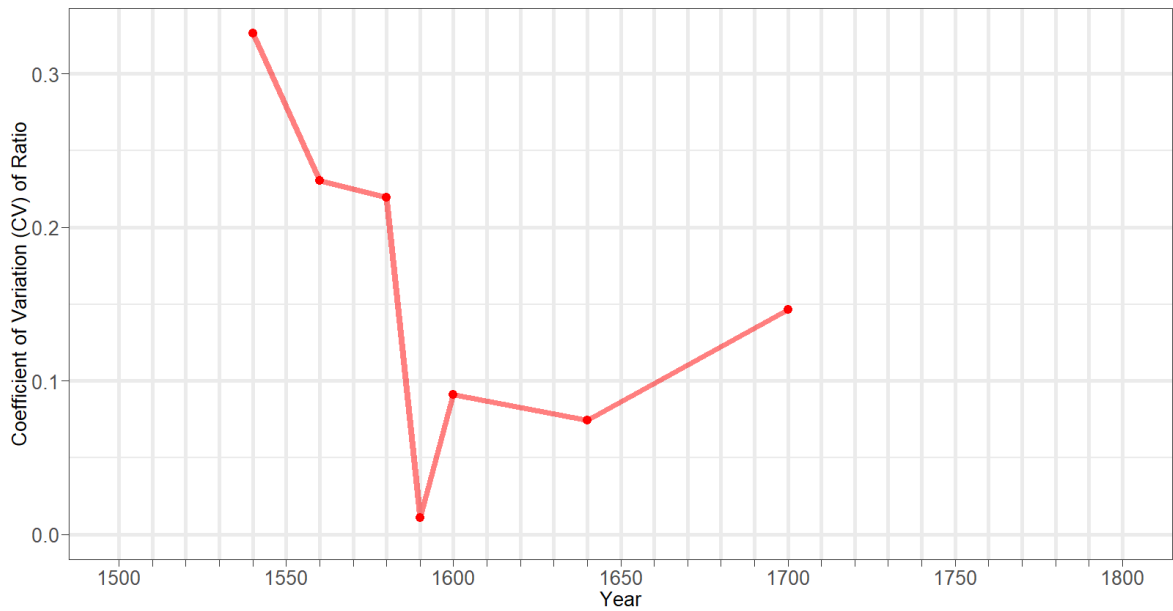


Figure 4.9. The coefficient of variation (CV) of the ratio of cod and beef in Paris.

Conclusions

The price ratios demonstrated a gradual drop in cod prices relative to both beef and herring during the study period. The increasing volumes of cod being introduced to the market from the Newfoundland cod fisheries came with lowering prices for fresh cod. With the relative value of cod decreasing compared to beef and herring, it became increasingly well-positioned as a lower-priced source of protein; substituting or supplementing to herring and beef supplies. This shift in relative value was particularly pronounced for cod relative to beef.

The relative change of value of cod compared to beef and herring was by no means smooth, with notable shorter-term departures from the broader trends. The long-term decrease in CV values suggest a gradual move towards increasingly stable prices. When going a step further and studying the CVs of the price ratio of cod compared to herring and beef, these also decreased over the long term, indicating the price relationship between both commodities also became more related with prices becoming more aligned. With prices more aligned, these products may have been better positioned to substitute for one another, as evident by their increasingly shared price movements.

4.1.2. Quantity Sources

Quantity information (i.e., fish catch amounts) for cod and herring is introduced in this section, and it is combined with the price information from chapter two. The following examples of quantity time series are not exhaustive. Active research is underway, that is outside the scope of this thesis, to evaluate total extractions from the oceans.¹⁰⁵ The fish catch information represents quantities of fish that were brought ashore by fishers, in some cases this could be the quantity of fresh fish, or after various stages of processing the fish. It has been collected by previous historians, coming from archival sources such as records kept for purposes of calculating taxes. A large volume of research has been (and is still being) undertaken by historians to develop catch series for European nations, often covering the study period from 1500 to 1800 CE. Research is active and new series are being developed, in particular cod landings from both eastern and western North Atlantic regions. For example, through the NorFish project, a time series of French fishing activity in Newfoundland has been developed.¹⁰⁶

An especially important and notable herring series has been developed through research over the last century and represents Dutch herring catches. In more recent decades, this work has culminated with a seminal publication from Bo Poulsen.¹⁰⁷ This has been achieved through original archival research, and by collating the efforts of previous scholars, resulting in time series for Dutch herring catches from several ports, spanning a period from as early as 1580 and continuing to 1800 and later. In the case of cod, a particularly significant series (both the magnitude of detailed catch volumes and level of completeness of the data) represents fishing from Iceland and Newfoundland by English and French boats.¹⁰⁸

The selected quantity information was uploaded to R following a similar (though somewhat simpler) process as the price information (see the methodology section in Chapter 2 for

¹⁰⁵ Holm, "A Revolution in Fish Supplies. 1500 to 1800 CE," (unpublished).

¹⁰⁶ Bernard Allaire. "Internal Norfish Report Ten: Total Catches (1500-1950)." *Internal NorFish Report, 2019* (Unpublished).

¹⁰⁷ Poulsen, *Dutch herring*; Van Bochove, Christiaan. "De Hollandse Haringvisserij Tijdens de Vroegmoderne Tijd." *Tijdschrift Voor Sociale en Economische Geschiedenis* 1 (2004).

¹⁰⁸ M. Haines, ed. 'Newfoundland, 1698-1833' in M.G Barnard and J.H Nicholls (comp.) HMAP Data Pages (<https://hydra.hull.ac.uk/resources/hull:2156>); P. Pope, ed. 'Newfoundland, 1675-1698' in M.G Barnard and J.H Nicholls (comp.) HMAP Data Pages (<https://hydra.hull.ac.uk/resources/hull:2157>); Allaire, "Internal Norfish Report Ten."

further description of the price information process). The series analysed in this section often have a high level of coverage of the study period, or periods of time within it. In some instances, when information is missing for particular years and locations, previous scholars have included assumptions such as interpolations to estimate this missing information. These are highlighted, where possible, in what follows.

4.1.3. Units of Quantity

The quantity units documented in primary sources are based on measurement standards of the time they were created in, usually barrels and lasts, and can be expected to vary to some extent over time and between locations. Thus, there have been efforts from scholars to convert the quantities to a standard (and uniform) measurement of metric tonnes, often as an equivalent to fresh fish. Examples of converting produce from salted and gutted back to a weight for fresh herring can be found in Poulsen's work for herring throughout European locations.¹⁰⁹ Conversion units are important as fish products in question may have been fresh fish straight from the sea, or they may have been processed with different methods such as salting, gutting, drying, or smoking. As such, the method of production is important as it will influence calculations on the total weight. All of these differences require conversions to ensure the amounts of product are comparable. Scholars often convert each to an equivalent of the total catch of fish extracted directly from the sea in metric tonnes.

The following section analyses quantities that are often equivalent to fresh fish catches in metric tonnes, though it is not always possible to do so. Quantity series were not always based on the same collection methodologies, thus uncertainties occur over the units of measurement, and thus their compatibility between locations. Due to this, it is often difficult to estimate their equivalence to total fresh fish catches. Thus, in some instances the quantity values have been included based on the units noted in the primary or secondary sources. This also reduces unnecessary assumptions when applying conversions.

¹⁰⁹ Poulsen, *Dutch Herring*, 141.

4.1.4. Quantity and Price Case Studies: Cod and Herring

Fish catch quantity information is a valuable indicator the level commodity substitution was occurring, contributing further to understanding supply and demand dynamics of the markets.¹¹⁰ With increased quantities of marine produce arriving to European markets, they were supplementing or replacing parts of diets. Case studies of particular locations are presented below. These are based on information available for quantities of fish caught during the study period. They focus on prominent locations where good quantity information is also available. (If a location was prominent and important, it is not surprising that information exists relating to it to this day and that it will have been studied to bear quantity series.) The case studies cover England, the Netherlands, and France.

English Cod

English cod catches in Icelandic waters are based on work published by Evan Jones in 2000.¹¹¹ In turn, Jones' work is based on historical observations from English archival records of the numbers of ships making voyages to the waters. This is based on observations of English ships fishing there, specifically the numbers of ships in a year. Jones presents this as a discussion of a limited number of years (sixteen to be precise), distributed over a period from 1528 to 1702. As an example, a total of 149 ships was described as having made the voyage to Icelandic waters for 1528. This was reported in a letter now reproduced in *Letters and Papers, Foreign and Domestic, Henry VII*, which was originally published by Her Majesty's Stationery Office, London, 1875.¹¹² This particular letter described a total of 149 ships travelling to "Yslonde", which is an old reference to Iceland. The author of the letter is not clear. The produce differed from stockfish, with the English having salted their fish, not practising the slow and time-consuming practice of drying their fish to create stockfish, as the Icelanders did.¹¹³

¹¹⁰ Ronald Shone. *An Introduction to Economic Dynamics* (Cambridge University Press, 2001), 27-47. Chapter 2 provides a detailed overview of supply and demand dynamics, including both price and quantities.

¹¹¹ Jones, *Economic Theory*.

¹¹² "Letters and Papers, Foreign and Domestic, Henry VIII." Vol. IV pt. ii, 1526-8, no. 5101.

<https://babel.hathitrust.org/cgi/pt?id=msu.31293104681808&view=1up&seq=1177>. Accessed November 29 2020.

Digitised version available at: <https://www.british-history.ac.uk/letters-papers-hen8/vol4/pp2208-2254>. Accessed November 29 2020.

¹¹³ Jones, *Economic Theory*, 11.

In as-yet-unpublished work, the following calculations were made to estimate metric tonnes of fresh fish catches per year, and the steps are described in what follows.¹¹⁴ Jones estimates the average tonnage of a ship to have been 57 tons (not metric tonnes). To estimate the weight of this ton, Jones suggests there were around “a thousand” cod or other fish for every four tons of a ship's burden. This thousand most likely referred to 1,200 units, rather than the 1,000 units applied in modern times. The measure of 1,200 units was commonly used at the time (as was also the case of a hundred meaning 120, as noted when discussing conversion for Southern England in Chapter 3, Section 2). Thus, an estimate of the total number of cod in a ship is achieved by dividing the total tonnage by four and multiplied by 1,200. An average weight for a single cod is assumed to be 8kg, based on a range of 5-12kg.¹¹⁵ Multiplying the total number of fish by 8 and dividing this by 1,000 leads to a metric tonne estimate. Multiplying this by the number of ships in a year leads to an estimate for total catch for that year. It is possible to summarise the various stages of the conversion from numbers of ships to metric tonnes by applying the formula. That is, the formula acts as a concise mathematical summary of the steps:

$$\text{Metric Tonnes of Cod} = \text{No of Ships} * \text{Ave Tonnage} / 4 * 1,200 * 0.008.$$

For example, for the year 1528 this gives an estimate of 20,383 MT, as outlined below:

$$20,383\text{MT} = 149 * 57 / 4 * 1,200 * 0.008.$$

Figure 4.10 (below) presents this cod quantity information (in blue) and examples of cod price information from southern England for comparison (in red and green). The cod quantity data begin, as mentioned above, in 1528 and immediately exhibit a large drop-off, continuing at depressed values to the end of the century. It is possible the trend was related to increased control over Iceland by Denmark in the 1570-80s.¹¹⁶ The quantities had increased by the early 1600s. When the next data point becomes available, for the year 1614, the value has now dramatically risen to 17,100 metric tonnes, and indeed rises again to 21,888 metric tonnes in 1628. English fishers may at this time have capitalized upon the *Treaty of London (1604)* that brought peace from that time and the following two decades,

¹¹⁴ Holm, “A Revolution in Fish Supplies.” (unpublished).

¹¹⁵ Ibid, These conversion assumptions are based on developing research by Holm et al. The range of 5-12kg can be found at the following URL:

https://ec.europa.eu/fisheries/marine_species/wild_species/cod_en.

¹¹⁶ Jones, *Economic Theory*, 2.

providing more stability to the fisheries around Iceland.¹¹⁷ A second decline began thereafter, following a peak in the 1630s. This broadly continued until the end of the century, with evidence for only one period experiencing a small increase during the 1650s and 1660s. This could be indicative of a resilience to shocks from conflicts, such as the First Anglo-Dutch Wars (1652 to 1654).¹¹⁸ Nonetheless, the gradual decline over the 1600s to the point of the almost complete disappearance of English ships fishing for cod in these waters may have arisen in large part from salt taxes, which severely reduced any profits, according to Jones.¹¹⁹ From the latter half of the 17th century, fishermen preferred to let their ships lie inactive rather than making the voyage to Iceland. The Dogger Bank and the North Sea instead became more important for English cod fishing.

Changes in available quantities of cod coincide with price changes at certain times. The slump in available quantities of cod from Iceland that occurred from the 1630s (see the blue dotted line on Figure 4.10) is followed by price increases for cod in southern England from the 1680s.

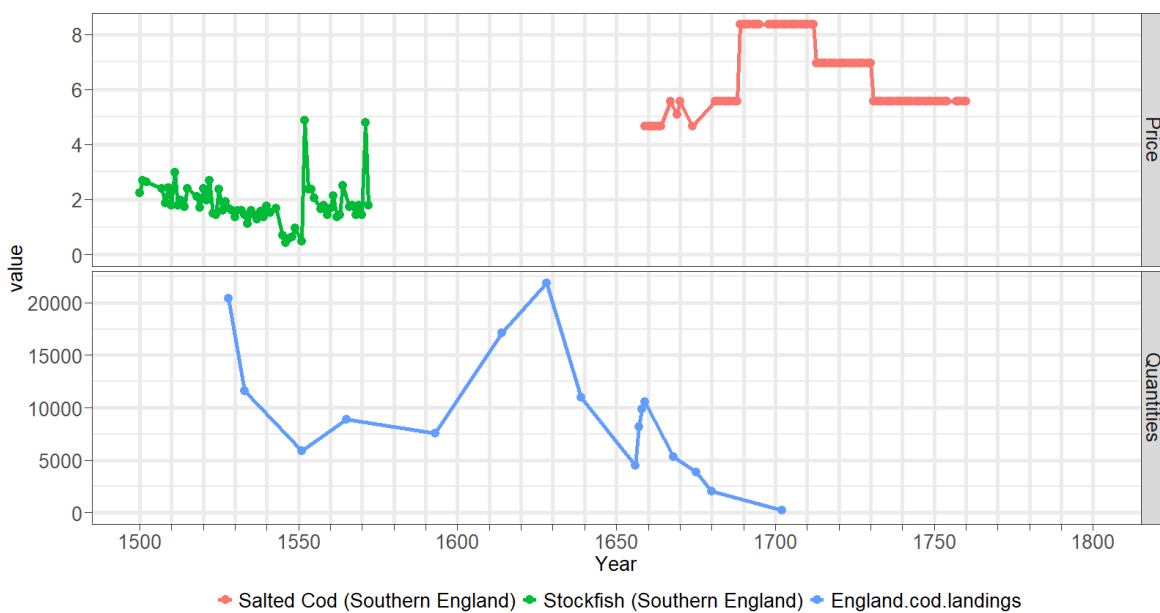


Figure 4.10. Cod quantity and price information for England. A trend line has been included to show medium to long term changes. Price is measured in grams of silver and quantities in metric tonnes.

¹¹⁷ Ibid, 6.

¹¹⁸ Ibid, 6.

¹¹⁹ Ibid, 7. Jones states “The level of tax on salt increased from a 5% ad valorem custom levied on imported salt in the sixteenth century to a 300% peace-time excise on English salt by the late eighteenth century.”

English Herring

Herring catch estimates for England come from three sources. The first two represent catches returned to Great Yarmouth in East Anglia, covering a period from 1598 to 1782. The third source comes from Hitzbleck and is representative of English herring exports over the period from 1661 to 1780.¹²⁰ These sources will later be compared to prices for herring in southern England (Figure 4.11).

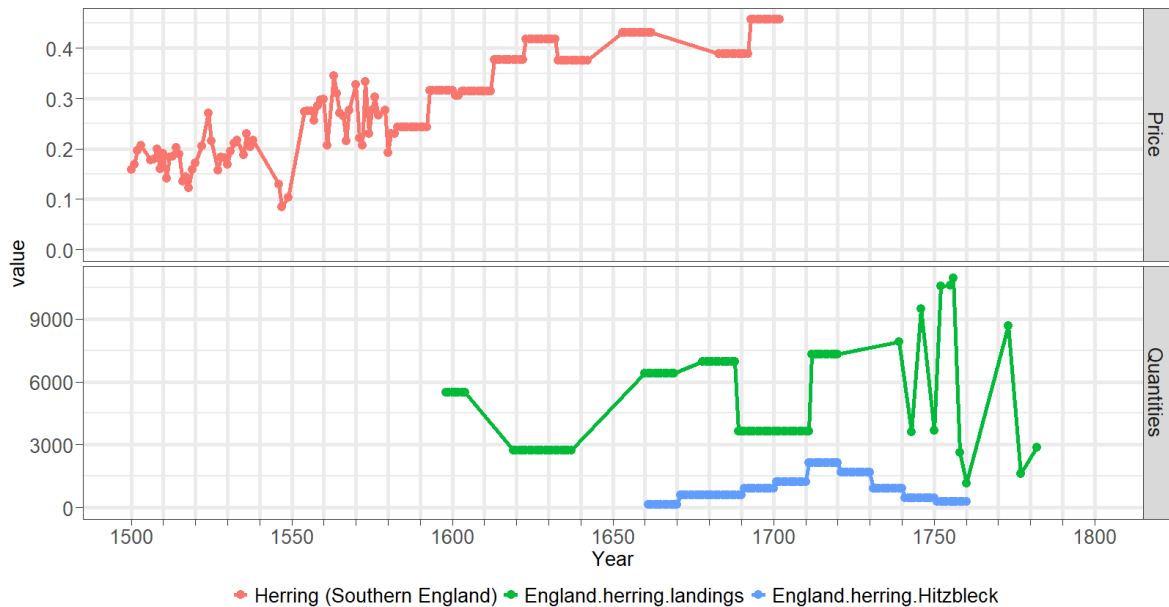


Figure 4.11. Herring quantity and price information for England. The price information represents Southern England and comes from the work of Rogers (see chapter 2). Quantities come from Poulsen, Hitzbleck and Michell and Nall.

The first of the two sources for Great Yarmouth are from A.R. Michell.¹²¹ Michell's figures are based on packed and cured herring for ships arriving at Great Yarmouth, covering a period from 1598 to 1720 and are measured in lasts. The information is sparse, comprising estimates for groups of years. Poulsen estimates that the "last" referred to here was made of 12 barrels that each weighed 127kg.¹²² To derive live catchweight, Poulsen adds approximately 20%. This is based on 14 barrels of cured herring equating to 17 barrels of

¹²⁰ Herbert Hitzbleck. "Die Bedeutung des Fisches für die Ernährungswirtschaft Mitteleuropas in vorindustrieller Zeit: unter besonderer Berücksichtigung Niedersachsens," PhD diss. (Georg-August-Universität, 1971), 274.

¹²¹ A. R. Michell. "The European Fisheries in Early Modern History," *The Cambridge Economic History of Europe* 5 (1977), 147.

¹²² Hitzbleck, (1971), 318. For more discussion, see Poulsen, *Dutch Herring*, 57.

unprocessed herring, giving a ratio of 1.21, which is rounded to 1.20, i.e., a 20% increase.¹²³

Thus, based on lasts, the live weight metric tonnes can be estimated as follows:

$$\text{Metric Tonnes} = \text{Lasts} * 12 * 127 / 1,000 * 1.20$$

For example, for the period from 1598 to 1604, this comes to 5,486 MT per year.

$$5,486 \text{ Metric Tonnes} = 3,000 \text{ Lasts} * 12 * 127 / 1,000 * 1.20.$$

The second source for Great Yarmouth is provided by Nall and covers the period from 1739 to 1782.¹²⁴ This information is based on records of the total number of barrels for domestic consumption that duty was paid on per year and covers 12 years. It is specifically for red herring, a product that was salted but not gutted and left to rest for two or three days before being smoked over a slow-burning fire in custom-built smokehouses.¹²⁵ This information came from reports published in 1785 by a parliamentary committee in England set up to understand the state of British fisheries.¹²⁶ The available figures are a total of red herring for both export and for domestic consumption. The barrel is again 127kg, and the 1.2 conversions used earlier are similarly re-applied for this red herring as was used for the cured herring.¹²⁷

$$\text{Metric Tonnes} = \text{Barrels} * 127 / 1,000 * 1.20$$

For example, in 1739:

$$\text{Metric Tonnes} = 51,859 * 127 / 1,000 * 1.20$$

Because the Great Yarmouth information is based on two different collections of quantity information (i.e., before 1720 and after 1739), it is difficult to compare them, as it is not clear they were developed with the same collection methodologies. The products were not clearly the same, that is red herring and salted or cured white herring cannot therefore be compared directly. Further, the assumption of the metric tonne equivalent for both may be imperfect. As shown in Figure 4.11 (above), it is evident that the magnitude of the

¹²³ Poulsen, *Dutch Herring*, 141.

¹²⁴ John Greaves Nall. *Great Yarmouth and Lowestoft* (Longmans, Green, Reader and Dyer, 1866), 329.

¹²⁵ Poulsen, *Dutch Herring*, 59.

¹²⁶ Nall, (1866), 326.

¹²⁷ Holm, "A Revolution in Fish Supplies." (unpublished).

catches is similar between both series when one replaces the other in the 1710s. It is reassuring that both series are at that time as it supports their accuracy.

The third source comes from Hitzbleck and is indicative of all English exports.¹²⁸ It covers the period from 1661 to 1780 and is measured in thousands of lasts. The information is taken from decadal summaries that were based on Sound Toll records that represent English herring catch exports travelling east to the Baltic through the Sound. It is not clear how much of the entirety of English herring exports this represented, but it does indicate supply and possibly demand in the Baltic area for English produce. This information does not show the same trends as the Great Yarmouth herring, which is more indicative of domestic consumption.

There is an overlap of herring price and quantity information for the 17th century and the early 18th century as shown in Figure 4.11, above. Price information for Southern England measured in grams of silver per kilogram of white herring produce (a fresh or uncured herring, as discussed in Chapter 2) is indicated in red, while the Great Yarmouth quantities (for both sources) are shown in green and the exports from England to the Baltic are in blue. For the first quarter of the 1600s, prices were increasing while the supply decreased, suggesting demand for herring remained, in the face of less supply. There were periods of conflict, such as the First Anglo-Dutch Wars from 1652 to 1654 and the second from 1665 to 1667. Poulsen observes conflict did create problems for the fisheries.¹²⁹ In the aftermath of the conflict, supplies recovered. During the 1660s and 1670s, supply increased. The reported quantities drop in the last few decades of the 1600s and remain low for the first few decades of the 1700s. Poulsen observed conflict in the early 1700s as creating substantial problems.¹³⁰

In the short term, based on available information, it is difficult to conclude how related the prices and the quantities are. Over the longer term, they follow similar trends when the information overlaps. With this information alone, the herring market performed well, providing substantial supplies, over much of the study period.

¹²⁸ Hitzbleck, (1971), 274. Values are converted from Lasts to tonnes by applying a value of 1.524 (=127 kg * 12 Barrels for a last). More information on the value of 127kg can be found on page 318.

¹²⁹ Poulsen, *Dutch Herring*, 225.

¹³⁰ *Ibid*, 225-6.

Dutch Herring

Of all nations exploiting the North Sea for herring, the Dutch herring fishery was dominant from at least the early 1500s to the end of the 1700s.¹³¹ Bo Poulsen undertook an extensive study of this fishery, published in 2008. Working parallel to Poulsen, economic historian Christiaan Van Bochove's cumulative efforts bring together many of the previous efforts to quantify the scale of the Dutch herring fishery and how they changed over time.¹³² Their work was influenced by earlier studies such as Wätjen's from early in the 20th century.¹³³ As part of these works, Poulsen noted the Dutch herring industry to be at a peak of production in the first half of the 1600s, with annual landings of between 30,000 and 60,000 metric tonnes, followed by a massive decline to less than 10,000 metric tonnes per year by the 1680s.¹³⁴

The final quantitative dataset, published by Van Bochove, includes fish catch series for seven locations (Enkhuizen, Maassluis, Brille, Rotterdam, Delfshaven, Schiedam, and Vlaardingen). Poulsen's efforts included standardisation of the information, in particular, that for Schiedam, representing the "Zuiderkwartier" (i.e., Southern Quarter) of the Netherlands, with archival documents known as the "Haringcertificatien" used to represent the entirety of fish catches for this fishery.¹³⁵ These were a standardised record and a requirement of the "College van de Grote Visserij". This was a Dutch body formed in the 1560s that very much controlled the Dutch herring industry,¹³⁶ and helped solidify Dutch strength in the fishery.¹³⁷ High levels of regulation of the industry allow for good estimates of the magnitude of the entire industry.¹³⁸ In the case of the "Noorderkwartier" (Northern Quarter), the information is based on "lastgeld" records,¹³⁹ which translates as "tax money". As for the motivation for the honest and accurate keeping of the lastgeld records, Wätjen states that he saw no evidence of complaints of under-reporting or evasion of tax,

¹³¹ Ibid, 43.

¹³² Christiaan van Bochove. "De Hollandse Haringvisserij tijdens de Vroegmoderne Tijd," *Tijdschrift voor Sociale en Economische Geschiedenis* (2004), 3-27.

<https://archieff.socialhistory.org/en/research/database-hollandse-haringvisserij-1500-1795>.

¹³³ Hermann Wätjen. *Zur Statistik der Holländischen Heringsfischerei im 17 und 18. Jahrhundert* (Duncker u. Humblot, 1910), 159-70.

¹³⁴ Poulsen, *Dutch Herring*, 45.

¹³⁵ Ibid, 133.

¹³⁶ Ibid, 43.

¹³⁷ Ibid.

¹³⁸ Ibid, 45.

¹³⁹ Ibid, 45.

but also acknowledges that this is not enough reason to state that it did not happen at all.¹⁴⁰ On balance, then, it is not likely that the information is significantly biased by under-reporting.

Due to the high quality of the series for Schiedam and its extensive coverage, it is the focus for the rest of this section. Also, it is concentrated upon due to the robust analysis completed by Poulsen and Van Bochove, which further informs its interpretation. This information is presented in Figure 4.12 (below). Quantities are in blue and prices for herring sold to large institutions near Amsterdam are in red, while the wholesale herring prices sold at the Amsterdam Exchange are in green. The quantity information begins in 1600. Focusing on long term trends, the quantities being a sharp long-term decline from around 1600 until around the 1630s. They then show a very gradual long-term increase up to around 1700, before beginning a decline in the following century. The wholesale herring prices share a period of substantial overlap with the quantities. While wholesale prices appear comparatively flat in their opening decades from the 1620s onward, Amsterdam institutional prices do appear to register a price increase (despite missing data) that may correspond to the period for which herring quantities are in their most dramatic decline immediately post-1600. This suggests that demand was still high and implies that the decline of Dutch herring catch up to the 1630s was not driven by demand-side economic changes and may instead reflect variations in natural herring abundance at this time, as well human influences such as warfare and piracy.¹⁴¹

¹⁴⁰ Wätjen, (1910), 171.

¹⁴¹ Poulsen, *Dutch Herring*, 224-30.

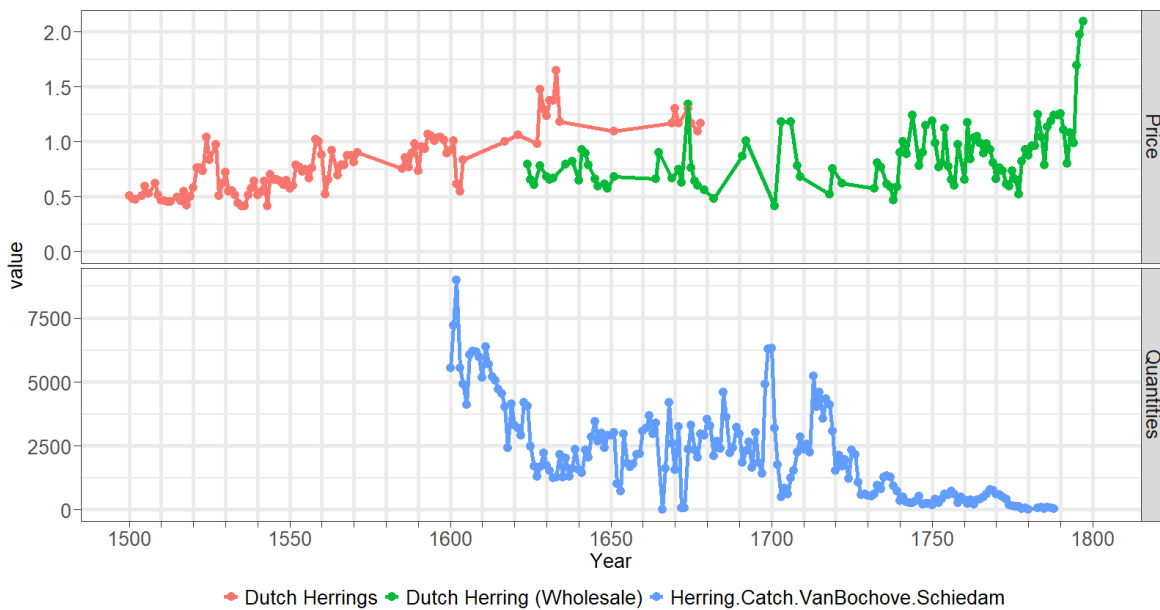


Figure 4.12. Dutch Herring catch quantities and prices. This version was first interpolated with straight lines and then smoothed, to allow a better understanding of the longer-term changes.

Thereafter we observe a comparatively flat price trend (despite considerable interannual variability) up and into the first decades of the 1700s (with wholesale prices by this time providing our sole price evidence). This is broadly matched by catch values, notwithstanding again a high interannual variability. A more dramatic change in catch amounts occurred in the 1720s, with further reduced values. Prices increase in the following decade. This response is not of the scale that might be expected given the magnitude of the decline in catch, however, suggesting that alternative sources of herring and increased quantities of cod were available as protein sources to continue supply and thereby ameliorate the observed price increase.¹⁴² There is an increase in prices in the 1790s, this increase appears for many prices and locations in the run-up to the Napoleonic Wars (1803 - 1815).

The Catch Per Unit Effort (CPUE) is used to study the quantities of fish extracted from the oceans.¹⁴³ More specifically, as stated earlier in the chapter (Section 4.1), the CPUE measure indicates the abundance of fish in the oceans, and higher CPUE values indicate more fish are available to be fished and vice versa. The CPUE is a measure that relates to

¹⁴² Poulsen, *Dutch Herring*, 227-8 discussed competition the Dutch herring was receiving from Scotland as a factor in Dutch herring decline.

¹⁴³ René Taudal Poulsen, and Poul Holm. "What Can Fisheries Historians Learn from Marine Science? The Concept of Catch per Unit Effort (CPUE)," *International Journal of Maritime History* 19, no. 2 (2007).

the size of a fish catch. It can therefore be used as another indicator of supply and demand dynamics. In a sense, the CPUE is a measure of how the ocean reacts to being fished, with values increasing if the ocean was producing more, for example. For this to work, the CPUE measure must, therefore, include an adjustment to control for the effort employed to bring in any given fish catch volume. Thus, it is based on two measures; the total catch and the units of effort needed to achieve this. The unit of effort is commonly measured as either the number of individuals or boats needed to bring in the total catch.¹⁴⁴ The choice of what unit to apply to measure effort is subjective, but efforts have been made to standardise it.¹⁴⁵ In this chapter, the unit of effort will be stated and remains the same across individual series, which is necessary to allow comparison of years within a series. In numerical terms, the CPUE is calculated as a ratio of catch amount to the effort put in. As an equation it can be represented as follows:

$$CPUE = \frac{Catch}{Effort}$$

The CPUE can also help diagnose supply and demand dynamics. The CPUE for Dutch herring catches has been calculated by Poulsen.¹⁴⁶ To generate the CPUE series, effort figures had been needed and were available from 1600 to 1795. Poulsen concludes that the CPUE for the Dutch herring fishery per boat per year remained quite stable over the entire period. The CPUE is also quite stable in the later part of the period, for example in Schiedam, the catch values tend to vary between 15 and 20 tonnes per voyage. This suggests much of the variability in Dutch herring catches was driven by ocean productivity, rather than the level of effort being put into fishing. Van Bochove also discussed effort, based on Poulsen's work for Schiedam from 1645 to 1795.¹⁴⁷ The CPUE shows similar trends to the catch. As mentioned, from the 1600s, a decline in the amount of herring caught is evident, and this occurs with the prices increasing.

In summary, the Dutch herring industry went into decline over the course of the 1700s, but the prices continued to increase. A proportion of this increase was related to inflation across all products in Amsterdam. Poulsen discussed reasons for this decline, such as a lack

¹⁴⁴ Poulsen, *Dutch Herring*, 131-2.

¹⁴⁵ *Ibid*, 91.

¹⁴⁶ *Ibid*, Ch.8, 130-59.

¹⁴⁷ van Bochove, (2004), 17-8.

of recovery in the relatively peaceful period of the early to mid-1700s due to high tariffs in other European states. He further notes the Norwegian and Scottish herring fisheries took their place. For the remainder of the 1700s, Poulsen notes a spatial distribution of herring fishers from the North Sea to Bohuslän. Following this, events such as the Napoleonic wars further aggravated the decline.¹⁴⁸

French Cod from Newfoundland

The French were a major early participant in the Newfoundland Grand Banks fishery. The following analysis is based on newly generated NorFish archival research that is establishing the number of French ships visiting Newfoundland waters to fish, building on previous research by Jacqueline Hersart De La Villemarque.¹⁴⁹ Thus, this is a measure of the effort put into the fishery (i.e., the number of boats). NorFish research has, however, combined this with tonnage estimates to provide an indicator of the magnitude of the French fishery in each year. The information covers different ports in France, and a period from the early to mid-1500s up to almost 1800 in some cases, dependent upon the port. Examples are included below in Figure 4.13, they were chosen due to their relatively good data coverage of the period. There was a price spike observed in Parisian prices in the later 1500s and peaking in 1592 during the French Wars of Religion (discussed in Section 4.1.1). This occurs in the period when Bordeaux was experiencing lowering catch levels. Landings at La Rochelle do show some decrease. Thus, this indicates disruption to fishing activity during periods of conflict in France in the latter half of the 16th century (conflict will be studied in further detail in Chapter 6). Specifically, based on the evidence, on the longer term there was less activity (i.e., fewer boats) in the lead up to the Siege of Paris in 1592, the peak of the civil war in France. The most prominent feature in Bordeaux is a flurry of activity that increased up to the mid-1500s, before decreasing after this for most locations, and remaining substantially lower from the 1600s to the end of the 1700s. Some locations did not come with this decline however, for example the port of Saint Malo.

¹⁴⁸ Poulsen, *Dutch Herring*, 241-2.

¹⁴⁹ Allaire, "Norfish Internal Report Ten"; Jacqueline Hersart De La Villemarque. *French Cod Fishing from 1500 to 1950: Statistics, Climate, Society* (1995).

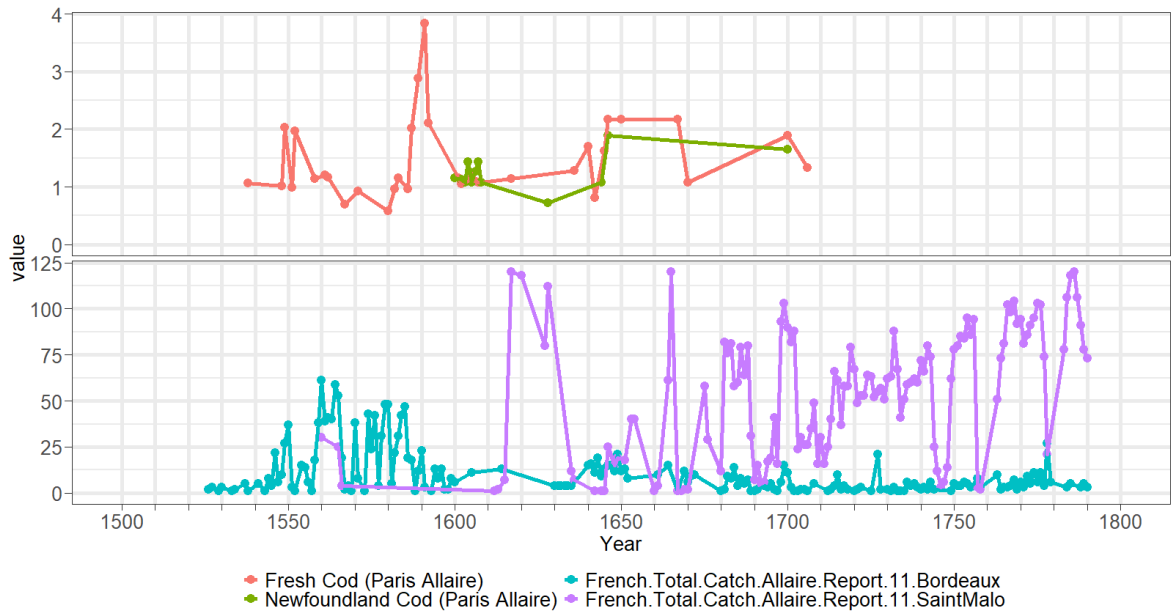


Figure 4.13. French Cod catches from Newfoundland. Prices for cod are showing red, and are for fresh cod, most likely not from Newfoundland. in Paris from Allaire’s first NorFish report.¹⁵⁰

Conclusions - Quantities

Over the long term, active and unpublished research from Holm et al is hypothesising quantities of both cod and herring landings arriving to European markets increased over the study period from 1500 to 1800.¹⁵¹ This would not have been the same message for each location in Europe, as can be seen in the case studies above for the likes of cod in England and herring for the Netherlands. Though, as larger quantities of cod arrived, it would have supplemented herring diets in locations where this cod arrived. Herring quantities also increased, though not to the same degree as cod, but would also have contributed further to diets.

On the medium and short term, common changes appear amongst different locations. For example, during the period of the Thirty Years’ War (1618 to 1848), Dutch herring, English returning cod from Iceland and English herring registered a decrease in catch amounts.

4.1.5. Conclusions

Price ratios are indicating that the relative value of cod was decreasing compared to beef. Thus, there was a gradual drop in cod prices relative to both beef and herring during the

¹⁵⁰ Allaire, “Internal Norfish Report Two.”

¹⁵¹ Holm, “A Revolution in Fish Supplies.” (Unpublished).

study period. As cod prices decreased, and quantities increased, it would have supplemented diets, more so than herring. It is possible that the decreasing value of cod relative to herring in Paris was influenced by the largest influx of cod. Thus, the increasing volumes of cod being introduced to the market from the Newfoundland cod fisheries came with lowering prices. Prices were becoming less volatile in Paris too, as indicated by the coefficients of variation. Also, the ratio of the prices was becoming less volatile too. This indicates that markets for beef, herring and cod were becoming more stable over time, and that the relationship between them was also becoming more stable. This would indicate that the products were better positioned to substitute one another.

The case studies for quantities in particular locations display how markets in European were often coming with decreasing quantities of marine produce from east Atlantic fisheries. With larger quantities coming from the Newfoundland fisheries, as indicated by Holm's proposed supply increase,¹⁵² Newfoundland produce became an increasingly dominant and significant component of supply.

4.2. Market Levels

This section focuses on "market levels". The market levels refer to wholesale markets and prices paid by large institutions for consumption (i.e., large consumers). Understanding the price dynamics for these two different market levels explains pressures on supply chains, which in turn indicate if markets were under pressure. Information for two market levels is available for Amsterdam with wholesale prices for the Amsterdam Exchange and prices paid by hospitals falling into a later and final stage in the supply chain. For France, prices from Bordeaux represent the wholesale market, while the prices for Paris represent a later point in the market with produce bought for consumption rather than resale.

4.2.1. Amsterdam - The Exchange and Large Institutions

The available price information for Amsterdam provides the clearest example of the operation of distinct price levels, with products sold at the wholesale market as well as later stages for consumption. For example, stockfish and herring were sold wholesale at the Amsterdam Exchange and were also sold in the large institutions. Although there is no clear

¹⁵² Holm, "A Revolution in Fish Supplies." (Unpublished).

evidence that these products were not traded directly from the wholesale market directly to these large institutions, we can infer that they were certainly part of distinct market levels, in which it is thus expected that prices from the wholesale market will be lower in the period for which both overlap, though with some potential commonality in trends observed between levels.

Figure 4.14 (below) thus shows the prices of wholesale herring (blue) and herring sold at St. Bartholomew's Hospital in Utrecht (red). They share an overlap of around 50 years beginning in 1628 and continuing to 1677. In both cases the prices are shown in grams of silver per kilogram of produce. With the available data, it is difficult to state with much certainty if the prices shared common movements in that time. As for the average price, it appears as expected that the wholesale prices were the cheap of the two. Over the periods that prices were available, this was 0.79Ag/kg and 0.86Ag/kg respectively. It is a more precise comparison to limit the range of values to the period the series overlap. In this case, the average for the wholesale market was 0.74gAg/kg while the prices at the hospital were closer to 1.28Ag/kg. This leads to a larger price difference between the two series, that is a 73% increase in prices between the market levels.

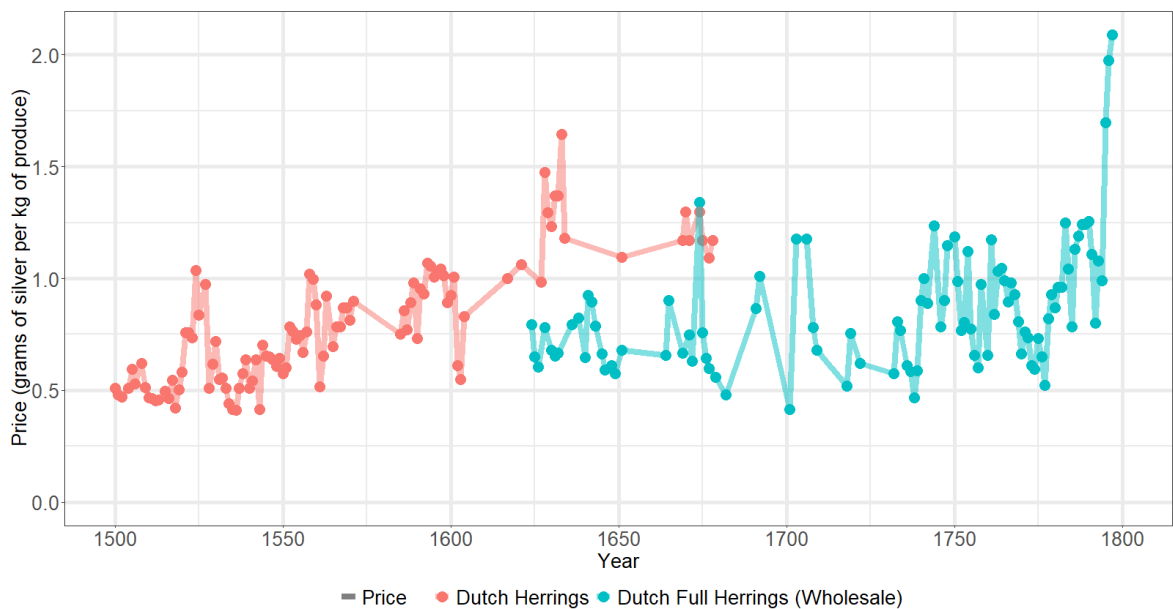


Figure 4.14. Dutch Herring prices at two market levels.

Figure 4.15 (below) shows the ratio of these two series (red dots), available for the period from 1628 to 1677. For most years, either one or both values are not available, thus the ratio cannot be computed. The blue trendline is indicative of the long-term prices changes

that occurred.¹⁵³ A value of 1 would indicate price parity between both series, whereas a value of 2 would indicate that herring sold in the hospital was twice the price of the wholesale equivalent. What we observe is an approximate average value of 1.5 over the whole period, implying the prices paid for herring were on average 50% higher than what was paid at the wholesale market. Values almost never fall below one, apart from on one occasion in 1674. The evidence thus confirms that herring did increase in price between the wholesale level and what was paid by the hospital. This increase varied slightly between one to over two, possibly reflective of the cost and profit structure prevailing for all the levels between those two market stages. Higher values occur in years when there was a larger difference in price between the two market levels. When the values are higher, customers in the large institutions were willing to, or needed to, pay a larger premium for herring. This indicates a pressure on the market, one that ultimately increased costs for the consumer. There are different scenarios that could cause this type of pressure, but it indicates that the market would have been under some stress when the ratio is higher. Conversely, when the ratio was lower, this suggests that the customers were paying less of a premium on prices that were paid at the wholesale markets. The ratio tended to be between 1.5 and slightly over 2 during the period from the 1620s to the 1670s shown below. It dropped though during the 1670s, reading price parity at one stage. This is quite likely to have been influenced by the Third Anglo-Dutch War (1672 to 1674), however, conflict-related influences will be discussed in more detail from Chapter 6 onwards. Price parity suggests that there was no premium paid by consumers at that time. This seems unlikely, though it is possible to hypothesise that the hospitals were able to negotiate low prices for reasons such as produce was of low quality.

¹⁵³ This is a “loess” trendline, calculated in R.

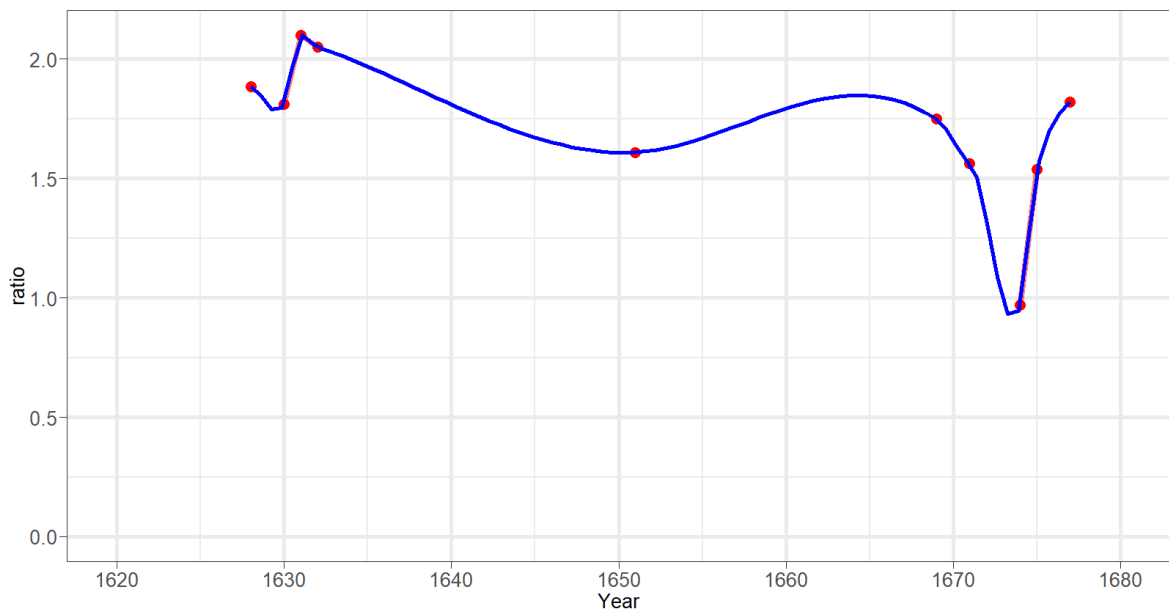


Figure 4.15. Ratio of herring prices in Amsterdam for herring at two market levels. The blue line is a “loess” fitted curve, which is used to estimate long term trends. The number of data points (i.e., red dots) is more sparse than earlier series, due to the necessity to have a value from both series to calculate a ratio value.

Figure 4.16 (below) shows stockfish prices, again for both the Amsterdam Exchange and St. Bartholomew’s Hospital, Utrecht. These series share a longer overlap, covering over 150 years of the study period from 1643 to 1795. Observed wholesale prices fell between 1-2Ag/kg for much of this time and including when they overlap with the other series. On the other hand, the prices in St. Bartholomew’s hospital ranged between 3-5Ag/kg and similarly this was the case on the period of overlap. Thus, prices may have doubled or tripled between these market levels, a much larger increase than observed for the herring.

The two cod price series display similar long-term trends, though limitations on the data availability make it difficult to be certain of this. The prices in the hospitals are experiencing a long-term increase. The wholesale prices display far more variation in the prices but maintain a similar long-term average until 1700. From 1700 they began to dip, halving in value. From around 1730 they began to increase again up to around 1750, hitting a value similar to the early 1700s again.

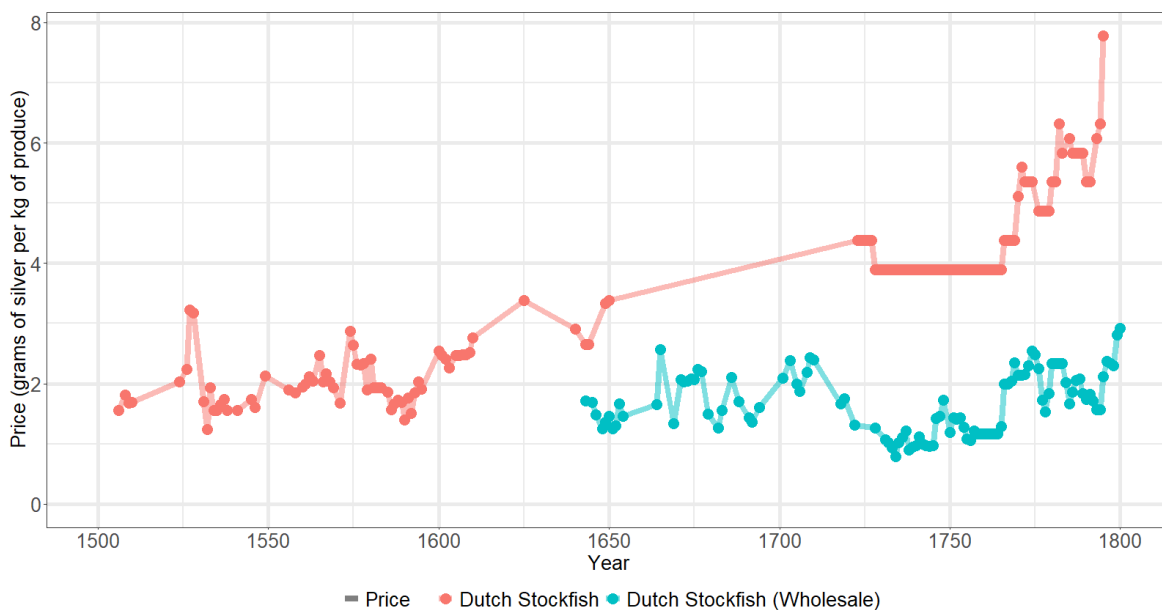


Figure 4.16. Dutch stockfish prices at two market levels.

Figure 4.17 (below) presents the ratio for the wholesale stockfish prices to those for St. Bartholomew's. Between 1650 and the early 1700s the ratio ranged between 2 and 3, but increased rapidly into the 1730s, peaking almost at 5, before dropping to a minimum of near 2 in the late 1740s. A recovery to values above 3 can be seen in the 1750s and 1760s, before a further plummet to below 2 in the late 1760s, and then a final longer-term increase until the end of the period. The dramatic price differentials that register through jumps in the wholesale to hospital price ratio, in which we see hospital prices varying from 1.5 to 5 times the price of wholesale cod suggests considerable instability in the markets. The jump from approximately 3 to 5 between the 1720s and 1730s is particularly notable, possibly indicative of problems in Amsterdam, such as those discussed in Section 4.1.4 and in Poulsen's analysis of the Dutch herring.¹⁵⁴ The multiple periods of increased price differences suggest that markets in Amsterdam and the surrounding regions experienced increased costs of moving produce from the wholesale end of the market to the consumer end.

The wholesale prices are more variable than those paid by St. Bartholomew's. This might be reasonable to expect, with more activity at the wholesale end, compared to the likes of contracts at the retail end for the larger institutions.

¹⁵⁴ Poulsen, *Dutch Herring*, 224-32.

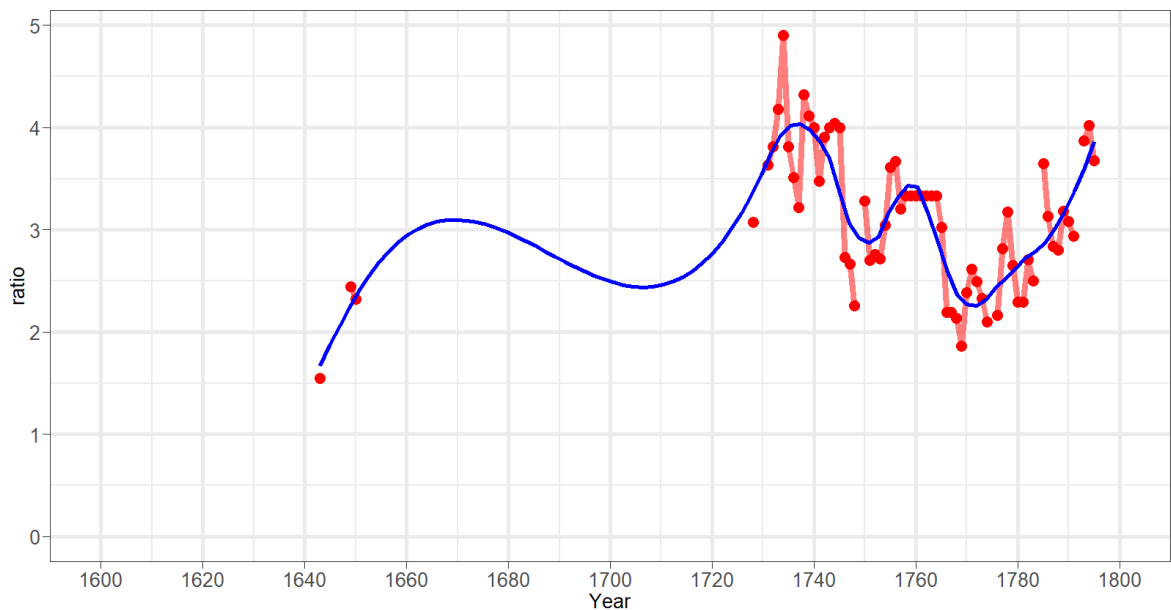


Figure 4.17. Ratio of stockfish prices. At St. Bartholomew’s Hospital in Utrecht compared to the wholesale prices from the Amsterdam Exchange.

Commodity Substitution between Cod and Herring

Cod and herring commodities were suitable dietary substitutes. The fresh, unprocessed products contained similar levels of nutrition (See Section 3.1). Thus, the commodity with the lower price acted as a cheaper source of nutrition. Stockfish, though, was a dried product, weighing around a quarter of its original weight after the removal of water.¹⁵⁵ As a result, stockfish was a denser source of nutrition (such as protein, calories, and fat) than herring. Thus, the price ratios based on a common kilogram of produce are not a direct indicator of the price of the nutrition the commodity provided but change of the ratio over time remains an indicator of whether commodity substitution is likely to have increased or not.

The wholesale prices for cod and herring do overlap for a significant period of time; thus, they are studied in more detail than the prices at St. Bartholomew’s hospital, for which there is less overlap. The ratio of the two wholesale price series is shown below in Figure 4.18. In the 1640s and 1650s, the ratio varied from almost 2 to 2.5, thus stockfish was more expensive than herring for a given weight, reflective of its greater nutritional density. The ratio thereafter began to display quite a large variance in values, ranging from less than 1.5

¹⁵⁵ The stockfish most likely originated from Norway or Iceland. As this was not the type of cod produce returned from Newfoundland.

in the 1690s to over 5 at the start of the 1700s, for example. The highest value occurred in 1701. Overall, by the 1710s, a long-term decrease began, as indicated by the spline, and bottomed out in the 1740s. Starting in the 1760s with a peak in the 1770s, we see a steady climb in the ratio, but one that is soon reversed and by the 1790s, the price difference was returning to parity for a given weight. The Fourth Anglo-Dutch War (1781 to 1784) is likely to have been related to the large change in price ratio. Such events will be further discussed from Chapter 6 onwards. During these periods when the lower ratio prevailed, the stockfish would have been a cheaper source of nutrition than herring, when considering its greater density in protein than the herring product. At times when the ratio was higher, purchasers may have made a more complex decision, judging prices versus weight and relative nutritional density, even if not fully conscious of modern-day nutritional values.

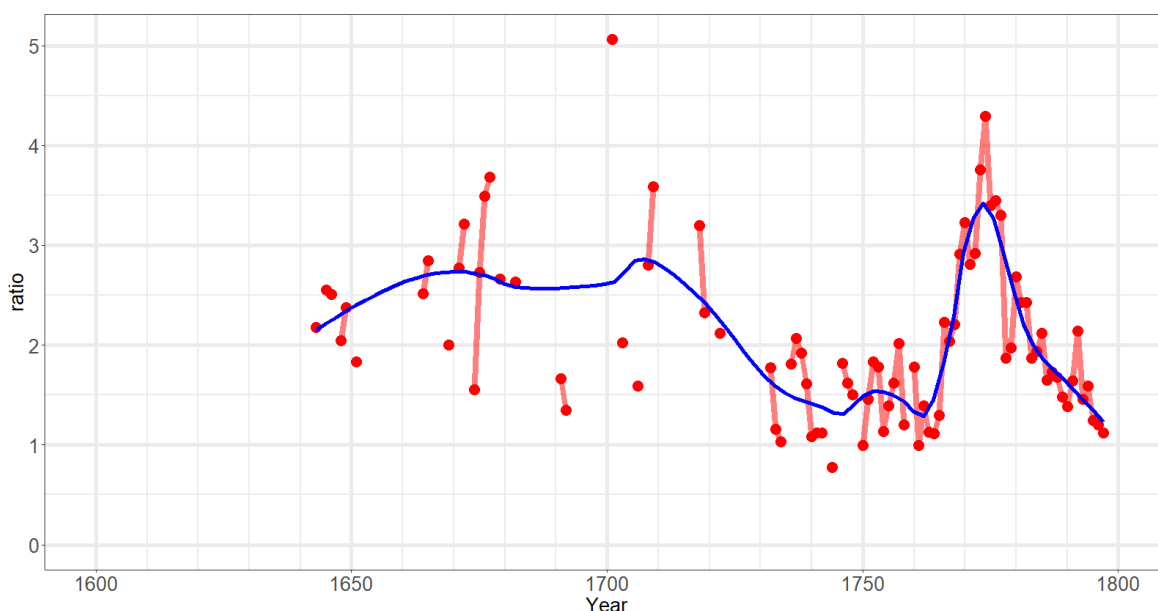


Figure 4.18. Ratio of stockfish compared to herring prices on wholesale markets in Amsterdam.

4.2.2. France - Bordeaux and Paris

Prices available from the port city of Bordeaux are for the wholesale market, while the prices for the inland city of Paris are for wealthy nobles and, thus, for another end of the market.¹⁵⁶ Price information is not at present available for the various levels from wholesale markets to prices paid by direct consumers. Research from the NorFish project has hypothesised eight price levels for the French market that could have existed between

¹⁵⁶ Allaire, "Internal Norfish Report Two," 8.

these two levels. The eight levels hypothesised in the internal report are 1) Anticipated sale by fishers before fishing season, 2) Fish purchased after arrival from Newfoundland, 3) Price per unit (ounce) on the market, 4) Between local merchants, 5) By hinterland merchant, 6) Between hinterland merchants and fishmongers, 7) Paid by the average client at the fishmonger stall, and 8) Paid by rich hinterland client.

The earlier levels are the price fishers anticipated before the start of the fishing season, while the later levels prices are based on contracts agreed for the purchase of fish by representatives of wealthy nobles in Paris. Each of these levels incurred further costs: production, transportation, wholesale to retail, branding/marketing, retail to local fishmongers and fishmongers to customers. The differential in prices is thus largely due to additional costs incurred by sellers at each level, including profits made (or maybe losses in bad deals). The vessel, gear, wages, and insurance are the most significant production costs, while transportation costs (or retail onshore/import costs) are also important, for example, overland transportation from Bordeaux to Paris. Other costs included branding/marketing and procurement mark-up by local/Parisian Fishmongers.

The large price difference between the Bordeaux wholesale market and prices paid by the wealthy in Paris is readily apparent for green cod. NorFish research has thus shown that for the period between 1533 and 1583 CE, based on available price information, green cod in Bordeaux was sold wholesale by fishers in the range of 11 to 19 denier per cod, while in Paris the price paid by wealthy nobles was in the range of 180 to 240 deniers per cod. This was a 12-fold increase in prices, which was larger than observed in Amsterdam and the surrounding region.¹⁵⁷ However, direct comparison is difficult with the case of Amsterdam, because the prices paid at the Amsterdam Exchange were at a later level. Possessing these earlier stages of wholesale pricing (for Bordeaux or anywhere) is quite rare, in particular “the anticipated sale price by fishers before fishing season”, as Allaire puts it.

Paris - Independent egg prices from Allaire and Hauser

Not all commodities that were sold at wholesale markets varied significantly in price from what was paid by the wealthy nobles, however. A case in point is the prices paid for eggs, available from both Allaire and Hauser (introduced in Chapter 2). This case also gives the

¹⁵⁷ Ibid, 7. These prices are calculated to the common unit of one cod.

opportunity to compare two different market levels again, with Allaire’s prices for wealthy nobles and Hauser’s for the wholesale market, and both for Paris. It is also useful to have independently sourced information from two different authors for the same location and commodity.

Figure 4.19 (below) displays the information from Allaire (red), and the prices from Hauser (blue).¹⁵⁸ Allaire’s data run from 1538 to 1756, while Hauser’s data run from 1505 to 1685, with both thus overlapping from 1536 to 1685. Notably, at the beginning and end of this overlap period, the prices are almost at parity. Thus, in this case, there appears to be no premium paid for purchasing at the later market stage. This can likely be explained by self-preservative properties of eggs, relative to fish products that must be actively preserved to survive long transportation times in edible form. Unlike marine fish products coming into Paris from considerable distances, eggs can also be produced more locally, thus keeping the price increase between the market levels much lower. Also, if and when bought in bulk (readily possible for noble houses), they may have been sold at a price more akin to that seen in the wholesale market.

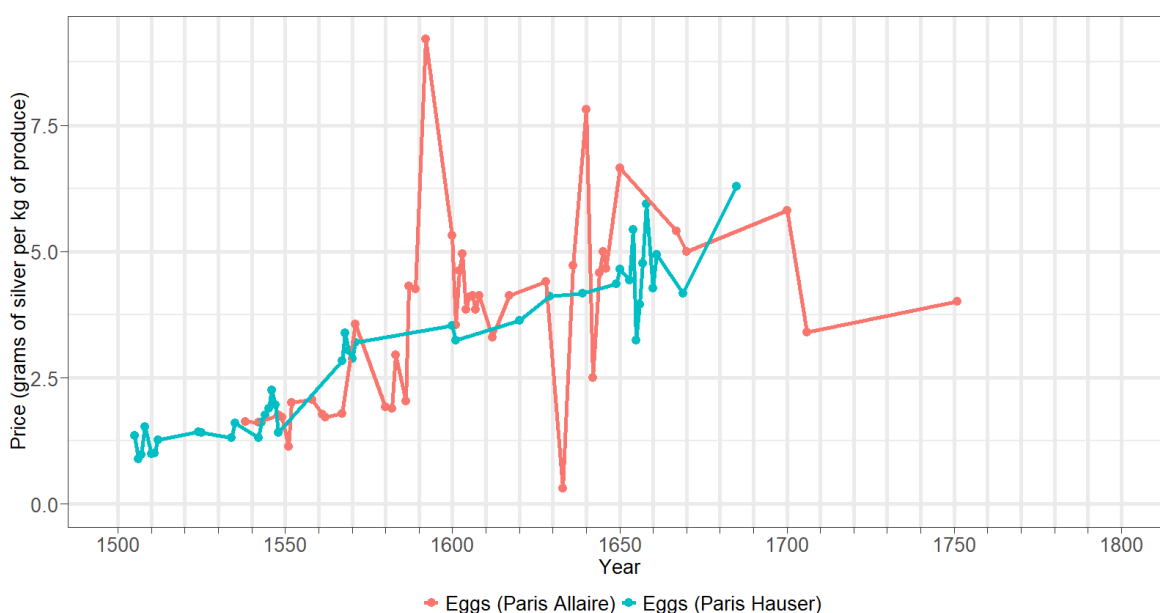


Figure 4.19. Prices for eggs sold in Paris. Two different sources, one representing the wholesale market and the other prices paid by wealthy nobles.

¹⁵⁸ See Section 2.1.3. Also, Allaire, “Internal Report One”; Henri Hauser. *Recherches et Documents sur l’histoire des prix en France depuis 1500 à 1800* (Paris, Les Presses Modernes: 1936), 135-8.

Next, the ratios of the prices from Allaire (i.e., those for the wealthy nobles) to those from Hauser (i.e., the wholesale market) are presented in Figure 4.20 (below). From the 1540s to 1570s, price levels were similar, and both exhibited an upward trend. This changed though for a short period by the end of the 1500s, with the wealthy paying substantially more than the wholesale market (this can be seen in both the ratios and the individual prices (Figure 4.19 and Figure 4.20). This may have been influenced by the Siege of Paris, which occurred in 1590 (see Section 4.1.1 for more information), when prices rose significantly in Allaire's price collection with a peak in 1592. This suggests it may have been more complex, or risky, to supply these wealthy nobles, possible due to tensions after the Siege of Paris. Or the entire supply chain was under pressure. The prices paid by the nobility soon dropped back to those nearer the wholesale for the opening decades of the seventeenth century, and both series diverged in price again by the 1650s, raising to almost the same level as seen around the Siege of Paris.

It is possible that the lower volatility of the wholesale price series arises as a consequence of missing data, however, the broad trend toward higher values in both series are nonetheless fairly well represented in Figure 4.19. Missing data may affect the ratios calculated for Figure 4.20 more acutely, given that the calculation of these values requires coincident data in each year, such that less data points are available overall. But again, the broad trends are reasonably clear, with the prices paid by nobles usually higher than the wholesale market, if not so dramatic as the differences observed in previous sections.

The stockfish and the eggs had a similar value for much of the study period. Thus, both products were relatively expensive, when compared to herring. In summary, eggs do not show the same dramatic price changes between the wholesale level up to prices paid by the wealthy as the marine fish produce. This is likely due to more complexes in transport, sourcing and supplying them.

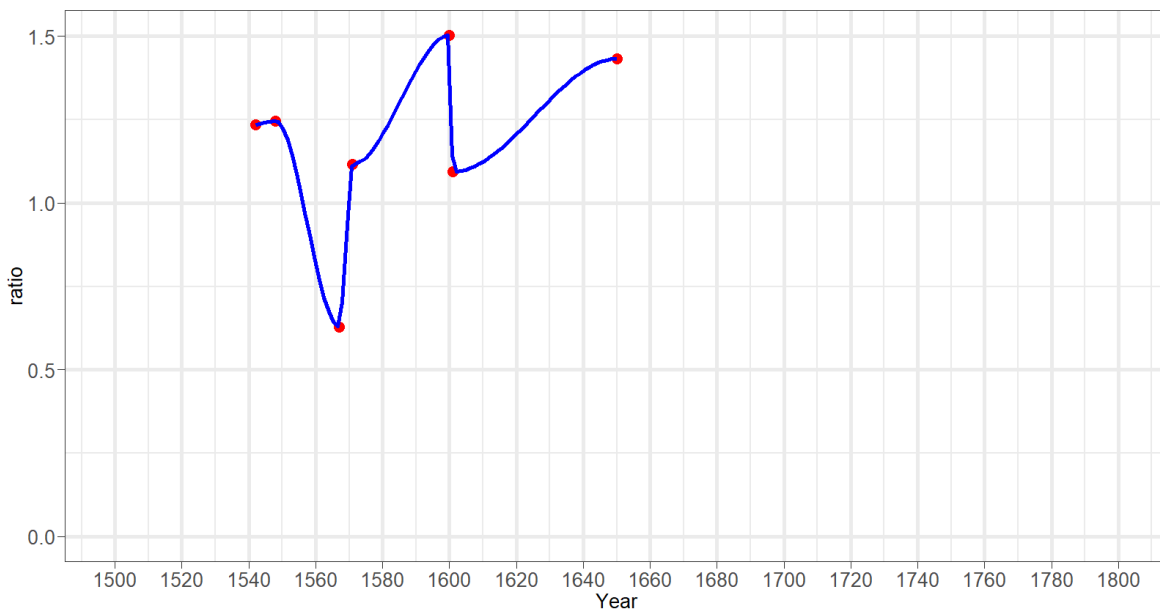


Figure 4.20. Ratio of egg prices in Paris. Two different sources (prices paid by the wealthy compared to the wholesale market).

4.2.3. Conclusions

Wholesale market levels often came with lower prices than the later levels. This is unsurprising as additional costs will be associated with each level of the supply chain. Wholesale prices may be showing more price variability too, though this is not certain due to insufficient data. One instance did occur for Dutch stockfish (Figure 4.16) from the 1720s to the 1760s, when the Dutch prices remained the same for a time while the wholesale prices continued to change. It is possible that this was due to agreements or contracts to maintain the same price for a period, however, this is not clear from the sources.¹⁵⁹ Thus, if this was the case for more examples, the greater exposure of this level to vagaries of catch or production most likely contributed to high price variability for the wholesale markets. Whereas variability in later levels may have been somewhat smoothed by stored supplies, or expectations and obligations to supply within certain price ranges or indeed at specific individual price points. A specific relevant example of this is evident for stockfish prices paid by St. Bartholomew's hospital, based on fixed-price contracts and supply agreements that sometimes lasted multiple years (Figure 4.16).

¹⁵⁹ Posthumus, vol. 2, 335.

The periods of larger price difference between the levels indicate times when the market, for the given locations studied, was under some sort of strain or pressure. This can be accredited to supply shortages, spikes in demand, or difficulties in the supply chain due to conflict and politics.

4.3. Conclusions

The changes in relative value (based on prices and price ratios) and shifts in the quantities of produce available suggest that commodity substitution was occurring, and diets were being supplemented by differing availability of marine produce. Holm's forthcoming study of total cod and herring extractions in Europe shows these total quantities increased.¹⁶⁰ The increasing supplies of cod returning from the Grand Banks of Newfoundland supplemented marine fish supplies, such as herring. For example, in the case of Paris, increased quantities of cod may have contributed to the decreasing value of cod relative to herring. Though this does not explain what was happening in other European locations, which will be explored in Chapter 5. Quantities of cod and herring did not increase in all locations, and as discussed in Section 4.1.5, evidence suggests that there were larger quantities of fish arriving from the west Atlantic, while eastern Atlantic fishing grounds were becoming less common as the source. The likes of the Dutch herring and English cod and herring quantities are examples that indicate decreasing supplies of these marine fish in that time. Thus, the extent that marine fish produce was replacing one another or products such as beef varied between regions.

Remaining with the case study of Paris, coefficients of variation (CV)s increased in the mid-1600s, indicative of a period of less integration in that time. The lower availability of price information that follows, though, leaves it unclear what occurred for the remainder of the 17th century and the 18th century. CVs were also applied to "ratios" of prices, this indicated cod produce became increasingly "co-integrated" with herring and beef, meaning cod increasingly shared similar price change with both commodities. Thus, indicating they were increasingly well suited to substitute for one another.

Prices were different between market levels, as were their dynamics. The wholesale levels display lower prices than the later levels. This is expected as cost will be associated with

¹⁶⁰ Holm, "A Revolution in Fish Supplies."

each level of the supply chain, increasing with distance from the wholesale market. There is limited evidence that wholesale prices show more price variability than prices at the later stages. In some cases, prices at later market levels were based on contracts and supply agreements that lasted terms spanning a number of years, thus causing the price variability to be lower. It is possible that the periods of larger price differences between the levels indicate times when the market, and thus the location, was under strain or pressure. Possibly this would have been due to supply shortages, high demand, or difficulties due to conflicts and politics.

5. Price Dynamics

Understanding levels of market integration can be achieved by studying commodities prices. Price changes over time and differences between locations relate to levels of market integration, with larger price differences indicating the possibility of less integration. Long-term price changes and groupings, based on 50-year periods of time, signal gradual change over the study period, (these are studied in Section 5.1). Comparing these 50-year groupings for different locations highlights both common features and when they diverged. The magnitude of the price differences between locations indicates the directions trade may have occurred and the level of costs due to the likes of transport, levies, and taxes. The regional price variations also highlight the extent to which market integration differed depending on geographical location.

To analyse market integration on a shorter term (i.e., decadal) basis, Section 5.2 focuses on decadal price averages and Coefficients of Variation (CV)s measured on a decadal scale. Decadal price averages provide a view of medium-term change, they also expose change in relative value between locations and different commodities. The CVs demonstrate the level of price volatility in each decade, thus indicating the extent of market integration and its evolution between each decade.

5.1. Long-Term Price Changes

Long-term price changes and differences between locations indicate degrees of market integration and commodity substitution. They also identify possible trade routes. These price changes and differences are analysed in this section through case studies of herring and cod. Beef and grain prices are included for comparison.

Price differences between locations indicate the possible directions in which transport occurred, and the costs associated with such transportation. Since trade routes are not known precisely for the products that the price series in this analysis represent, hypothetical routes are described. Trade routes were necessary for market integration to have occurred. Without trade or communication between locations, the concept of market integration would have been meaningless. For herring, a trade route diagram introduced later indicates possible movements of produce, including price information for each

location to aid in tracing price differences. In the case of cod, a diagram is also provided, though more emphasis is placed on the products, rather than the trade routes.

It is crucial to understand the market level that each price series represented (see Chapter 3.2 for further discussion of market levels). It may often be the case that wholesale prices for each location are preferable to study. This earlier market level incurred less costs than the levels that followed (such as prices paid by consumers), with further costs incurred between each level. Thus, comparing wholesale prices between regions represents the costs associated with transport from one wholesale market to another and should include a less complex set of assumptions (for example, contracts and dynamics of supply and demand) than later market levels that have incurred further costs. Wholesale price information is not always available, however, and prices paid at later market levels are studied by necessity in such instances. Comparisons based on these later market levels are more complex as products sold here incurred more costs than their wholesale counterparts. The benefit of studying these prices is that they indicate the relative value of a commodity in different locations, as well as degrees of commodity substitution and market integration.

The following analyses are based upon the price series introduced in Chapter 2, and the common price unit of grams of silver per kilogram of produce is again applied. Each series is summarised with an average price for each 50-year period within the study period. These averages are a long-term measure of price behaviour; they also decrease the influence of short-term and medium-term variation, such as individual years with relatively large or small values. Further, the groupings decrease problems caused by years for which price information is not available. Fifty-year groupings have been similarly applied by scholars such as Victoria Bateman, in her wheat-based study of the evolution of markets in early modern Europe.¹⁶¹

¹⁶¹ Victoria Bateman. "The Evolution of Markets in Early Modern Europe, 1350–1800: A Study of Wheat Prices," *The Economic History Review* 64, no. 2 (2011).

5.1.1. Herring

The 50-year price averages for herring are shown below (Table 5.1), summarising prices for Amsterdam, Antwerp, Barcelona, Frankfurt, Gdańsk, Munich, Nuremberg, Paris, Southern England, Stockholm, and Vienna.

Table 5.1. Herring prices for 50-year periods. Covering a selection of locations in eastern, southern, northern and central Europe. Ordered from lowest price to highest from the first half of the 1600s. “N” represents the number of years with price information in each 50-year grouping.

Commodity	1500-1549	1550-1599	1600-1649	1650-1699	1700-1749	1750-1799
Herring (Southern England)	0.18 (n = 36)	0.27 (n = 43)	0.37 (n = 43)	0.42 (n = 27)	0.46 (n = 3)	
Herring (Munich)	0.35 (n = 13)	0.49 (n = 36)	0.50 (n = 21)			
Herring (Barcelona)	0.52 (n = 7)	0.76 (n = 6)	0.67 (n = 28)	0.72 (n = 44)	0.56 (n = 34)	0.56 (n = 24)
Dutch Herring (Wholesale)			0.71 (n = 17)	0.75 (n = 14)	0.79 (n = 22)	0.98 (n = 47)
Herring (Nuremberg)	0.31 (n = 36)	0.45 (n = 32)	0.73 (n = 18)			
Herring (Vienna) 01	0.40 (n = 8)	0.62 (n = 38)	0.93 (n = 27)	0.90 (n = 11)	0.78 (n = 34)	
Dutch Herrings	0.58 (n = 46)	0.84 (n = 36)	1.10 (n = 15)	1.18 (n = 8)		
Herring (Gdansk) 01	0.76 (n = 18)	0.74 (n = 42)	1.16 (n = 48)	1.21 (n = 45)	0.87 (n = 23)	0.64 (n = 35)
Herring (Stromming Stockholm)			1.76 (n = 16)	1.51 (n = 42)	2.13 (n = 20)	
Herring (Frankfurt)	0.75 (n = 11)	1.17 (n = 26)	2.54 (n = 13)	2.45 (n = 1)	2.15 (n = 6)	
Herring (Antwerp)	0.99 (n = 50)	2.00 (n = 50)	2.85 (n = 1)			
Herring (Paris Allaire)	2.37 (n = 2)	3.06 (n = 15)	3.38 (n = 18)	3.99 (n = 2)	2.99 (n = 3)	2.78 (n = 1)
Herring (Sill Stockholm Series 01)			3.53 (n = 14)	3.32 (n = 41)	3.99 (n = 20)	
Herring (Sill Stockholm Series 02)					3.80 (n = 27)	

Over the entire period and all regions, the 50-year price averages vary from a lowest value of 0.18 grams of silver per kilogram of produce, which occurred in Southern England in the first half of the 1500s, to and a maximum of 3.99 grams of silver per kilogram of produce, occurring in Paris in the 1650s and Stockholm in the first half of the 1700s. Thus, prices varied by a maximum multiple of over 22 (i.e., the ratio from smallest to largest 50-year price averages), this across all regions and 50-year periods. This could be perceived as a large difference, with herring costing at its greatest differential up to 22 times more depending on the period and location it was purchased in. Many factors influenced this difference, including inflationary change over time and regional variations. In part, the price difference was also due to the regional variation. For example, the price difference between Southern England and Stockholm was most likely influenced by proximity to production sites, with Southern England being closer to production sites in the North Sea, and hence the produce sold in Stockholm may have incurred greater cost due to the produce traveling further from the North Sea. The price differences are also influenced by the market level that the prices represent, i.e., the wholesale markets and consumer

markets. For example, in Paris the prices represent a higher-priced market that was based on contracts agreed for the supply of food to wealthy nobles. Evidence suggests that herring prices increased more than ten-fold between what was paid at the wholesale markets in Bordeaux and what was paid by these wealthy customers in Paris.¹⁶²

To give an indication of the average price for herring in Europe during the early modern period, the midpoint of maximum and minimum prices values is 2.084 grams of silver per kilogram of produce. Based on the available price series, this is indicative of an average price of a kilogram of herring over the study period and across market levels.

2.084gAg per kg of Herring.

Prices did change over time, often following similar long-term trends between regions and products. Inflation over the study period caused a gradual long-term price increase, most of which occurred during the Price Revolution from 1500 to the early 1600s, at around 1-2% per year. Following the Price Revolution, the long-term price trend tended to stay stable or deflate slightly until the end of the 1600s. A divergence between price series is more common in the 1700s. The evolution of the 50-year prices over time represents long-term change. Changes *between* each 50-year average are also of interest and are summarised below (Table 5.2). By comparing these changes for each location, it identifies diverging trends, in turn indicating the evolving price differences between locations.

Beginning with movements from the first half of the 1500s to the 1550s and through to the first half of the 1600s, 50-year price averages increased in almost all locations. These periods are thus characterised by the price increases expected of the Price Revolution. There are a limited number of exceptions, specifically Barcelona and Gdańsk, that show decreasing prices. Between both halves of the 1600s, however, prices began to decrease in more locations, specifically Vienna, Stockholm, and Antwerp. This trend toward decreasing prices is even more prominent between the second half of the 1600s and the first half of the 1700s, when prices in most regions are by this point decreasing (London, Amsterdam and Stockholm being the only exceptions in displaying increasing prices, though the London increase is quite modest at 0.035). Finally, between both halves of the 1700s, although less

¹⁶² Allaire, "Internal Norfish Report Two."

information is available, however, a divergence became more apparent, as prices increased in Amsterdam and Barcelona, and decreased in Gdańsk and Paris.

Table 5.2. Herring prices differences/changes between each 50-year period.

variable	From 1500 to 1550	From 1550 to 1600	From 1600 to 1650	From 1650 to 1700	From 1700 to 1750
Herring (Southern England)	0.09	0.098	0.055	0.035	
Herring (Munich)	0.14	0.017			
Herring (Barcelona)	0.24	-0.094	0.055	-0.163	0.0045
Dutch Herring (Wholesale)			0.038	0.037	0.1867
Herring (Nuremberg)	0.14	0.275			
Herring (Vienna) 01	0.22	0.310	-0.033	-0.121	
Dutch Herrings	0.26	0.260	0.080		
Herring (Gdansk) 01	-0.02	0.425	0.044	-0.335	-0.2356
Herring (Stromming Stockholm)			-0.256	0.618	
Herring (Frankfurt)	0.42	1.368	-0.092	-0.298	
Herring (Antwerp)	1.01	0.845			
Herring (Paris Allaire)	0.69	0.313	0.613	-0.998	-0.2068
Herring (Sill Stockholm Series 01)			-0.207	0.669	
Herring (Sill Stockholm Series 02)					

On the longer term, price differences between regions were, in summary, gradually increasing in the 1500s and moving into the 1600s. This was largely due to an inflationary trend associated with the Price Revolution that was similar over most price series. This changed during the 1600s, however, with the price series no longer all following the same trajectory, and some starting to display a long-term price decrease. In the 1700s, this divergence became more apparent, in the absence of the Price Revolution's regular trend in increasing prices amongst most commodities.

Large Producers: The Dutch and English

Both the Dutch and English were nations heavily involved in herring fishing.¹⁶³ The Dutch produced what was considered a high-quality herring product, while the English produce may have been a lower-priced "red herring" commodity in some instances.¹⁶⁴ The possible trade routes for the Dutch are discussed in more detail due to a larger amount of information being available for them.

¹⁶³ Poulsen, *Dutch herring*.

¹⁶⁴ *Ibid*, 71.

Southern England

In the case of price information for Southern England, much of the herring information derives from prominent locations such as Cambridge (see Section 2.1.3). Cambridge was part of East Anglia, thus it is quite likely herring sold there came from the nearby ports of East Yarmouth (see Chapter 3.1). Table 5.3, below, presents the 50-year average prices in Southern England for herring, salted cod, stockfish, beef, and wheat. This allows a comparison of prices for these different products. Herring was the lowest priced commodity consistently for each 50-year period. The prices for herring range from 0.18 to 0.46 grams of silver per kilogram, gradually increasing over each successive 50-year period.

Table 5.3. Southern England prices with 50-year averages for fish products. (Herring, salted cod and stockfish) and wheat and beef for comparison.

Commodity	1500-1549	1550-1599	1600-1649	1650-1699	1700-1749	1750-1799
Herring (Southern England)	0.18 (n = 36)	0.27 (n = 43)	0.37 (n = 43)	0.42 (n = 27)	0.46 (n = 3)	
Wheat (Southern England)	0.19 (n = 50)	0.41 (n = 50)	0.79 (n = 50)	0.82 (n = 50)	0.63 (n = 50)	0.91 (n = 50)
Beef (Southern England)	0.76 (n = 50)	1.45 (n = 50)	2.42 (n = 50)	3.04 (n = 50)	3.12 (n = 50)	4.37 (n = 50)
Salted Cod (Southern England)				6.24 (n = 27)	6.79 (n = 50)	5.57 (n = 9)
Stockfish (Southern England)	1.73 (n = 42)	2.05 (n = 20)				

In comparison to herring, stockfish prices are available for a shorter period, that is the 1500s; they were approximately ten times the price for herring per kilogram of produce. Salted cod prices are available later in the study period, i.e., from 1650 to 1750, and commanded even more of a price premium, at around 15 times that of herring. Thus, throughout the period, herring was priced substantially lower per kilogram of produce.

In part, the price difference is explained by the nutritional content of the foods. As an alternative to prices based on a kilogram of produce, an inspection of the number of calories of protein that the respective products contained is instructive. The flesh of herring and cod provide similar levels of nutrition in their raw states, for nutrients such as fat, calories, and protein. This flesh of both is approximately one fifth to about one quarter protein when in its raw state (see Section 3.1).¹⁶⁵ Not all marine fish products were sold in this form, however, and stockfish was a dried product, for example. Peter Pope estimated a weight ratio of wet to dry fish of 1:4.9.¹⁶⁶ Thus, a dried fish such as the stockfish may have

¹⁶⁵ Hayes, *Naval Diets*, 203.

¹⁶⁶ Peter Pope. "Early Estimates: Assessment of Catches in the Newfoundland Cod Fishery, 1660-1690," *Marine Resources and Human Societies in the North Atlantic Since 1500* (1995), 36, Note 7.

been approximately five times as dense with nutrients such as protein and fat. In this scenario, the price premium of 10 or 15 decreases to 2 or 3 times the price (i.e., 10/5 and 15/5) when based on the prices per gram of protein. In more detail, stockfish is around 15 times as expensive as herring when considering weight alone, but the stockfish contains in the region of five times as much protein as herring, leading to stockfish being instead valued at three times that of herring per gram of protein.

Beef prices for the 50-year periods were consistently positioned between cod and herring products and ranged from 0.76 to 4.37 grams of silver per kilogram of produce. Beef was four times the price of herring per kilogram of produce in the first half of the 1500s, increasing over the study period. Thus, this ratio increased to approximately seven by the 1600s and stayed around that level until at least the early 1700s, before information was no longer available for both products. Thus, beef came with a price premium when compared to herring, one that was not influenced significantly by protein content. Further, beef continued to become more expensive relative to herring during the 18th century, continuing a trend of herring also being a lower-priced protein alternative to beef.

Wheat was a particularly important commodity during the study period and has thus been extensively studied as such.¹⁶⁷ Thus, comparing herring prices to this staple food explains the relative market importance of herring. To begin, it can be noted that wheat was the second lowest priced of the four products considered here, being only slightly more expensive than herring (for example, it was just 5.9% more expensive in the first 50-year period). This is based on prices in grams of silver per kilogram of respective produce. Thus, herring and wheat began the period sharing similar prices based on this measure of value. Their relative value shifted significantly over time, however, with the wheat prices almost doubling that of herring in the second half of the 1650s (93.7% premium). This difference became less marked during the first half of the 1700s, declining to a 38.4% difference. Wheat provided about half the amount of protein of beef and fish.¹⁶⁸ Thus, the price of an equivalent unit of protein from wheat was significantly more than that provided by herring. With herring coming cheaper relative to wheat, it offered food security as a lower-priced

¹⁶⁷ For example, Victoria Bateman. *Markets and Growth in Early Modern Europe* (Routledge, 2015); Abbott Payson Usher. "The General Course of Wheat Prices in France: 1350-1788," *The Review of Economic Statistics* (1930).

¹⁶⁸ Hayes, "Naval Diets," 203.

alternative, and therefore held potential as a commodity substitute. As wheat became progressively more expensive than herring, with this difference peaking in the period 1600-49 at double the price and remained more expensive thereafter (if not so dramatically), it is possible in locations such as hospitals and other institutions that wheat in diets was substituted or supplemented by herring.

Price series not only maintained a similar level of integration, but also a similar ability to substitute for one another. The degree of market integration in a location may have remained similar if the price differences between products remained similar over time. Prices in Figure 5.1 (below) are for Southern England. The prices have been again log-transformed to visually reduce the influence of a price divergence that occurs from inflation. A price difference grows between products if they are all experiencing inflation (based on the absolute values of the products, the relative values such as ratios and percentage difference would remain the same). This alone would not indicate a change in market integration for a price series. The log transformation of prices removes this effect. In other terms, the log transform allows easier identification of relative price differences, that is percentage premiums of one product compared to another. Thus, if the relative price difference remained similar, the graph displays a similar sized gap. In the case of Southern England, prices increase in nearly every instance between periods, the only exceptions being a decrease in wheat prices between 1650 to 1700 and salted cod from 1700 to 1750. Both herring and beef maintained a similar price difference (relative gap).

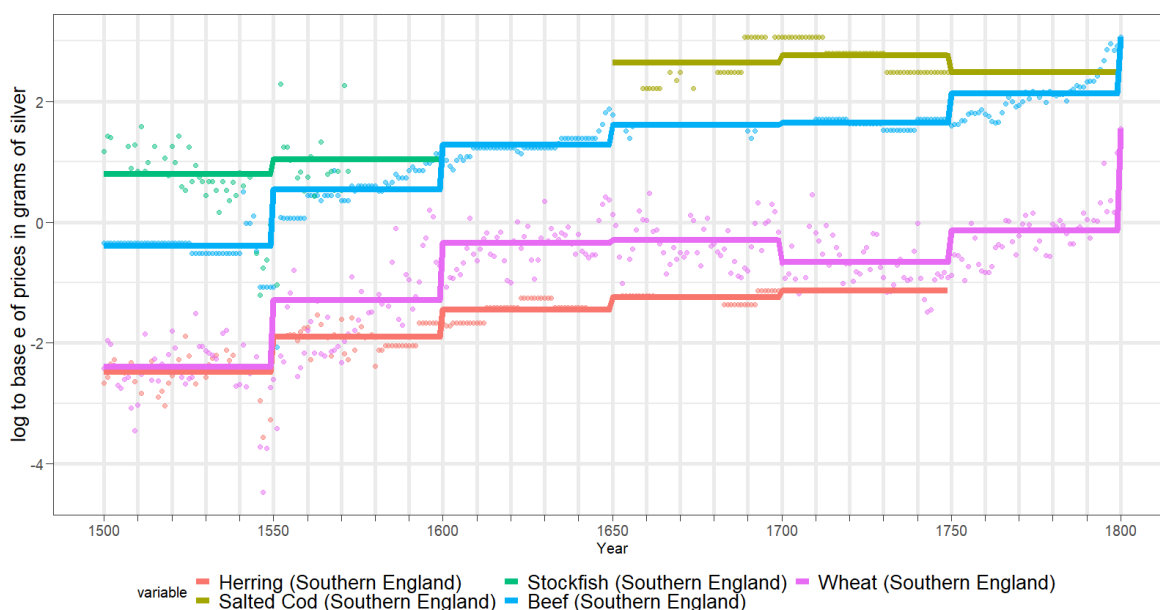


Figure 5.1. Southern England commodity prices over each 50-year period.

The price series that represent Southern England are in summary telling a story of different, but connected, product markets in that location. Herring and wheat were the cheaper commodities, wheat being a dietary staple, and both being established markets. Their relative values per kilogram diverged over the study period, with herring becoming progressively cheaper. This gradually increased the likelihood that herring supplemented diets for some as a commodity substitute for wheat. Beef was substantially more expensive than herring, and this differential increased over the study period. Thus, we may posit that this would have further increased the attractiveness of herring as a potential alternative to beef.

Amsterdam including Utrecht and Leiden

The well-established Dutch North Sea herring trade was the largest during the early modern period from the 16th century or earlier to the end of the 18th century.¹⁶⁹ The Dutch were a wealthy and powerful nation at this time, experiencing their so-called “Golden Age” beginning before, and continuing over the course of the 17th century.¹⁷⁰ Herring was sold wholesale at the Amsterdam Exchange, situated in Amsterdam itself. Non-wholesale prices (i.e., for consumers) have been derived from records from St. Bartholomew’s Hospital in Utrecht, while salted cod prices come from St Catherine’s hospital in Leiden. Both locations are approximately 35km outside of Amsterdam. Thus, transport costs must have been relatively low compared to those incurred for transport to other countries.

The distinction between market levels is important, as prices naturally differed between them. Costs increased between levels, from wholesale upward, due to the myriad of activities that occurred at each stage to facilitate their onward sale, including storage, marketing and processing the produce (see section 5.1.2 for an example of costs for cod). In the case of Amsterdam, herring prices were approximately 50% higher for consumers, represented by the hospitals in Utrecht and Leiden, than the wholesale market prices at the Amsterdam Exchange. This premium did not change dramatically over the study period.

¹⁶⁹ Poulsen, *Dutch Herring*, 43.

¹⁷⁰ Jonathan Irvine Israel. *The Dutch Republic: its rise, greatness, and fall, 1477-1806*. vol. 321 (Oxford: Clarendon Press, 1995).

Prices in both market levels¹⁷¹ increased gradually over each 50-year period, at a regular and quite uniform rate. They are amongst the most uniform herring price series of any included in this chapter. One series is available for the first two centuries of the study period and the other covers the last two. For each series, the increases between each 50-year period are regular, also the price gap between both series remains similar in each 50-year period. Thus, in the case of herring in Amsterdam, prices indicate that the pressures and dynamics between the two market levels did not change dramatically, and most likely maintained a similar level of integration between both levels.

The 50-year average prices for Amsterdam are shown below for herring as well as wheat, stockfish, meat, and salted cod (Table 5.4). Most of these products experienced similar trends of gradual increase in the long term. This suggests that the markets for these products were all quite stable, when shorter-term shocks are smoothed out by aggregating into 50-year periods (shorter-term variance is, however, also of interest, and is examined further in Section 7.4). Wheat (from non-wholesale markets) was the only product that behaved differently, (prices in the period 1500-49 will be ignored as they are substantially different than later periods.¹⁷²). For the period that prices overlap between 1500 and 1650, the non-wholesale herring prices are similar in the Netherlands. Wheat was to some degree more expensive per kilogram at the start with herring the more expensive by the end). This relationship between wheat and herring is not the same as that observed in Southern England, and this regional comparison will be studied later.

Table 5.4. 50-Year average prices in Grams of Silver per Kilogram of produce in Amsterdam. (Herring, stockfish, salted cod, meat, and wheat).

Commodity	1500-1549	1550-1599	1600-1649	1650-1699	1700-1749	1750-1799
Dutch Herring (Wholesale)			0.71 (n = 17)	0.75 (n = 14)	0.79 (n = 22)	0.98 (n = 47)
Dutch Wheat (Utrecht Non-Wholesale)	5.20 (n = 50)	0.76 (n = 47)	0.96 (n = 34)	0.81 (n = 34)	0.70 (n = 50)	0.94 (n = 49)
Dutch Herrings	0.58 (n = 46)	0.84 (n = 36)	1.10 (n = 15)	1.18 (n = 8)		
Dutch Stockfish (Wholesale)			1.50 (n = 5)	1.74 (n = 23)	1.41 (n = 29)	1.80 (n = 50)
Dutch Stockfish (Non-Wholesale)	1.87 (n = 20)	1.99 (n = 33)	2.65 (n = 15)	3.38 (n = 1)	3.98 (n = 27)	4.86 (n = 43)
Dutch Meat	0.97 (n = 7)	2.57 (n = 4)	3.19 (n = 41)	3.85 (n = 43)	3.86 (n = 50)	3.87 (n = 50)
Dutch Salted Cod (Non-Wholesale)	0.58 (n = 26)					

¹⁷¹ That is Dutch Herring Wholesale prices and “Dutch Herrings”, which came from St. Bartholomew’s Hospital in Utrecht.

¹⁷² The difference is quite large; thus, the prices (nominally the same) might well have been different types of wheat, but this is unclear.

Herring was lower priced than meat in this location also (both sets of prices from non-wholesale markets). Meat displayed higher rates of price increases than herring, thus increasing the price premium paid for meat compared to marine fish products.

Comparison of Dutch and English Herring Prices

Table 5.5 below presents average herring prices for both Southern England and Amsterdam in 50-year periods. Over both locations, these 50-year averages range from 0.18 to 0.93 grams of silver per kilogram of produce, and in absolute terms are quite different between locations. Herring prices in Southern England are substantially cheaper than in Amsterdam, indeed being even cheaper than the Amsterdam wholesale. This indicates that English produce was of lower quality than the Dutch herring. This is further supported by this English herring not being at wholesale prices, but rather prices paid in Cambridge at King’s College, (see Section 2.1.3). It is notable that wheat, an important staple food, displayed similar prices in both locations, even more so from 1650 to the end of the study period (See Table 5.3 and Table 5.4). Thus, the similar prices for wheat in both locations suggest the wheat markets were closely aligned between both locations. In the case of herring, the relative price difference between English and Dutch herring remains similar for periods that price information is available to compare them. That is, herring prices in London were around 39% to 45% of the price of the Dutch product. And this English herring is around 63% to 67% of the price of the Dutch wholesale product.

Table 5.5. 50-year averages for herring in Amsterdam and Southern England.

Commodity	1500-1549	1550-1599	1600-1649	1650-1699	1700-1749	1750-1799
Herring (Southern England)	0.18 (n = 36)	0.27 (n = 43)	0.37 (n = 43)	0.42 (n = 27)	0.46 (n = 3)	
Dutch Herring (Wholesale)			0.71 (n = 17)	0.75 (n = 14)	0.79 (n = 22)	0.98 (n = 47)
Dutch Herrings	0.58 (n = 46)	0.84 (n = 36)	1.10 (n = 15)	1.18 (n = 8)		

Possible Trade Routes from Amsterdam

Each location in the following section is situated along hypothetical trade routes from Amsterdam. This attempts to understand the influence of trade routes on herring prices. Depending on the location, produce may have travelled along coasts, such as from

Amsterdam to Gdańsk.¹⁷³ Others will have moved along rivers, for example along the Rhine, which was commonly used for the transport of different commodities, such as timber.¹⁷⁴ Products were transported along the Rhine to the likes of Frankfurt.¹⁷⁵ Dutch fish travelled along the Rhine from Amsterdam.¹⁷⁶ Herring markets in Nuremberg and Gdańsk were well established, trading a standard herring product over long periods of time and sharing connections such as Lübeck.¹⁷⁷ Lübeck was an important trading city, though as price information is limited for Lübeck, it is not included in this analysis. Nuremberg and Gdańsk shared a trade link. For example, merchants of Nuremberg used to unload their Polish lead from Danzig at Lubeck for further transport to various markets.¹⁷⁸ It can be hypothesised that herring produce may have also followed this trade route.

Below (Diagram 5.1) is an overview of a hypothetical flow of trade of herring from Amsterdam, based upon prices 1600 to 1649. This period was chosen as price information is available for many locations. Trade will, of course, have occurred over different routes and to other locations, thus this diagram is not intended to represent all possible trade routes. The diagram below uses blue lines to represent trade by coast, and green to indicate trade by river (or land, though this is not certain). The method of transport was highly influential in determining costs. For English transport, James Masschaele states the cost for maritime produce was significantly less than land, with a ratio of cost between land, river, and sea being 8:4:1.¹⁷⁹ If a price difference exists between two locations, the location with the higher prices is more likely to be a location that commodities were traded to, rather

¹⁷³ Erik Lindberg. "Club Goods and Inefficient Institutions: Why Danzig and Lübeck Failed in the Early Modern Period," *The Economic History Review* 62, no. 3 (2009): 604-628, 611; Wim Blockmans, Mikhail Krom, and Justyna Wubs-Mrozewicz, eds. *The Routledge Handbook of Maritime Trade Around Europe 1300-1600: Commercial Networks and Urban Autonomy* (Taylor & Francis, 2017), 361.

¹⁷⁴ Aoife Daly. "Timber, Trade and Tree-Rings. Dendrochronological Analysis of Structural Oak Timber in Northern Europe, C. AD 1000 to AD 1650" (University of Southern Denmark, 2007). See section on Mechanisms of Transport, 193.

¹⁷⁵ John Parry. "Transport and Trade Routes," in *The Cambridge Economic History of Europe*. Ed. E. E. Rich, and C. H. Wilson (Cambridge University Press, 1967): 155-219, 185.

¹⁷⁶ *Ibid*, 175.

¹⁷⁷ Karl-Erik Frandsen. "The Scale and Politics of Gdansk's Salted Herring Trade in the Late Sixteenth Century," *International Journal of Maritime History* 16, no. 2 (2004): 145-167; Wolfgang von Stromer. "Nuremberg in the International Economics of the Middle Ages," *Business History Review* 44, no. 2 (1970): 210-225.

¹⁷⁸ Erik Lindberg. "The Rise of Hamburg as a Global Marketplace in the Seventeenth Century: A Comparative Political Economy Perspective," *Comparative Studies in Society and History* 50, No. 3 (2008), 650.

¹⁷⁹ James Masschaele. "Transport Costs in Medieval England," *Economic History Review* (1993), 273.

than from. This will be noted in the following examples to indicate the possible direction of trade of herring.

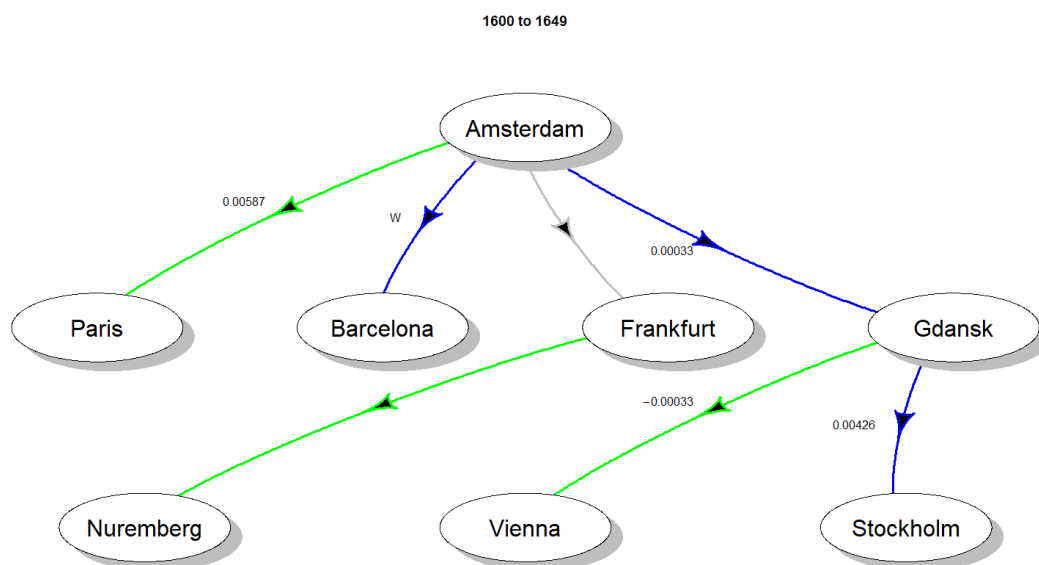


Diagram 5.1. Amsterdam Herring Trade from 1600 to 1649.¹⁸⁰

Blue lines indicate transport most likely by sea and green mostly likely by river. The price difference is indicated on each segment of a trade route in grams of silver per kilogram of produce.

Amsterdam to Paris

Herring in Paris was a substantially higher-priced commodity than its counterpart in Amsterdam. Wholesale prices are not available for Paris, thus the comparison is based on the prices available at a later stage in the market, that is, the prices based on procurement contracts for wealthy nobles. These prices will be compared against the prices for the likes of hospitals in the regions surrounding Amsterdam, thus they may still represent different levels in the market, but both will be non-wholesale prices and thus more comparable than wholesale prices. For the two locations, herring prices overlapped during the 17th century only. In both 50-year periods of this century, prices are approximately four times higher in Paris (Table 5.6, below). If this herring was a similar product in both locations, and was traded to Paris, this suggests a large price increase reflecting increased costs, principally

¹⁸⁰ It is possible that much herring never travelled directly through Amsterdam and instead may have been traded directly down the Rhine from the Rotterdam area. See Bo Poulsen. "Markets, prices and consumption: The herring trade in the North Sea and Baltic region, c. 1600-1850," in *The Dynamics of economic Culture in the North Sea and Baltic Region in the late Middle Ages and early modern period* (Uitgeverij Verloren, 2007), 17.

transport. However, the product would not have been traded from hospitals near Amsterdam to the tables of the wealthy nobles in Paris, thus the cost is not entirely indicative of costs of transport and trade. However, it is indicative of a premium being paid in Paris compared to Amsterdam and the surrounding region, while it is also possible that hospitals paid less than the wealthy nobles or accepted somewhat lower quality produce.

Table 5.6. 50-Year averages for herring in Paris and Amsterdam (referred to as “Dutch”).

Commodity	1500-1549	1550-1599	1600-1649	1650-1699	1700-1749	1750-1799
Dutch Herring (Wholesale)			0.71 (n = 17)	0.75 (n = 14)	0.79 (n = 22)	0.98 (n = 47)
Dutch Herrings	0.58 (n = 46)	0.84 (n = 36)	1.10 (n = 15)	1.18 (n = 8)		
Herring (Paris Allaire)	2.37 (n = 2)	3.06 (n = 15)	3.38 (n = 18)	3.99 (n = 2)	2.99 (n = 3)	2.78 (n = 1)

Uncertainty in what constitutes a different level motivates the examination of different potential levels in the case of Paris. When examining Paris further, it must be noted that it is the capital city and sits centrally within France, well connected to the surrounding country and hinterland. A large collection of price series is presented below (

Table 5.7), coming from multiple collections of price-series collections, i.e., from Allaire, Hauser, and Baulant (discussed in Chapter 2). All of these prices represent the premium market for wealthy nobles and the prices paid by large institutions, with the exception of the wheat prices which are wholesale. To test if the different price collections are comparable, a commodity that is common to more than one source, i.e., eggs, was studied in Chapter 3. Prices are very similar for this commodity, suggesting these sets of price information may have represented a very similar level in the Parisian market, and that nobles were not receiving a higher quality of product than the large institutions or were receiving or negotiating preferential prices.

Table 5.7. Paris prices. Sources: Allaire, Hauser and Baulant.

Commodity	1500-1549	1550-1599	1600-1649	1650-1699	1700-1749	1750-1799
Salted Cod (Paris Allaire)	1.04 (n = 4)	1.26 (n = 16)	0.92 (n = 9)	1.54 (n = 2)	1.33 (n = 1)	
Wheat (Paris Baulant)	0.36 (n = 50)	1.04 (n = 50)	1.08 (n = 50)	1.12 (n = 50)	0.82 (n = 50)	0.85 (n = 39)
Newfoundland Cod (Paris Allaire)			1.21 (n = 11)		1.65 (n = 1)	
Fresh Cod (Paris Allaire)	1.37 (n = 3)	1.50 (n = 15)	1.27 (n = 13)	1.80 (n = 3)	1.61 (n = 2)	
Beef (Paris Allaire)	1.76 (n = 2)	2.55 (n = 13)	2.85 (n = 19)	4.16 (n = 3)	4.16 (n = 3)	3.56 (n = 1)
Herring (Paris Allaire)	2.37 (n = 2)	3.06 (n = 15)	3.38 (n = 18)	3.99 (n = 2)	2.99 (n = 3)	2.78 (n = 1)
Eggs (Paris Hauser)	1.44 (n = 18)	3.07 (n = 5)	3.84 (n = 6)	4.73 (n = 11)		
Butter (Paris Hauser)	2.55 (n = 16)	4.53 (n = 6)	6.89 (n = 3)	7.13 (n = 12)	6.79 (n = 24)	8.04 (n = 37)
Bread (Paris Hauser)					1.08 (n = 7)	1.17 (n = 33)

Amsterdam to Barcelona

Barcelona is another coastal market, situated along the western Mediterranean Sea. Coastal trade from Amsterdam to the Mediterranean occurred during the study period.¹⁸¹ Thus products such as herring may well have been traded between Amsterdam to Barcelona by such routes. The application of the 50-year averages is important for Barcelona, as over the short term Feliu expressed reservations about studying this herring price series on an annual level, due to high amounts of price variability (see Section 2.1.3).¹⁸² The 50-year averages alleviate some of this uncertainty by removing year on year price volatility. Herring prices did not exactly follow the familiar long-term trend of price increase that characterises the Price Revolution; instead, prices decreased in the first half of the 1600s and increased again during the latter half. They did, however, decrease in the first half of the 1700s, and maintained a similar price level in the latter half of that century.

¹⁸¹ Milja Van Tielhof. "The Rise and Decline of the Amsterdam Grain Trade," in *Food Supply, Demand and Trade: Aspects of the Economic Relationship between Town and Countryside Middle Ages-19th Century (2012)*: 85-99, 89. "In the last decade of the sixteenth century grain shortages in Southern Europe, especially Italy, caused a structural expansion of the Dutch trade network. Shipmasters and merchants from Holland ventured into the Mediterranean, got to know the navigation routes, the ports and local customs, and managed to develop an extensive shipping and trading network within a limited period of time".

¹⁸² Gaspar Feliu, (1991), 121.

Mutton, herring and bacalao prices are shown below (Table 5.8). Herring prices were significantly lower than the other two products, based on the price per kilogram of produce. Herring was in a range of one fourth to one sixth the price of mutton and bacalao and was thus a low-cost source of protein. With mutton being so expensive relative to herring, the consumption of herring would have been encouraged as the cheaper source of protein. On the other hand, bacalao was denser in nutrition such as protein and thus it is possible that the price for herring and bacalao was similar when measured in cost based on the grams of protein. (i.e., the conversion of 1:4.9, mentioned earlier and applied by Peter Pope).¹⁸³

Table 5.8. 50-year average prices in Grams of Silver per Kilogram of produce in Barcelona. (Bacalao, herring and sheep meat). Barcelona product prices over each 50-year grouping (bacalao, herring and mutton).

Commodity	1500-1549	1550-1599	1600-1649	1650-1699	1700-1749	1750-1799
Herring (Barcelona)	0.52 (n = 7)	0.76 (n = 6)	0.67 (n = 28)	0.72 (n = 44)	0.56 (n = 34)	0.56 (n = 24)
Wheat (Barcelona)	0.46 (n = 50)	0.79 (n = 50)	0.96 (n = 50)	0.90 (n = 50)	0.74 (n = 50)	1.02 (n = 50)
Bacalao (Barcelona)		3.05 (n = 9)	2.72 (n = 43)	3.57 (n = 49)	3.20 (n = 39)	3.14 (n = 28)
Mutton (Barcelona)			4.06 (n = 32)	3.58 (n = 50)	3.17 (n = 50)	3.73 (n = 50)

In the case of Barcelona, the available herring prices are those from religious institutes. These herring prices were higher than those paid at the Amsterdam Exchange, though less than the prices paid by St. Bartholomew’s Hospital in Utrecht near Amsterdam (see Table 5.9 below). Thus, it is unlikely that this herring was transported from Amsterdam, as it would be unprofitable. It is also possible that institutions in Barcelona negotiated lower prices, or simply that they were different qualities of herring produce.

Increasing amounts of cod arriving in Barcelona from the Grand Banks could have been influential on herring prices remaining relatively low, compared to cod. That is, if the increasing cod quantities were replacing or supplementing herring supplies.

Table 5.9. 50-year averages for Amsterdam (referred to as “Dutch”) compared to Barcelona.

¹⁸³ Peter Pope. “Early Estimates: Assessment of Catches in the Newfoundland Cod Fishery, 1660-1690,” *Marine Resources and Human Societies in the North Atlantic Since 1500* (1995), 36 Note 7.

Commodity	1500-1549	1550-1599	1600-1649	1650-1699	1700-1749	1750-1799
Herring (Barcelona)	0.52 (n = 7)	0.76 (n = 6)	0.67 (n = 28)	0.72 (n = 44)	0.56 (n = 34)	0.56 (n = 24)
Dutch Herring (Wholesale)			0.71 (n = 17)	0.75 (n = 14)	0.79 (n = 22)	0.98 (n = 47)
Dutch Wheat (Utrecht Non-Wholesale)	5.20 (n = 50)	0.76 (n = 47)	0.96 (n = 34)	0.81 (n = 34)	0.70 (n = 50)	0.94 (n = 49)
Wheat (Barcelona)	0.46 (n = 50)	0.79 (n = 50)	0.96 (n = 50)	0.90 (n = 50)	0.74 (n = 50)	1.02 (n = 50)
Dutch Herrings	0.58 (n = 46)	0.84 (n = 36)	1.10 (n = 15)	1.18 (n = 8)		
Dutch Stockfish (Wholesale)			1.50 (n = 5)	1.74 (n = 23)	1.41 (n = 29)	1.80 (n = 50)
Dutch Stockfish (Non-Wholesale)	1.87 (n = 20)	1.99 (n = 33)	2.65 (n = 15)	3.38 (n = 1)	3.98 (n = 27)	4.86 (n = 43)
Bacalao (Barcelona)		3.05 (n = 9)	2.72 (n = 43)	3.57 (n = 49)	3.20 (n = 39)	3.14 (n = 28)
Dutch Meat	0.97 (n = 7)	2.57 (n = 4)	3.19 (n = 41)	3.85 (n = 43)	3.86 (n = 50)	3.87 (n = 50)
Mutton (Barcelona)			4.06 (n = 32)	3.58 (n = 50)	3.17 (n = 50)	3.73 (n = 50)
Dutch Salted Cod (Non-Wholesale)	0.58 (n = 26)					

Amsterdam to Frankfurt to Nuremberg

Price differences indicate that trade could have occurred from Amsterdam to Frankfurt and Nuremberg (see Table 5.10). Frankfurt prices were higher than those in Nuremberg. Thus, this is in contrast to Diagram 5.1 which suggested the product would have travelled from Amsterdam to Frankfurt to Nuremberg. The price information instead indicates trade may have occurred in the opposite direction, that is from Nuremberg to Frankfurt. Or this could be reflecting different abilities to negotiate in each location, or different qualities of produce being sold. In the cases of Amsterdam and Frankfurt, prices came from hospitals, while in Nuremberg they came from a monastery. As was also the case in Barcelona (discussed earlier in this section), herring was cheaper in the religious institutions than the hospitals. It is unclear if this was a general trend though over different locations.

Table 5.10. Herring Prices for Non-wholesale pieces for Amsterdam, Frankfurt, and Nuremberg. Wholesale prices for Amsterdam have also been included.

Commodity	1500-1549	1550-1599	1600-1649	1650-1699	1700-1749	1750-1799
Dutch Herring (Wholesale)			0.71 (n = 17)	0.75 (n = 14)	0.79 (n = 22)	0.98 (n = 47)
Herring (Nuremberg)	0.31 (n = 36)	0.45 (n = 32)	0.73 (n = 18)			
Dutch Herrings	0.58 (n = 46)	0.84 (n = 36)	1.10 (n = 15)	1.18 (n = 8)		
Herring (Frankfurt)	0.75 (n = 11)	1.17 (n = 26)	2.54 (n = 13)	2.45 (n = 1)	2.15 (n = 6)	

Table 5.11 shows prices specific to Frankfurt. The terrestrial meats (i.e., mutton, beef, and veal) display similar 50-year prices to one another here, and we may thus infer that these products had high potential to act as substitutes for one another, perhaps particularly during supply shocks when one or several were reduced in availability, necessitating the (at least part) abandonment of choices made based upon cultural or other preferences.

Herring was around a half to three quarters the price of the terrestrial meats, but from 1500 to 1650, herring and the terrestrial meats followed a similar trend in their 50-year averages. After this, they began to diverge, with herring decreasing in price while beef continued to become more expensive. This divergence between beef and herring is already observed in locations such as Amsterdam, thus representing another example of herring becoming better positioned to act as a lower-priced source of nutrition than beef and other terrestrial meats.

Wheat was similar in price to herring for most 50-year periods from 1500 to the mid-1700s (there is insufficient information to compare in the latter half of the 1700s). There was an exception in the latter half of the 1600s, when wheat halved in price compared to herring, before returning to the familiar trend of similar prices in the first half of the 1700s. It is not clear why this occurred, but a candidate for this large temporary divergence is the elevated level of conflict that occurred during the 17th century (see chapter 5 for more discussion on conflict). Thus, for much of the study period, herring and wheat maintained a similar relative value in terms of grams of silver per kilogram of produce. This similarity being familiar from other locations discussed thus far.

Table 5.11. Information for Frankfurt. Covers barley, beef, herring, mutton, rye, veal, and wheat.

Commodity	1500-1549	1550-1599	1600-1649	1650-1699	1700-1749	1750-1799
Barley (Frankfurt)	0.39 (n = 5)	0.61 (n = 15)	0.95 (n = 32)	0.69 (n = 42)	0.85 (n = 45)	1.85 (n = 47)
Rye (Frankfurt)	0.42 (n = 27)	1.14 (n = 46)	1.71 (n = 37)	1.51 (n = 30)	1.61 (n = 34)	2.40 (n = 40)
Wheat (Frankfurt)	0.61 (n = 18)	1.21 (n = 18)	2.33 (n = 22)	1.10 (n = 14)	2.19 (n = 31)	3.46 (n = 50)
Herring (Frankfurt)	0.75 (n = 11)	1.17 (n = 26)	2.54 (n = 13)	2.45 (n = 1)	2.15 (n = 6)	
Beef (Frankfurt)			3.43 (n = 34)	2.76 (n = 43)	3.65 (n = 11)	4.95 (n = 40)
Veal (Frankfurt)			3.70 (n = 22)	2.77 (n = 24)	3.86 (n = 8)	5.16 (n = 42)
Mutton (Frankfurt)	0.76 (n = 4)	1.34 (n = 2)	3.77 (n = 23)	3.23 (n = 42)	3.77 (n = 11)	4.86 (n = 41)

Table 5.12 (below) presents price averages salt, herring, and rye for Nuremberg. Prices are available from 1500 to around 1650 and rye is studied in this instance as an alternative to wheat. Rye and herring experienced substantial increases across the three periods, more than doubling and almost tripling in price; this is in keeping with Price Revolution inflation levels. Herring remained more expensive than rye in each 50-year period. Rye was, though, a product that tended to be cheaper than wheat per kilogram, often at around half the price in other regions examined. Thus, measured in prices of grams of silver per kilogram

of produce, herring may have been a similar price relative to wheat, if prices were available for Nuremberg.

Table 5.12. Nuremberg prices in grams of silver per kilogram of produce. (Rye and herring).

Commodity	1500-1549	1550-1599	1600-1649	1650-1699	1700-1749	1750-1799
Salt (Nuremberg)	0.12 (n = 47)	0.18 (n = 49)	0.28 (n = 39)			
Rye (Nuremberg)	0.16 (n = 50)	0.30 (n = 50)	0.42 (n = 41)			
Herring (Nuremberg)	0.31 (n = 36)	0.45 (n = 32)	0.73 (n = 18)			

In summary, Amsterdam, Frankfurt, and Nuremberg display common long-term trends, namely price increases for the first 150 years, in line with expectations for this era of Price Revolution, followed by a drop for 50 to 100 years and then a recovery. These trends are common throughout most locations studied in the chapter.

Amsterdam to Gdańsk, Vienna and Stockholm

Considerable trade is known to have occurred between Amsterdam and Gdańsk.¹⁸⁴ It also occurred from Gdańsk to Stockholm. When herring arrived at locations such as Gdańsk, it was then traded on to other locations in Poland.¹⁸⁵

Gdańsk is situated in the northern part of modern-day Poland, on the coast of the Baltic sea, within the Gulf of Gdańsk, and was an important location for trade, both Hanseatic and Dutch, amongst other parties.¹⁸⁶ Gdańsk displays consistently higher average prices than Amsterdam (Table 5.13 below). After holding quite steady for the first two 50-year periods (1500-49, 1550-99), these prices increased with the 50-year averages peaking in the second half of the 1600s. As common to a number of locations, there then followed a price decline in the 1700s. This appears particularly steep in the case of Gdańsk and continued in the latter half of the 1700s. This 18th century drop in herring prices may be at least partly attributable to a change in trading patterns registered in the Sound Toll registers, with herring fished off the coast of Bohuslän (a Swedish province along its west coast) becoming dominant in the Baltic and selling in large quantities.¹⁸⁷

¹⁸⁴ Edwin Ernest Rich, and Charles Henry Wilson. *The Cambridge Economic History of Europe. Vol. 5, The Economic Organization of Early Modern Europe* (Cambridge University Press, 1977), 188.

¹⁸⁵ Furtak, 28.

¹⁸⁶ Karl-Erik Frandsen. "The Scale and Politics of Danzig's Salted Herring Trade in the Late Sixteenth Century," *International Journal of Maritime History* 16, no. 2 (2004), 149 & 159.

¹⁸⁷ Poulsen, *Dutch Herring*, 96.

The trend of beef becoming increasingly higher priced compared to herring, as observed elsewhere, is quite pronounced in Gdańsk. Beef began as the cheapest product, standing on average at around two thirds the price of herring between 1500-49; this is unusual as in most other locations beef came with a premium. But by the second half of the 1500s, beef had more than doubled in price and became more expensive than herring. It remained this way for the rest of the study period, indeed becoming increasingly more expensive than herring.

For locations where data is sufficiently available, however, it can be seen that not all terrestrial meat prices behaved the same. Pork remained at a similar average price throughout the overall period, more comparable to that of herring, particularly through the 1600s and first half of the 1700s. At these lower prices, pork was also a relatively low-price source of protein, compared to beef.

Table 5.13. Gdańsk 50-year average prices of commodities. Includes beef, cow, veal, pork mutton and herring.¹⁸⁸ Gdańsk product prices over each 50-year period.

Commodity	1500-1549	1550-1599	1600-1649	1650-1699	1700-1749	1750-1799
Pork (Gdansk)		0.90 (n = 22)	0.85 (n = 27)	0.91 (n = 23)	0.91 (n = 31)	1.08 (n = 24)
Mutton (Gdansk) Series 1		0.67 (n = 14)	1.15 (n = 14)	0.88 (n = 43)	1.20 (n = 1)	
Herring (Gdansk)	0.76 (n = 18)	0.74 (n = 42)	1.16 (n = 48)	1.21 (n = 45)	0.87 (n = 23)	0.64 (n = 35)
Veal (Gdansk)	0.57 (n = 2)	0.71 (n = 26)	1.17 (n = 21)	1.41 (n = 35)	1.05 (n = 47)	0.86 (n = 32)
Beef (Gdansk)	0.49 (n = 6)	1.10 (n = 37)	1.66 (n = 43)	1.98 (n = 50)	1.90 (n = 50)	2.02 (n = 39)
Cow (Gdansk)					1.31 (n = 32)	1.84 (n = 19)
Mutton (Gdansk) Series 2					1.16 (n = 48)	1.27 (n = 42)

Of Vienna, price information for herring and stockfish are shown below (Table 5.14). Herring prices are lowest, while stockfish are highest. The 50-year averages for herring prices follow the now-familiar trend of increase, in this case up to the first half of the 1600s, then decline during the subsequent periods.

Table 5.14. Vienna prices in grams of silver per kilogram of produce. (Herring and stockfish).

¹⁸⁸ A second series for beef in Gdańsk was excluded because the values are very high compared to everything else. Further analysis is required to establish the reasons underlying this and assess the veracity of these prices. Also, it appears to be the case that meat from female cattle was distinguished as “cow”, while “beef” as male cattle or steers.

Commodity	1500-1549	1550-1599	1600-1649	1650-1699	1700-1749	1750-1799
Herring (Vienna) 01	0.40 (n = 8)	0.62 (n = 38)	0.93 (n = 27)	0.90 (n = 11)	0.78 (n = 34)	
Beef (Vienna) 01	0.86 (n = 9)	1.08 (n = 36)	1.69 (n = 24)	1.62 (n = 4)	1.88 (n = 4)	
Beef (Vienna) 02	0.74 (n = 33)	1.16 (n = 15)	1.98 (n = 36)	1.51 (n = 27)	1.76 (n = 38)	1.95 (n = 19)
Stockfish (Vienna)				4.11 (n = 12)	3.82 (n = 50)	2.44 (n = 1)
Cheap Stockfish (Vienna)				1.88 (n = 3)	1.99 (n = 38)	2.03 (n = 15)

There were two types of stockfish products on the market; one was a cheaper product, but it is not clear why from the sources. This lower-priced product came with prices per kilogram that were similar to beef. The other stockfish product was, by contrast, roughly twice as expensive across the period considered. It was also four times the price of herring, but as stockfish contained around four or more times as much protein as herring, this indicates that they shared a remarkably similar price per gram of protein.

A perspective from Northern European fish markets is provided by studying Stockholm, which was a more isolated market on the European periphery and separated by the intervening Baltic.¹⁸⁹ Prices are available from 1600 to 1750, with two distinct types of herring sold in Stockholm; the first is the familiar North Sea “Sill” herring and the second is a herring sub-species from the East-Baltic known as “Stromming” (see Section 2.1.3). Stromming was a lower valued product, at around half the price. Prices averages are shown below (Table 5.15) for the 50-year periods, also presenting herring, pork, and oxen for comparison. Oxen is most likely comparable to beef products sold in other locations, possibly only differing by name. Oxen and sill prices overlap during the 1600s, with similar prices in the first half of this period, but then diverge in the second half with oxen prices increased while sill prices remained similar, based on the 50-year price averages. Thus, the price divergence, with beef becoming more expensive than herring, as was also apparent in Gdańsk.

Table 5.15. 50-Year averages for herring (both stromming and sill), pork and oxen in Stockholm.

Commodity	1500-1549	1550-1599	1600-1649	1650-1699	1700-1749	1750-1799
Herring (Stromming Stockholm)			1.76 (n = 16)	1.51 (n = 42)	2.13 (n = 20)	
Oxen (Stockholm)			3.40 (n = 13)	4.32 (n = 9)		
Herring (Sill Stockholm Series 01)			3.53 (n = 14)	3.32 (n = 41)	3.99 (n = 20)	
Herring (Sill Stockholm Series 02)					3.80 (n = 27)	
Pork (Stockholm)					7.70 (n = 43)	

¹⁸⁹ Eastern Europe has not been covered and this will make for an interesting study in future research.

Stockholm pork prices are only available during the first half of the 1700s, during which time the average price is about twice that of herring, different than seen in the case of Gdansk with beef becoming more expensive than herring. These high pork prices provide further evidence of the price difference between herring and terrestrial meats that was also observed for beef and in Gdańsk.

For Amsterdam, Gdansk, Vienna and Stockholm, herring prices for each location are shown in Table 5.16, below. Herring prices started to decline for some time from the mid-1600s onwards either to the end of the 1700s or in some instances seeing a partial price recovery in that time. Beef prices, on the other hand, were increasing more so than herring.

Table 5.16. Herring prices for Amsterdam, Gdansk, Vienna and Stockholm.

Commodity	1500-1549	1550-1599	1600-1649	1650-1699	1700-1749	1750-1799
Dutch Herring (Wholesale)			0.71 (n = 17)	0.75 (n = 14)	0.79 (n = 22)	0.98 (n = 47)
Herring (Vienna)	0.40 (n = 8)	0.62 (n = 38)	0.93 (n = 27)	0.90 (n = 11)	0.78 (n = 34)	
Dutch Herrings	0.58 (n = 46)	0.84 (n = 36)	1.10 (n = 15)	1.18 (n = 8)		
Herring (Gdansk)	0.76 (n = 18)	0.74 (n = 42)	1.16 (n = 48)	1.21 (n = 45)	0.87 (n = 23)	0.64 (n = 35)
Herring (Stromming Stockholm)			1.76 (n = 16)	1.51 (n = 42)	2.13 (n = 20)	
Herring (Sill Stockholm Series 01)			3.53 (n = 14)	3.32 (n = 41)	3.99 (n = 20)	
Herring (Sill Stockholm Series 02)					3.80 (n = 27)	

Conclusions - Herring

During the Price Revolution, which occurred between the late 15th century and the first half of the 17th century herring prices were increasing in almost all locations. In the period from 1650-1699, these prices began to diverge between regions, that is some regions continued to see increasing prices while others decreased. By 1700-1749, however, most regions were decreasing in price. Wheat and herring shared similar long-term price dynamics and prices. Thus, herring wheat may have replaced one another at times.

The relative value of herring computed to beef changed. Beef was more expensive than herring. The extent of the difference depended on the period and location. During 1650-1699, when some locations began to display decreasing prices when compared to 1600-1649, clear increases continued for beef. The premium paid for beef was increasing, in particular during the 18th century. This progressively increased the position of herring as a lower-priced alternative protein source to beef. Thus, as now known to be common to many locations, beef was a higher-priced food compared to herring, and in all locations,

herring was a lower-priced alternative to beef. It is also notable that these divergences in prices occurred during the General Crisis from the early 17th century to the early 18th century. As the overall supply of herring gradually increased over the study period (see Chapter 1), its increased abundance may have influenced the relatively decreasing herring prices. It is also evident from the present analysis that herring, cod, wheat, and beef did share common long-term price dynamics, clearer when averaged over 50-year periods, within given regions. In some cases, common trends appear to prevail between certain locations, Amsterdam being a notable example. This implies a degree of integration between the different market locations and products, which will be discussed further in Section 5.2.

5.1.2. Cod

Cod markets were divided into distinct products. From the West Atlantic came the bacalao and green cod, and from the east came stockfish and salted cod. More specifically, cod had been long fished from well-established grounds in the Northeast Atlantic off Iceland and Norway, returning stockfish and salted cod produce. At the outset of the 16th century, however, Europeans began fishing in the Northwest Atlantic, and returned bacalao and green cod from the Grand Banks off Newfoundland. Stockfish was commonly exported from Norway.¹⁹⁰ The English brought salted cod back directly from fishing off Iceland (see Chapter 3). The Newfoundland salted cod became more dominant, though, from 1600 and on until the end of the study period.¹⁹¹ These different products and fishing grounds, as well as the locations they were usually traded to, are summarised below in Diagram 5.2.

¹⁹⁰ Arnved Nedkvitne. *The German Hansa and Bergen 1100-1600* (Böhlau Verlag, 2014).

¹⁹¹ Holm, "The North Atlantic Fish Revolution," 2.

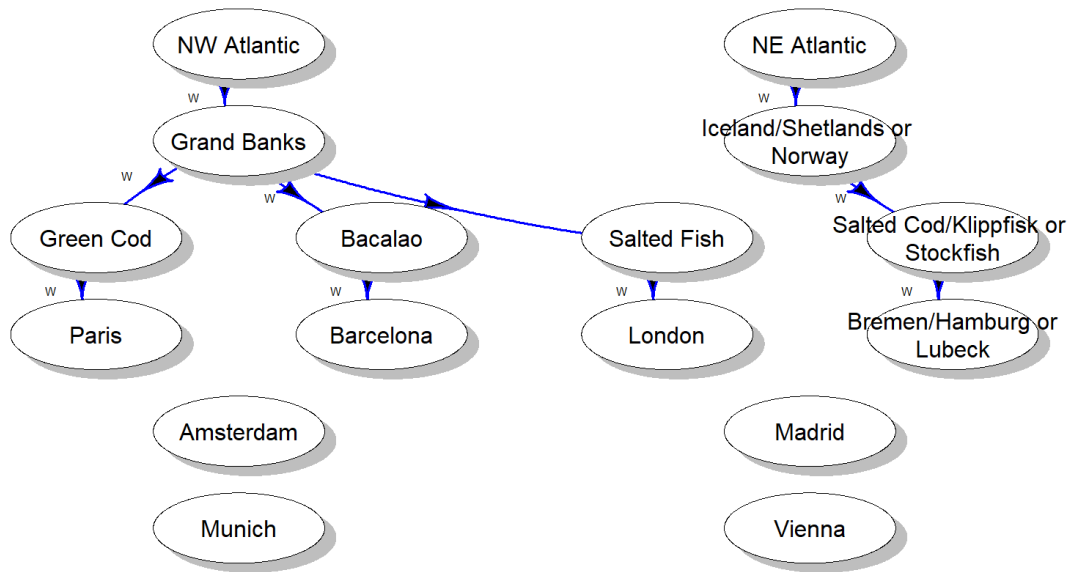


Diagram 5.2. Example of possible European cod trade routes in period 1600-1649.¹⁹² “W” indicates transport may have been by water.

Prices for different cod products, and in different locations, are given below (Table 5.17). This covers Amsterdam, Paris, Barcelona, Bergen, London, Munich, and Vienna. When price series are available for more than one product in a given location, they are also included and are revealing the relative value of the products. At their extremes, the 50-year average values range from 0.004 grams of silver per kilogram of produce for a stockfish product in Vienna, to 3.41 in Barcelona for the more expensive Bacalao product. They thus differ by a factor of greater than 850. Such a large range stretches credibility and suggests the quantity conversions drawn from the secondary literature need further refinement. The midpoint of these two values is 1.73gAg, though the lower value of 0.004 grams of silver per kilogram of produce is most likely pulling this value down excessively as an indicator of average prices over the entire research period. This is also covering the different cod products. The equivalent value for herring is slightly over 2gAg, but with the differing level of available data underlying these values, it is not clear how well they serve in comparison.

¹⁹² This diagram is not exhaustive, it includes examples of possible trade routes. It is based on a review of the literature and citations noted through the discussion in this chapter. A general discussion of the products and where they are sold can be found in Chapter 1.

Table 5.17. Cod prices with 50-year averages. Covering Amsterdam, Paris, Barcelona, Bergen, London, Munich, and Vienna.

Commodity	1500-1549	1550-1599	1600-1649	1650-1699	1700-1749	1750-1799
Salted Cod (Paris Allaire)	1.04 (n = 4)	1.26 (n = 16)	0.92 (n = 9)	1.54 (n = 2)	1.33 (n = 1)	
Newfoundland Cod (Paris Allaire)			1.21 (n = 11)		1.65 (n = 1)	
Fresh Cod (Paris Allaire)	1.37 (n = 3)	1.50 (n = 15)	1.27 (n = 13)	1.80 (n = 3)	1.61 (n = 2)	
Dutch Stockfish (Wholesale)			1.50 (n = 5)	1.74 (n = 23)	1.41 (n = 29)	1.80 (n = 50)
Stockfish (Bergen)	1.52 (n = 50)	1.57 (n = 50)	1.58 (n = 1)			
Dutch Stockfish (Non-Wholesale)	1.87 (n = 20)	1.99 (n = 33)	2.65 (n = 15)	3.38 (n = 1)	3.98 (n = 27)	4.86 (n = 43)
Bacalao (Barcelona)		3.05 (n = 9)	2.72 (n = 43)	3.57 (n = 49)	3.20 (n = 39)	3.14 (n = 28)
Stockfish (Munich)	2.18 (n = 13)	2.99 (n = 38)	2.82 (n = 23)			
Dutch Salted Cod (Non-Wholesale)	0.58 (n = 26)					
Salted Cod (Southern England)				6.24 (n = 27)	6.79 (n = 50)	5.57 (n = 9)
Stockfish (Southern England)	1.73 (n = 42)	2.05 (n = 20)				
Stockfish (Vienna)				4.11 (n = 12)	3.82 (n = 50)	2.44 (n = 1)
Cheap Stockfish (Vienna)				1.88 (n = 3)	1.99 (n = 38)	2.03 (n = 15)

Example of Transport Costs for Bacalao in Bilbao

Price gaps between locations were influenced by transportation costs and taxation.¹⁹³ Other costs were manpower, storage, and levies. Summaries based on documentary evidence that describe different costs associated with the trade and transport of cod are valuable. Such examples give a more specific or nuanced view of what drove the cost differences between regions. One available record, examined in what follows, is an account from the “Public Notary of His Majesty” from the town of Bilbao describing costs associated with the transport and arrival of Newfoundland cod in 1567.¹⁹⁴ It also gives a glimpse into the labour and roles played by both genders in the procurement and transportation of fish.

The document records costs in the local currency, that is, reales. These prices have been converted to grams of silver and the quantities to kilograms of product, thus providing costs in grams of silver per kilogram of produce. The reported quantity and type of fish arriving from “Terranova” was 230 quintals of codfish. They landed at the port of Castro de Urdiales, which is between 20 km and 30 km from Bilbao. They came with a total price of 3,741 reales, which was to include the costs outlined below. The produce was brought by Juanes de Ybayeta and transported between these locations in two pinnaces. The hiring of the

¹⁹³ Regina Grafe. *Distant Tyranny: Markets, Power, and Backwardness in Spain, 1650-1800* (Princeton University Press, 2011), 38-42; Victoria Bateman. *Markets and Growth in Early Modern Europe* (Routledge, 2015), 125.

¹⁹⁴ David Quinn, Alison M. Quinn, and Susan Hillier. *New American World. Volume IV. Newfoundland from Fishery to Colony. Northwest Passage Searches*, vol. 4 (Arno Press, 1979), 99-100. Record 585.

pinnaces to transport this produce cost 230 reales. An additional 82 reales was required for labour-related costs, as itemised below in Table 5.18. This represents the cost of bringing fish from a boat to the market.

Table 5.18. An example of costs from boats to market for cod coming from Newfoundland. After arriving in Bilbao in Spain in 1567.

Task	Reales
2 girls carrying fish	8
5 men fold and pile fish	48
Straw under the fish	12
Girls taking fish to public scale	7
To the men weighing the fish	7
Total	82

There were further documented costs, with 34 reales paid for the storehouse where the fish were kept prior to being sold in Bilbao, 34 reales paid in duty, 85 reales paid in dues to his majesty, 260 for clothes, 430 for food, drink, and board, 66 reales for a horse back journey. All these costs came to a total of 1,221 reales for transport and related costs:

$$230 + 82 + 34 + 34 + 85 + 260 + 430 + 66 = 1,221$$

This left a remainder of 2,520 as potential profit after these deductions, i.e., $3,741 - 1,221 = 2,520$.

$$3,741 - 1,221 = 2,520$$

The 1,221 reales represent the total transport costs, including all taxes and expenses as outlined above. The value of $1,221/3,741 = 33\%$. Thus, the total price of the fish included a 33% total for various transport and related costs, showing that these transport costs were a significant factor in deciding the price of the cod.

$$1,221/3,741 = 33\%.$$

To convert these prices to grams of silver per kilogram of produce, the first step is to know the number of grams of silver that the reale comprise of. In the 1500s, this was made approximately of 3.2g of silver.¹⁹⁵

$$1 \text{ Reale} = 3.2 \text{ Grams Silver.}$$

The quantity needs to be converted from quintal to kilograms. A Spanish quintal consisted of 100 libras, thus weighing around 46kg, based on the Libra being equivalent to the English Pound (see Section 3.2).

$$1 \text{ Spanish Quintal} = 46\text{kg.}$$

230 quintals of cod cost 3,741 reales in Bilbao, thus one quintal was worth 16.27 reales.

$$1 \text{ Quintal Cod} = 16.27 \text{ Reales.}$$

1kg of cod costs 0.35 reales, based on $16.27/46 = 0.35$.

$$1\text{kg cod} = 0.35 \text{ Reales.}$$

As a reale was worth 3.2 grams of silver, a kilogram of cod cost 1.12 grams of silver, based on $3.2 \times 0.35 = 1.12$.

$$1\text{kg cod} = 1.12 \text{ grams of silver.}$$

To understand how that compares to the bacalao price series from Feliu's work (i.e., the price series analyses thus far for bacalao in Barcelona), the closest year is taken, which is 1574. In that year, 1 Kg of Cod costs 1.499 Grams of Silver.

$$1\text{kg cod} = 1.499 \text{ grams of silver}$$

Thus, the price increase between the two locations is 34%. This could reflect costs of shipping the fish further to Barcelona. This similarity of the two prices, rather than a large magnitude of price difference, reinforces the reliability of both sources.

¹⁹⁵ Gaspar, (1991), 19.

Cod Products

The various cod products were different combinations of fresh, salted, and dried produce. Specifically, these are stockfish, salted cod, bacalao, and green cod.

Stockfish

Stockfish came from Icelandic and Norwegian fishing grounds. Price series are available for Amsterdam, London, Munich, and Vienna (see Table 5.19 below),¹⁹⁶ and represent the consumer markets (i.e., hospitals, religious institutions, and municipal records), with the exception of one price series for the wholesale market in Amsterdam. The Dutch stockfish price series, which is for St. Bartholomew's Hospital in Utrecht (see Section 2.1.3), is the only series with information for all 50-year periods. Using this as a comparator for the other three locations, the prices are quite similar in most instances when they overlap. This evidence does indicate a close relationship between the prices in each location over the longer term, when inter-annual variability is averaged out, suggesting that these markets were well integrated, at least over the long term. Based on the available evidence, a large divergence occurred between Amsterdam and Viennese prices in the latter half of the 18th century, however. Dutch prices increased while the prices in Vienna decreased. This shift was quite significant and resulted in prices in Amsterdam being twice as expensive as in Vienna.

Table 5.19. Stockfish prices for Amsterdam (i.e., Dutch), Munich, London, and Vienna.

Commodity	1500-1549	1550-1599	1600-1649	1650-1699	1700-1749	1750-1799
Dutch Stockfish (Wholesale)			1.50 (n = 5)	1.74 (n = 23)	1.41 (n = 29)	1.80 (n = 50)
Dutch Stockfish (Non-Wholesale)	1.87 (n = 20)	1.99 (n = 33)	2.65 (n = 15)	3.38 (n = 1)	3.98 (n = 27)	4.86 (n = 43)
Stockfish (Munich)	2.18 (n = 13)	2.99 (n = 38)	2.82 (n = 23)			
Stockfish (Southern England)	1.73 (n = 42)	2.05 (n = 20)				
Stockfish (Vienna)				4.11 (n = 12)	3.82 (n = 50)	2.44 (n = 1)

¹⁹⁶ In the case of Madrid, there is a product described as "dried fish" in Hamilton's work (Hamilton's work was discussed in Section 2.1.3, Hamilton. *American treasure and the price revolution in Spain, 1501-1650*; Hamilton. *War and prices in Spain: 1651-1800*). This may well have been stockfish. The prices, though, were very high relative to the stockfish prices. It is not clear if this is cod or something similar to stockfish, thus it has not been included in the present analyses.

Each location is described below to understand the position of stockfish in the markets relative to herring. This further explains how stockfish acted as a source of nutrition relative to this product.

For Amsterdam, wholesale stockfish prices are first available from the 1600s onward, with a 50-year average of 1.5 grams of silver per kilogram of produce for the 1601-49 period (Table 5.20 below). By the close of our study period, in the latter half of the 1700s, the 50-year average is 1.8 grams of silver per kilogram of produce, a 20% increase over the opening period, but prices are quite stable. When prices overlapped, i.e., for the 17th and 18th centuries, this wholesale stockfish was between a third to a half the price of the stockfish sold at a higher market level, namely to St. Bartholomew’s Hospital. The stockfish here also displayed relatively stable prices, but with increases over each 50-year period of a greater scale than seen in the wholesale. The good availability of price information, in addition to the stable and regular price increase, suggests a high degree of stability in that market, though the process of averaging may disguise shorter-term variability (though shorter-term variability will be discussed in Section 5.2). This stockfish was over three times the price of the herring, but as a dried product it was denser in protein than non-dry (i.e., wet) herring (see Section 5.1.1 for Southern England). Thus, they both may have had a similar value based on their nutritional content for the likes of protein. Herring may even have been slightly better value in this scenario.

Table 5.20. Dutch stockfish cod and herring. (There are two Dutch herring products in this table. The “full herring” product refers to herring sold at wholesale markets, while the “herrings” product relates to non-wholesale prices paid in St. Bartholomew’s hospital near Amsterdam.

Commodity	1500-1549	1550-1599	1600-1649	1650-1699	1700-1749	1750-1799
Dutch Herring (Wholesale)			0.71 (n = 17)	0.75 (n = 14)	0.79 (n = 22)	0.98 (n = 47)
Dutch Herrings	0.58 (n = 46)	0.84 (n = 36)	1.10 (n = 15)	1.18 (n = 8)		
Dutch Stockfish (Wholesale)			1.50 (n = 5)	1.74 (n = 23)	1.41 (n = 29)	1.80 (n = 50)
Dutch Stockfish (Non-Wholesale)	1.87 (n = 20)	1.99 (n = 33)	2.65 (n = 15)	3.38 (n = 1)	3.98 (n = 27)	4.86 (n = 43)

The prices for Munich are available during the first half of the study period, i.e., from 1500 to the mid-1600s (Table 5.21, below). During this period, stockfish was a substantially more valuable product than the herring, at around six times the price. If the comparison is instead based on nutritional content, this price premium for stockfish would be substantially reduced, though it still many have been slightly more expensive than herring.

Table 5.21. Price in Munich for Stockfish (cod) and herring.

Commodity	1500-1549	1550-1599	1600-1649	1650-1699	1700-1749	1750-1799
Herring (Munich)	0.35 (n = 13)	0.49 (n = 36)	0.50 (n = 21)			
Stockfish (Munich)	2.18 (n = 13)	2.99 (n = 38)	2.82 (n = 23)			

Viennese prices are also available for 1500-1549, 1550-1599 and 1600-1649 to 1650 (see Section 2.1.3 and Table 5.22). Stockfish was approximately four times the price of herring per kilogram of produce during the 1650-1699 and 1700-1749 periods. Thus, stockfish and herring may have been similarly priced substitutes for one another based on protein content.

Table 5.22. Price in Vienna for Stockfish (cod) and herring.

Commodity	1500-1549	1550-1599	1600-1649	1650-1699	1700-1749	1750-1799
Herring (Vienna)	0.40 (n = 8)	0.62 (n = 38)	0.93 (n = 27)	0.90 (n = 11)	0.78 (n = 34)	
Stockfish (Vienna)				4.11 (n = 12)	3.82 (n = 50)	2.44 (n = 1)

Salted Cod

Salted cod often referred to produce landed in the Northeast Atlantic, in particular in English fisheries, though the exact provenance (in terms of fishing grounds) of this product is not always clear from the literature. The available salted cod prices are shown below in Table 5.23. The most extensive series is for Paris, covering a period from the beginning of the 1500s to the first half of the 1700s. Available prices cover Amsterdam briefly, with information for the first half of the 1500s. Southern England prices are available for the last three 50-year periods under consideration, thus there is unfortunately little overlap between the price series for the three locations. Nonetheless, and with this in mind, significant differences in the prices in each location can be noted. Dutch prices were less than half those of Paris, and Paris prices were less than one quarter those of Southern England.

Table 5.23. Salted cod prices.

Commodity	1500-1549	1550-1599	1600-1649	1650-1699	1700-1749	1750-1799
Salted Cod (Paris Allaire)	1.04 (n = 4)	1.26 (n = 16)	0.92 (n = 9)	1.54 (n = 2)	1.33 (n = 1)	
Dutch Salted Cod (Non-Wholesale)	0.58 (n = 26)					
Salted Cod (Southern England)				6.24 (n = 27)	6.79 (n = 50)	5.57 (n = 9)

Measured in grams of silver per kilogram of produce, there were large differences between herring and salted cod (see Table 5.24, below). For Amsterdam, non-wholesale salted cod prices are available for the period 1500-1549, during which time prices were very similar to Dutch non-wholesale herring per kilogram of produce (0.58 grams of silver per kilogram of produce). The situation appears different in Southern England, with a very large difference between the herring and salted cod prices, the latter being in the region of 15 times as expensive. Seeing as the difference is substantial in the two locations, it is possible that these products represented quite different customers or types of products. In Paris, salted cod was over three times the price of herring.

Table 5.24. Salted cod and herring in Southern England, Paris, and Amsterdam. (“Dutch” is Amsterdam).

Commodity	1500-1549	1550-1599	1600-1649	1650-1699	1700-1749	1750-1799
Herring (Southern England)	0.18 (n = 36)	0.27 (n = 43)	0.37 (n = 43)	0.42 (n = 27)	0.46 (n = 3)	
Dutch Herring (Wholesale)			0.71 (n = 17)	0.75 (n = 14)	0.79 (n = 22)	0.98 (n = 47)
Salted Cod (Paris Allaire)	1.04 (n = 4)	1.26 (n = 16)	0.92 (n = 9)	1.54 (n = 2)	1.33 (n = 1)	
Dutch Herrings	0.58 (n = 46)	0.84 (n = 36)	1.10 (n = 15)	1.18 (n = 8)		
Herring (Paris Allaire)	2.37 (n = 2)	3.06 (n = 15)	3.38 (n = 18)	3.99 (n = 2)	2.99 (n = 3)	2.78 (n = 1)
Dutch Salted Cod (Non-Wholesale)	0.58 (n = 26)					
Salted Cod (Southern England)				6.24 (n = 27)	6.79 (n = 50)	5.57 (n = 9)

Briefly looking at stockfish and salted fish prices in Southern England, stockfish prices were available earlier in the research period, while salted cod prices were only available towards the end. It is not possible to compare their prices in any one period because they do not overlap, however, it is possible that salted cod replaced the stockfish.

Bacalao in Spain

Peter Pope referred to a triangular trade, a key component of which was a flow of labour and resources from England to Newfoundland and the Grand Banks. This resulted in bacalao being transported to Iberia. Finally, to complete the cycle, produce such as wine was transported back to England.¹⁹⁷ Bacalao in Barcelona was described earlier (see Section 5.1.2) as more expensive than herring; in the range of 4 to 6 times the price. Bacalao price series became available from the early 1600s; it was less expensive than mutton, at approximately three quarters the price. Thus, the bacalao was a cheaper source of protein than mutton.

¹⁹⁷ Pope, “Fish into wine”.

Green Cod in France

The French and English were two particularly dominant fishing groups at the Grand Banks and Newfoundland region from some time in the 1600s onwards. The French had a preference for producing and consuming a salted (but not dried) cod product derived from their cod catch in the area, known as “green cod”. Prices for three cod products sold in Paris are shown below in Table 5.25. Fresh cod (most likely locally sourced) and Newfoundland cod maintained similar prices. The salted cod was the cheapest of the three. It maintained a similar price gap with the other two commodities over the 50-year periods considered, with a difference of approximately 0.3 grams of silver per kilogram of produce. Thus, the relative values of the three commodities remained quite stable during the study period.

Table 5.25. Green cod, Newfoundland cod and salted cod price in Paris.

Commodity	1500-1549	1550-1599	1600-1649	1650-1699	1700-1749	1750-1799
Salted Cod (Paris Allaire)	1.04 (n = 4)	1.26 (n = 16)	0.92 (n = 9)	1.54 (n = 2)	1.33 (n = 1)	
Newfoundland Cod (Paris Allaire)			1.21 (n = 11)		1.65 (n = 1)	
Fresh Cod (Paris Allaire)	1.37 (n = 3)	1.50 (n = 15)	1.27 (n = 13)	1.80 (n = 3)	1.61 (n = 2)	

The green and fresh cod prices in Paris were approximately half that of the Bacalao in Barcelona. Further, they followed similar trends over time. They follow similar long-term trends, indicating they may have been integrated to one another to a degree. (See Section 5.2 for more discussion on integration).

Conclusions - Cod

Cod products were more expensive than herring when measured in prices based on grams of silver per kilogram of produce. This changed, however, in many instances if prices were based on the value of the relative nutritional content, such as protein. Usually, cod still maintained a premium from this perspective, but much less so or even became similar in value.

The range of average cod prices, from lowest to highest 50-year periods and over all regions, was larger than herring. This is evidence of a less integrated market for cod. The market was also divided into many different products and fished from both European waters as well as the more remote Grand Banks and Newfoundland coastal waters. This can be seen as a further reason for the large range. As bacalao was usually twice the price

of green cod, this in itself explains almost a degree of the broad range of prices over all cod products. Both the maximum and minimum 50-year prices occur in the second half of the 1600s, suggesting higher price volatility in that period. CV values in Section 5.2 will study this volatility more extensively.

In Paris, price information is available to compare the prices for three cod products. The arrival of the Newfoundland produce came with different relative values compared to the Northeast Atlantic cod products. It aligned quickly with these products, however, in the sense that it maintained a similar price difference with them over each 50-year period that price information is available for.

Prices in Southern England are available for stockfish at the start of the study period, and by the end, they were only available for salted cod. As discussed earlier, this is evidence that there may have been a halt to stockfish on English markets and a replacement by salted cod.

As was also the case for herring compared to beef, as beef became increasingly expensive in the latter half of the research period, cod would have been a cheaper source of protein.

5.1.3. Conclusions

The prices of cod, herring, wheat, and meat varied significantly between the regions included in this chapter (Table 5.26 below). Herring came with a ratio of 22 over all 50-year periods and locations. Cod is lower again at 15, even though this ratio is over the different cod products. Beef was the most stable with a ratio of 10, this is even with beef prices increasing over the time period. Wheat had the highest value at 27.

Table 5.26. Minimum, maximum, and mid-point prices over all 50-year averages and locations.

Product(s)	Min	Max	Mid-Point	Min/Max Ratio
Herring	0.18	3.99	1.91	22
Cod	0.45	6.79	3.17	15
Wheat	0.19	5.20	2.50	27
Beef	0.49	4.95	2.23	10

With a trend of increasing beef prices, in particular relative to cod and herring, this led to these fish products acting as a progressively lower-priced source of nutrition. Cod was more

expensive than herring when based on the measure of kilograms of produce. When nutrition content is accounted for, this changes and in some cases, cod became a lower priced alternative based on protein content.

Wheat and herring prices behaved similarly at times. Their relative value did change at times, creating the possibility that one became lower-priced substitute for the other when these differentials occurred.

5.2. Market Integration and Medium-Term Price Changes

Price variability can indicate the degree of market integration prevailing for a given product (see Section 2.2.6). The analysis in this section is based on a medium-term time scale, making use of aggregated annual data to study trends at a decadal resolution. Based on what data is presently available, it is not possible to meaningfully study shorter-term market responses. By thus basing the analysis on underlying values that represent years, rather than shorter intervals such as days, weeks, months, and quarters, very short-term variability is removed. Coefficients of Variation (CV, introduced in Chapter 2) can however be calculated at a decadal level using the annual prices, with higher CV values (i.e., higher variability within any decade) being consistent with a less integrated market. To complement the decadal CV analysis, the price information is studied through decadal averages. This further highlights the medium-term price dynamics.

Market integration had been studied extensively, from qualitative discussions to complex quantitative econometric models. In 2012, Giovanni Federico stated that the topic of market integration had seen a boom in the previous 15 years, with analyses generally focused on the last two centuries.¹⁹⁸ Due to the historical information available, prior to World War II, it is more difficult to analyse degrees of market integration. As Federico also observes, the complex variety of methods and different approaches that have been applied

¹⁹⁸ Giovanni Federico. "How much do we know about market integration in Europe?" *The Economic History Review* 65, No. 2 (2012), 493; Giovanni Federico. "Market Integration from Measurement to Economic Analysis: A Survey of the Recent Literature," CEPR (*Discussion Paper No. DP12902*, April 2018): <https://ssrn.com/abstract=3184207>; Paolo Malanima. *Pre-Modern European Economy: One Thousand Years (10th-19th Centuries)*, Vol. 5 (Brill, 2009); "Market Integration and the Welfare of Europeans (INMARWEL)," European Research Council (ERC) Advanced Grant No. 230484, (2009-2013).

to questions of market integration have resulted in difficulty in achieving a consensus on much of the research in the literature.

The topic of market integration in European nations during the early modern period has been studied for commodities such as wheat. This product is often studied due to its position as an important dietary staple. The existence of vast quantities of price information today is testament to this. For example, Victoria Bateman's study of European market growth and development from 1350 to 1800 CE is based on wheat prices.¹⁹⁹ Bateman's analysis shows that market integration levels for wheat were similar in the later 1700s as they were in the 1800s, and that there had been a deterioration in market integration levels in the late 16th century before a recovery to levels seen in the 16th century by the 18th century.²⁰⁰ The chart below (Figure 5.2) presents wheat prices, including decadal averages. The trends are quite similar in many locations, following the gradual long-term inflation that came with the Price Revolution, before decreasing during the General Crisis, and starting to increase again in the lead up to the mid-1700s and until the end of that century.

These wheat prices are studied in the common unit of grams of silver per kilogram of produce introduced in Chapter 2. They have been log-transformed for the graph. Thus, as is the case with log-transformed values, 0 on the y-axis represents a value of 1 gram of silver per kilogram of produce.²⁰¹ Also, every increase of 1 on the y-axis represents a doubling of price, while a decrease of 1 represents a halving of price. These log transforms improve the visualisation of the price changes by preventing relatively large values from dominating and suppressing lower ones. The wheat prices are studied below to allow comparison of herring and cod, to understand relative levels of market integration across the different products.

¹⁹⁹ Victoria Bateman. *Markets and Growth in Early Modern Europe* (Routledge, 2015), 10.

²⁰⁰ Victoria Bateman. "The Evolution of Markets in Early Modern Europe, 1350–1800: A Study of Wheat Prices," *The Economic History Review* 64, no. 2 (2011), 465.

²⁰¹ Log to the base 2 has been applied in this section.

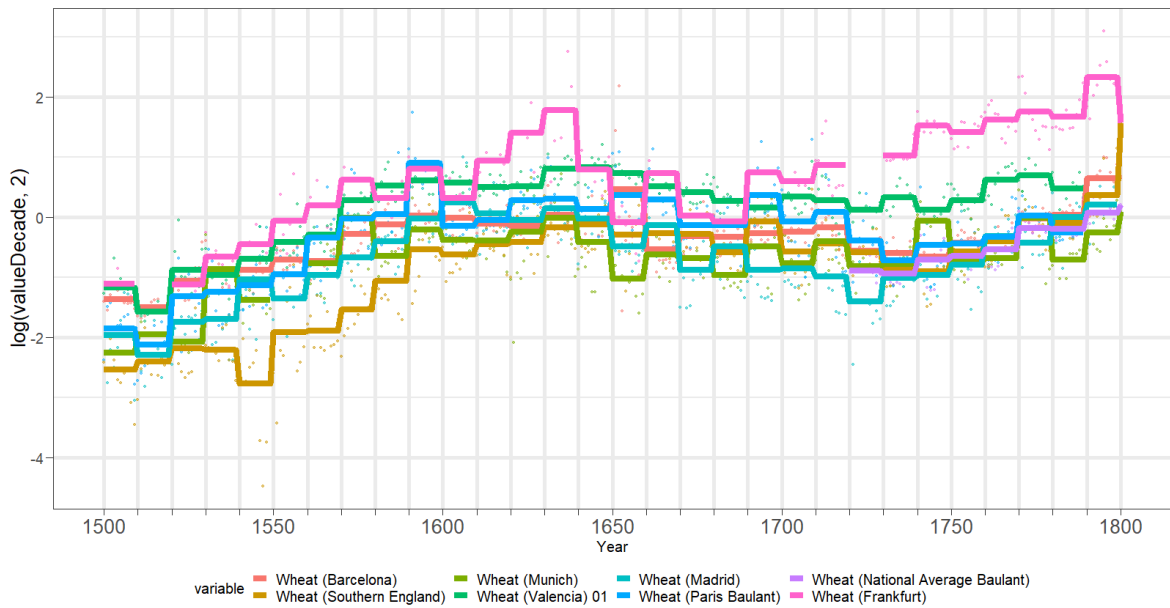


Figure 5.2. Wheat prices. Covers Barcelona, Southern England, Munich, Valencia, Madrid, Paris, and Frankfurt.

Decadal CV values for wheat (Figure 5.3, below) range between almost 0.0 and over 0.6, with most varying between 0.2 and 0.4. There are clear trends in this through time and between location, and wheat will later be compared to herring and cod to understand their respective levels of market integration.

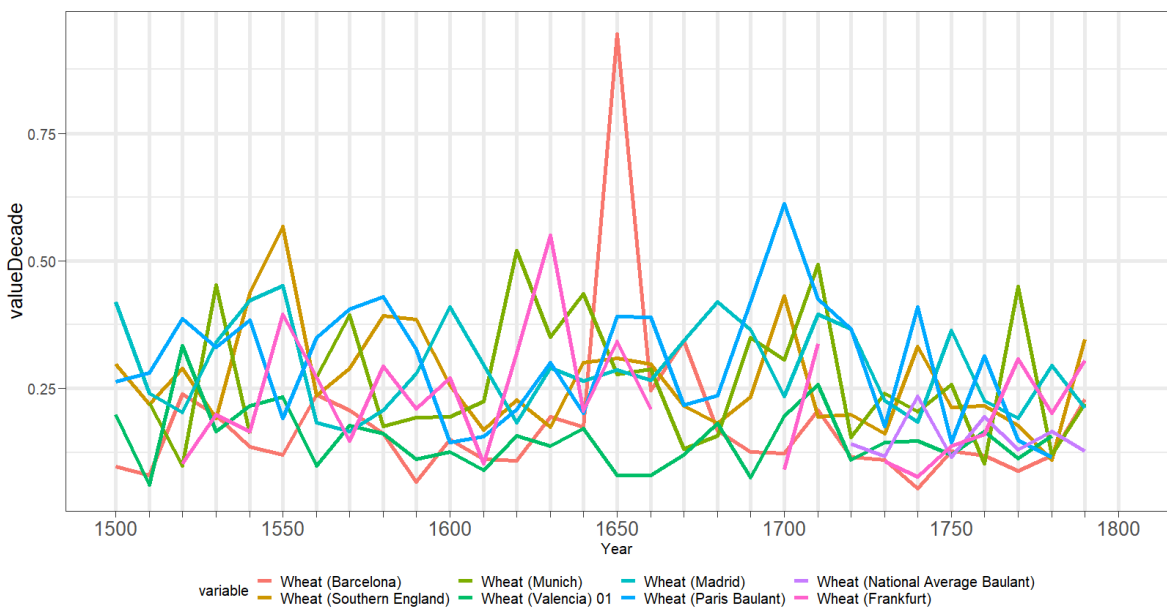


Figure 5.3. Wheat Coefficients of Variation (CV)s. Includes prices in Barcelona, Southern England, Munich, Valencia, Madrid, Paris, and Frankfurt. CV values are displayed on the y-axis.

Scholars have also extensively studied commodities other than wheat. For example, Süleyman Özmucur has analysed commodities such as rice, sugar, honey, and meat.²⁰² These analyses usually have not extended to marine fish such as cod and herring. In recent years, there have been studies on individual countries, such as Regina Grafe's analysis of bacalao in Spain for the period from 1650 to 1800 CE.²⁰³ Thus, the analysis of herring and cod in this section offers a comparison of their levels of market integration compared to that of wheat.

5.2.1. Herring Markets

Decadal price averages for herring markets are not as “regular” as those displayed for wheat (Figure 5.4 below for herring), in the sense that herring prices series are not as closely aligned to one another as was the case for wheat. The prices are more dispersed than was the case with the wheat prices shown earlier in Figure 5.2. Prices, however, do display common trends. There are examples of large changes occurring at the same time in multiple series, such as Paris, Stockholm, and Stockholm in the 1590s, when they display relatively large price increases. Caution must be exercised in simply attributing these changes to a trade-driven integration of the respective markets, however. It is possible that other common underlying factors intermittently drove the changes across locations (e.g., political events such as war or environmental factors such as drought).

²⁰² Süleyman Özmucur et al. “Did European Commodity Prices Converge During 1500–1800,” in *The New Comparative Economic History: Essays in Honor of Jeffrey G. Williamson* (Cambridge MA: MIT Press, 2007).

²⁰³ Regina Grafe, *Distant Tyranny*.

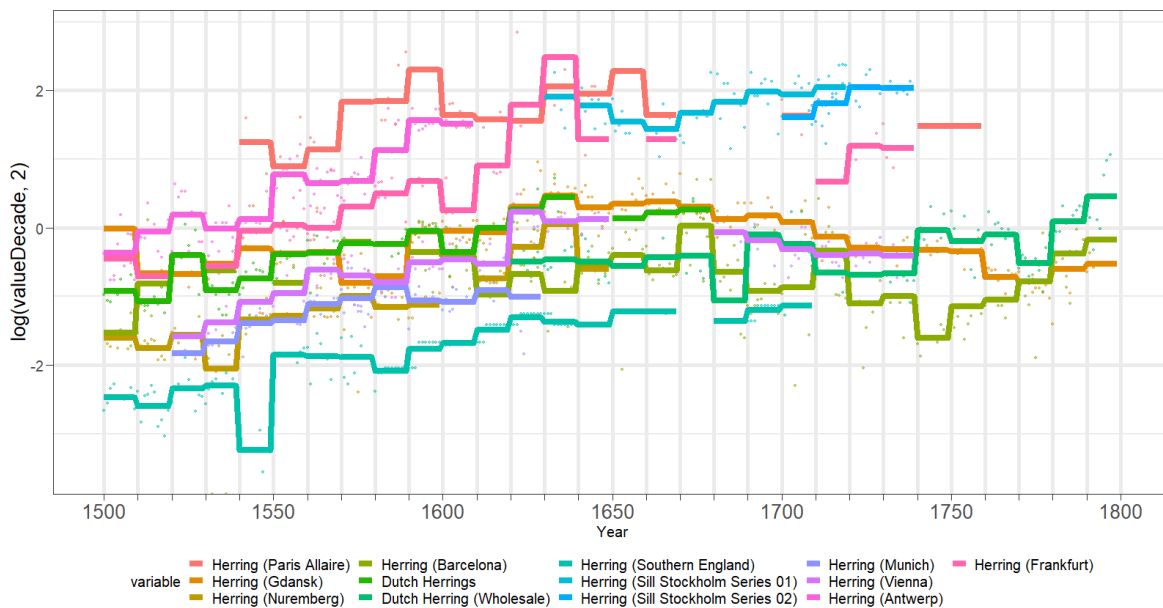


Figure 5.4. Herring prices in grams of silver per kilogram. Covers locations in Northern, Southern, Western and Central Europe. Values have been log-transformed with a base of 2. Individual points are based on price information at an annual resolution. The solid lines are average values for each decade.

The CV has been calculated for each decade, again based on annual prices (Figure 5.5 below). Thus, the extent of year-on-year variability in each decade can be discerned, from which a number of scenarios can be inferred (and refined thereafter with further evidence and analyses).²⁰⁴ The Nuremberg and Gdańsk price series were for example the most stable based upon their respective CV values. They display very little long-term change compared to one another between 1500 and 1650. This suggests a number of potential scenarios, none of which are mutually exclusive and may even be part dependent. Such low values may thus imply a considerable integration within each location between products, in which price stability is maintained by effective substitution between products (e.g., here herring price stability might be maintained by supplies of protein substitutes such as mutton from local hinterlands). This stability might also be maintained by longer-distance trade (i.e., market integration with other locations). Here, hypothetical shortfalls in herring supplied via established trade linkages are filled by herring (or indeed other protein substitutes) sourced through new or secondary links as merchants move to take advantage of

²⁰⁴ Such as direct primary written or archaeological evidence of trade (i.e., market integration) between the locations studied, and correlation or more advanced regression-based analyses of similarities in price behaviour between locations. For example, see Helmut Lütkepohl. *New Introduction to Multiple Time Series Analysis* (Springer Science & Business Media, 2005). This included advanced methods such as Vector Autoregressions (VAR), Vector Error Correction Models (VECM)s and Structural VARs and VECMs.

temporary opportunities to gain from higher prices in supply-restricted markets.²⁰⁵ This will have the effect of maintaining price stability as reflected by the CV values, evening out the price impact of the supply restriction in one region across all regions with which it trades. Such an integrated market can be deemed to “perform” well according to the definition of Robertus van der Spek and others.²⁰⁶ As was earlier stated when presenting prices (rather than their CV values), common external factors may have been underlying both markets and driving these similar levels of stability, in the absence of integration (e.g., a conducive climate, lack of conflict). A notable short-term divergence from the prevailing stability did occur between the 1620s and 1640s, with dramatic price variability observed in Nuremberg but not in Gdańsk. The CV values generally stay in a range of between 0.1 to 0.3, but with a maximum of over 1.14, and at the other extreme touching the absolute minimum possible of 0.0. These are slightly lower than what was observed for wheat, thus indicating that herring prices were slightly more stable. Thus, this is in keeping with an interpretation of greater integration, even if this cannot be confirmed on this evidence alone.

²⁰⁵ Multiple such examples are described in Mark Casson, and Catherine Casson. *The Entrepreneur in History: From Medieval Merchant to Modern Business Leader* (London, Palgrave, 2013).

²⁰⁶ Namely, “the capability of markets to adapt to exogenous shocks” without exhibiting large price increases driven by supply shortages because these are negated by trade (see Robertus J. van der Spek, Bas van Leeuwen, and Jan Luiten van Zanden. “An Introduction: Markets from Ancient Babylonia to the Modern World,” in *A History of Market Performance: From Ancient Babylon to the Modern World*, eds. Robertus J. van der Spek, Bas van Leeuwen, and Jan Luiten van Zanden (London: Routledge, 2015), 1-16, 3).

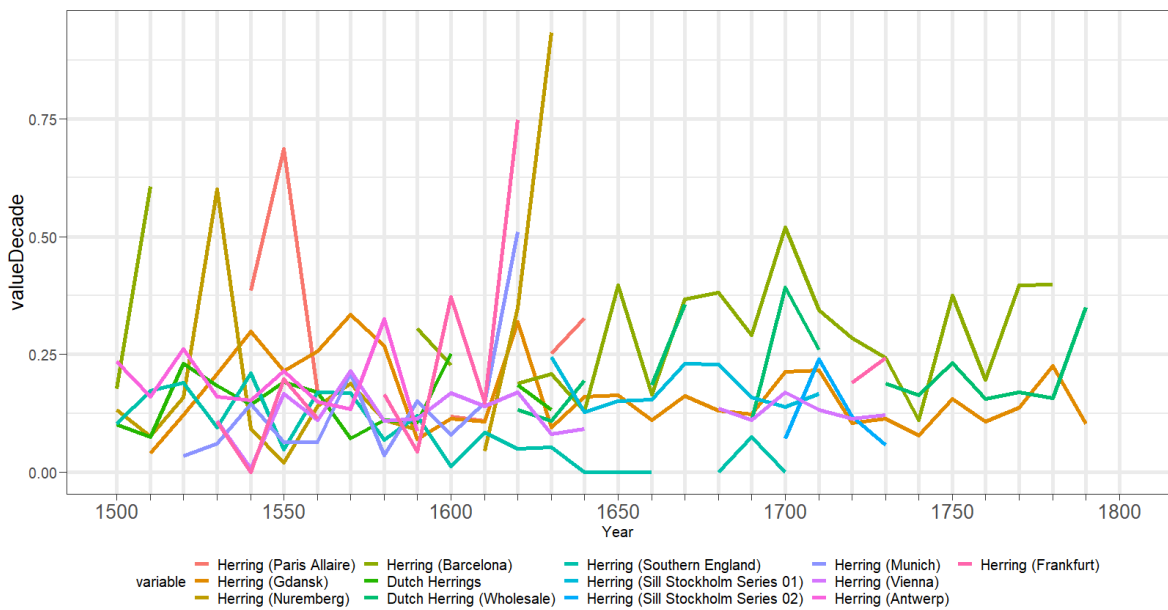


Figure 5.5. Coefficient of Variation for selected herring price series. (CV value displayed on the y-axis), representing the volatility within each series and how this volatility changes over time.

There also exist notable periods of clearly higher price volatility (i.e., higher CV values). For example, Nuremberg in the 1530s displayed volatile herring prices, and these were even more dramatically variable a century later in the 1630s. This latter episode was during the Thirty Years' War (1618 to 1648), and it is not surprising that prices were more volatile in that time. The 1630s were also a period of high volatility for herring in Stockholm. The prices in Paris showed some rather large CV values during the 1550s (see Appendix 3). These periods of volatility occurred during the French War of Religions, which compounded economic problems in Paris as elsewhere in France.²⁰⁷ This conflict likely influenced food supplies, in turn causing price variability. This did not only occur for herring though, the majority of the food products in Paris saw price increases in that time.²⁰⁸

The Nuremberg and Gdańsk herring markets are within regions that share common trading connections such as the important city of Lübeck (as discussed in Section 5.1.1). Herring price series for the two locations overlap for the period from 1535 to 1640. In the latter part of this period, prices in Nuremberg are very volatile. This was different for Gdańsk. Thus, if herring produce was traded between the two locations, Nuremberg was

²⁰⁷ Henry Heller. *Labour, Science and Technology in France, 1500-1620* (Cambridge, 2002), 119, notes that “there is no question that the combination of the ravages of war, the burden of heavy taxation, the decline in population, and the lowering of profit margins was responsible for a serious economic regression” by the end of the sixteenth century in France.

²⁰⁸ Allaire, “Internal Norfish Report One”.

experiencing larger price increases during the 16th century and first half of the 17th century (See Appendix D, Figure E.11), consistent with a potentially reduced integration between their markets at this time.

There are further periods when price series display contrasting levels of price volatility. Some locations displayed relatively lower price volatility than others. For example, herring prices in Southern England were relatively more stable than most locations; these low CV values indicating price stability in the region at the time and implying (though not confirming) integration within and between proximate markets in the region. Herring prices in Gdańsk were another series that displayed relatively low CV values, again implying considerable integration. Further, this series contains information for almost all years and for the majority of the three-century study period. Well preserved and detailed records were necessary to create such price series. The very existence and survival of these robust records strongly suggest the Southern England and Gdańsk markets were well-established markets that many have drawn effectively upon hinterlands and broader trade links.

By the mid-1700s, many of the series displayed lower volatility than in the previous century, indicating periods of stability in the aftermath of the General Crisis. Not all locations displayed this increased stability, with herring prices in Amsterdam becoming increasingly volatile. This occurred when the decline in the Dutch herring industry that began in the latter half of the 17th century and continued during the 18th century.²⁰⁹ It is possible the increased Dutch price volatility was related to pressure on the market from increasing herring prices. Conversely, in the case of Gdansk, increased supply of herring from Bohuslän is likely to be a factor that contributed to price decreases. This supply of herring may have also contributed to lower price variability in Gdansk.

In conclusion, evidence based on a combined reading of price trends and corresponding CV values indicates herring markets may have been slightly more integrated than wheat. It is difficult to say this with certainty, however. Wheat being supplied from a dispersed set of locations (i.e., farms) may have led to higher price variability than herring, which was coming from a smaller number of locations (i.e., ports). Contributing further to increased price volatility, wheat was exposed to factors that would have had a “fast” effect (i.e.,

²⁰⁹ Poulsen, *Dutch Herring*, 241.

within a year in some cases) through the likes of environmental disasters and climate. This is unlikely to have been the case for herring.

The level of integration certainly varied through time, with a broad if not universal toward greater integration in the 1700s, after considerable variability seen in the preceding periods when the Price Revolution and General Crisis occurred. The most notable period of increased price volatility occurred between the 1620s and 1640s, with many series displaying significantly higher CV values than normal. This occurred during the Thirty Years War (1618 to 1648), illustrating the influence of conflict in promoting price volatility through many potential mechanisms, not least perhaps in suppressing or reversing market integration (discussed further in Chapter 6). Thus, following a period of disintegration in the 17th century, markets appeared to be similarly integrated by the end of the 18th century as they had been in the 16th century.

5.2.2. Cod Markets

Available cod prices cover Barcelona, Paris, Amsterdam, and Southern England (Figure 5.6 below). In some instances, these series are based on prices of cod returned from the Grand Banks fisheries, while other series are based on prices of salted cod and stockfish from Icelandic and Norwegian fisheries.

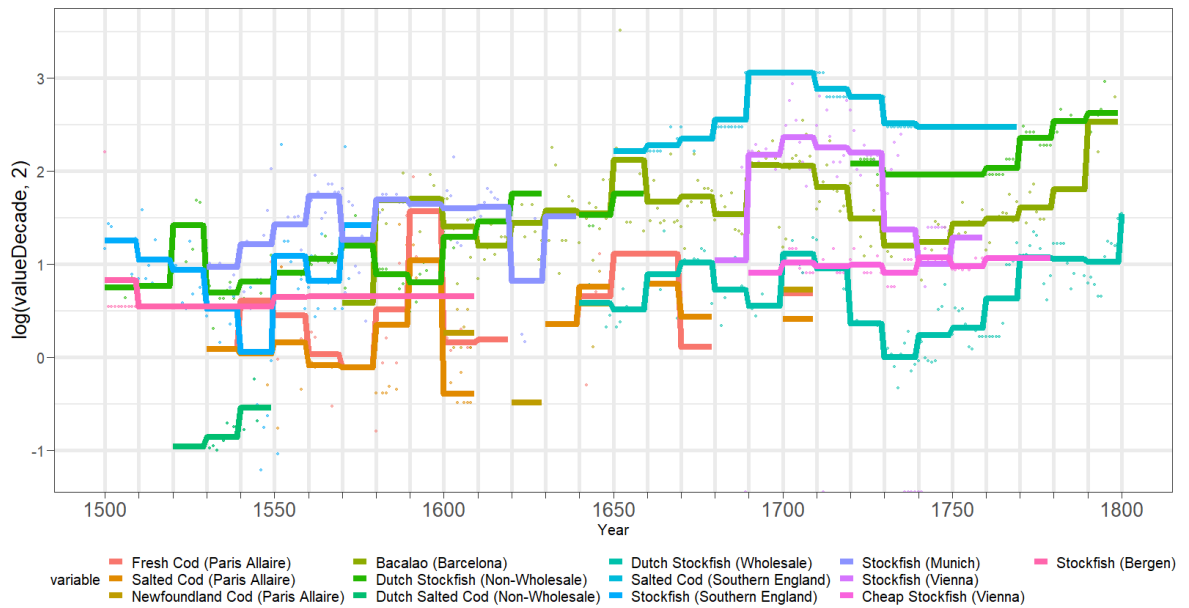


Figure 5.6. Cod prices in Southern England, Barcelona, and Paris. In Paris, they represent different cod products from both Newfoundland and Iceland. Prices are annual and represented by the dotted lines. These have been log-transformed.

There were different cod products, as discussed in Section 5.1.2. In Paris, the salted “green cod” was sold, while in Barcelona it was often the salted and dried bacalao. Both products were sourced from the Grand Banks.²¹⁰ Stockfish produce from the Northeast Atlantic was also available on some markets. There are examples of markets that sold different products over time, with the Southern English markets being such an example. Here stockfish was available at the start of the study period up to the 1570s, with salted cod prices becoming available from around 1650 up to the 1750s.

As already noted, larger CV values indicate (though cannot confirm) less integrated markets. Such values occurred at various times, and not always simultaneously across the different series. In the 1590s, cod prices in Paris displayed a peak, most likely the result of problems caused by the French Wars of Religions in the latter half of the 16th century. This change did not occur in the Spanish cod prices and several scenarios may thus be inferred, including that Spanish markets were simply isolated from (not integrated with) the Parisian markets and their associated supply chains. Alternatively, they may have been integrated to some degree, but there existed sufficient integration with other markets such that supplies could be sourced elsewhere or re-routed to avoid troubled regions such as Paris.

²¹⁰ For Paris this was confirmed by personal communication from Allaire on 14th March 2019.

Many of the observed CV values fall within a range of 0.1 to 0.3, similar to herring and slightly lower than wheat. There was a notable maximum of almost 0.8 for stockfish in Vienna in the 1680s, and minimum values of 0.0 for some decades (see Figure 5.7, below). Disregarding the unusually high values for Vienna, the highest CV values reached a maximum of approximately 0.6. Despite all the variability on display, it is notable that there is no strong trend of decreasing CV values over the long term for cod. There was also not a clear long-term trend of decreasing CV values for herring and wheat. There are some indications that higher CV values for cod occurred in the 16th century relative to the 18th century, however, there are less price series available to analyse later in the study period, and this could have influenced the apparent increase in price stability.

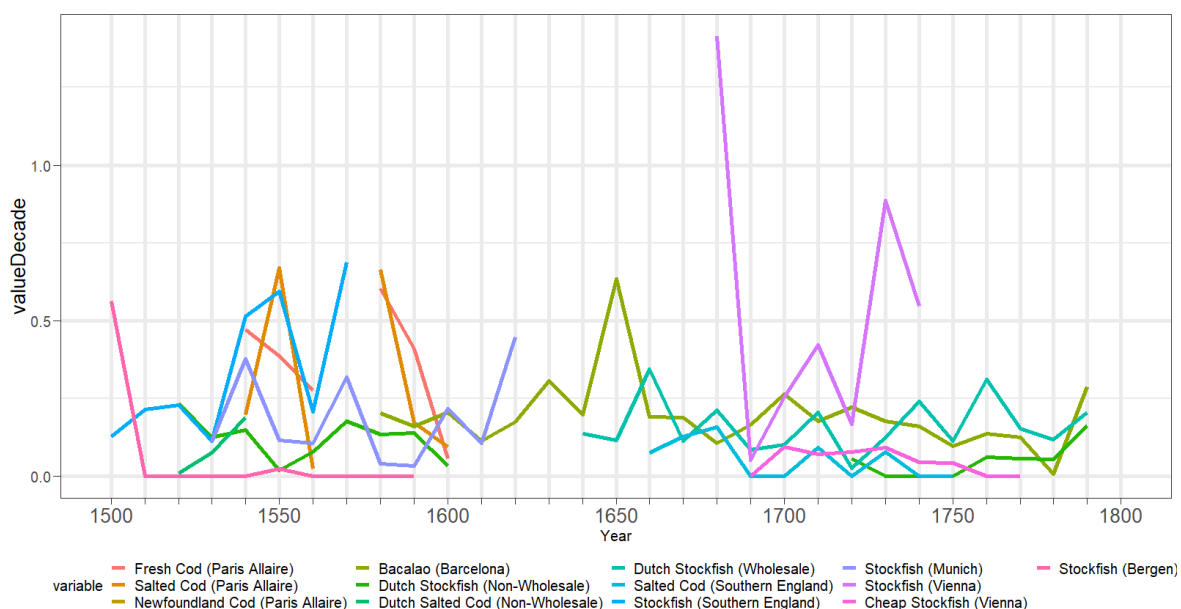


Figure 5.7. Coefficient of Variation (CV) for cod price series.

Southern England is an example of a location where prices for two different cod products are available - stockfish and salted cod. Stockfish exemplifies a product whose prices were quite volatile early in the study period. The available prices for this product cover the period from the early 1500s to the 1570s. In addition to their depiction in Figure 5.6 and Figure 5.7, above, these prices are also shown in Figure E.6 (Appendix D), offering a simplified visualisation. Salted cod prices become available in the 1650s and continue for a century, providing an example of a series that grows more stable later in the study period, as indicated by decreasing CV values. These prices, however, were often fixed in being based on multi-year contracts. This naturally results in a decreased variability, such that these

prices do not reflect the full price dynamics of the market at that time, perhaps reflecting prevailing market prices only at times of contract renewals or renegotiations. This caveat must be kept in mind when considering their evidence for market integration, but nonetheless it is notable that the prices of the period were comparatively stable and, moreover, became increasingly so through time.

Prices in Spain show some of the most dramatic changes during the study period, specifically during the 1650s. This occurred in the 1650s, as evident in Figure 5.6 with the dramatic spike in prices in 1652.²¹¹ Regina Grafe's *A Distant Tyranny* observed the extent of integration of fish markets within Spain in the period from 1650 to 1800.²¹² Her analysis indicates that markets selling cod produce from Newfoundland did display degrees of integration between regions in the country. This is evident in the cod CVs in this chapter, which began to decrease over the period from 1650 to 1800.

In Conclusion, as was also the case for wheat and herring, the available prices suggest changing levels of integration through the study period, with the mid-1600s showing the lowest levels of integration. The available price evidence is often consistent with increased integration of cod markets during the 18th, returning to the levels seen in the 16th century or being slightly more integrated.

5.2.3. Comparison Between Northern and Southern Europe

Barcelona is an example of a southern European location while Gdańsk and Stockholm are examples of northern European locations. The following example explores whether these northern and southern European locations shared similar or opposing price trends. The analysis also provides an insight into the existence and extent of inter-regional integration between these further removed regions. Two examples are given. The first is based on prices from each of Stockholm and Barcelona, while the second is from Gdańsk and Barcelona. (For more detail, Appendix 3 discusses each location in further detail.)

²¹¹ Possibly difficult to see, this is the red dot in 1652 that is near the top of the chart.

²¹² Regina Grafe, *Distant Tyranny*.

Barcelonian Bacalao and Stockholm Herring

Studying bacalao in Barcelona, and going further afield to herring prices in Stockholm, the prices are available simultaneously for both locations from the 1630s (Figure 5.8). Stromming (a lower quality herring product) prices are observed to decrease in Stockholm while bacalao prices increase in Barcelona up to the 1670s. This contrasting price trajectory is similar to that shown in the previous example, reinforcing the picture of strong demand for marine fish as a premium product in Spain, while it was becoming a cheaper source of nutrition in northern Europe.²¹³ There were also contrasting price movements between the two products in the following decades for which the data run in parallel, though in the last decade of the 1600s they both displayed a notable increase, reflecting a common trend of increases for many products and locations are the close of the study period.

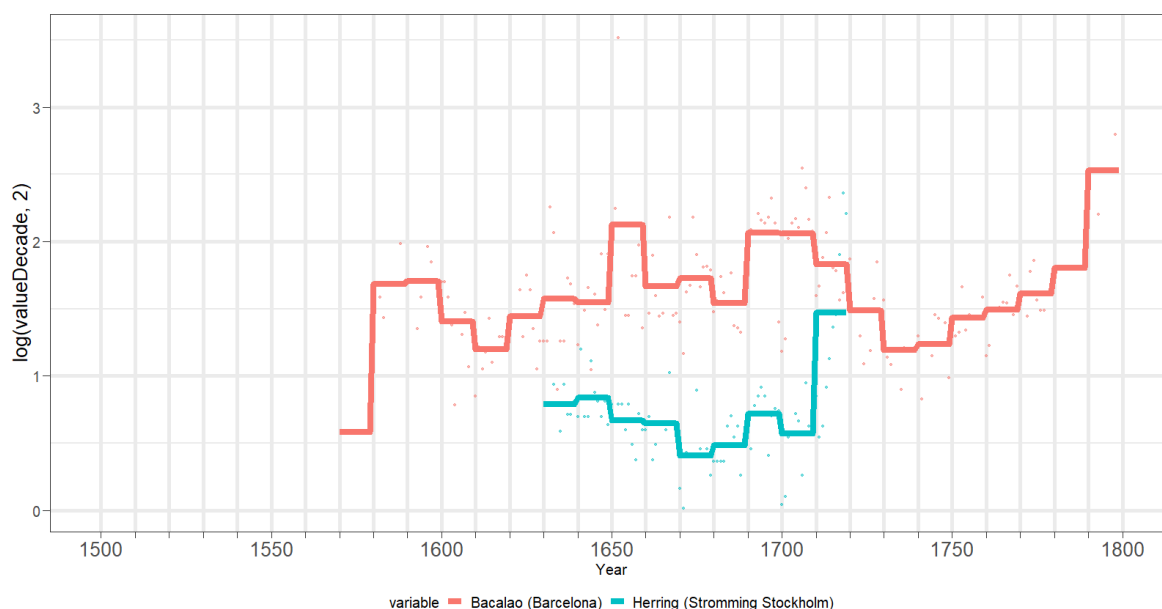


Figure 5.8. Prices in Stockholm for herring and Barcelona for bacalao.

Herring prices were stable during the 1650s, in comparison to the volatile prices that occurred in Barcelona in that time (see Figure 5.9, below). Also, in the 1710s, the final decade for which herring prices are available, prices became quite volatile in Sweden, while prices were trending toward greater stability in Barcelona. Again, this is evidence

²¹³ This inference must be made with caution, as it is not possible to compare the same product in both regions. Nonetheless, it is not the absolute price difference that is important here, but the relative trajectory of prices in both locations that suggests this.

supporting a lack of integration between both locations, or more specifically, they were not being influenced or reacting in the same manner to the same underlying influences.

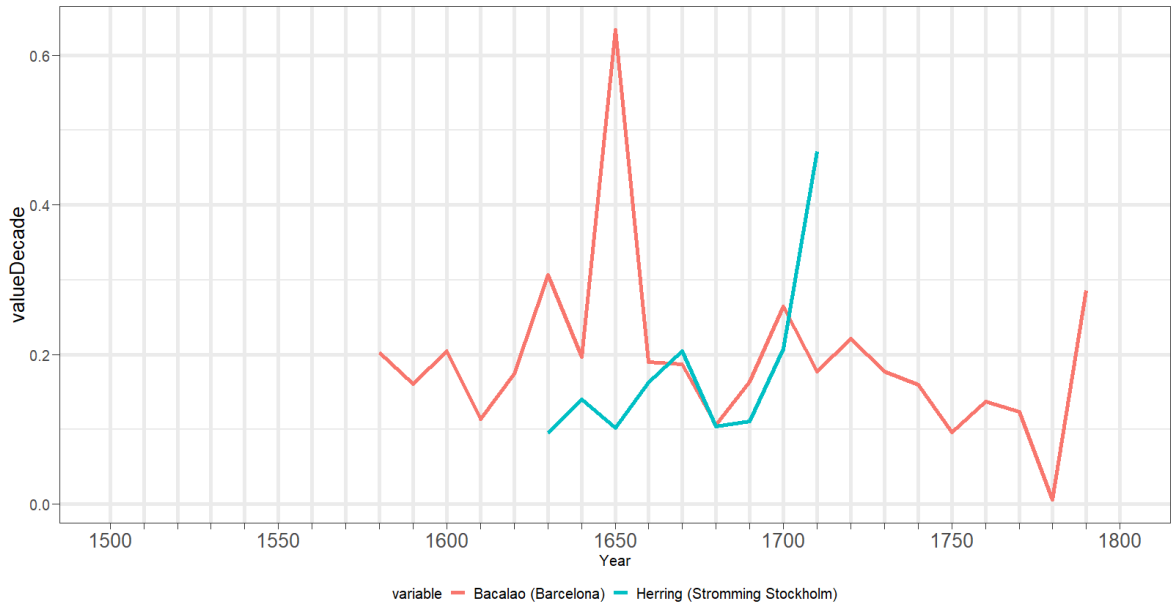


Figure 5.9. CV of prices in Stockholm for herring and Barcelona for bacalao.

Barcelonian Bacalao and Gdańsk Herring

Information is available for both series from the 1570s (see Figure 5.10 and Figure 5.11 below). Prices were increasing for both much of the time until the middle of the 1600s. Gdańsk herring displayed a predominantly downward trend in price from this time to almost the end of the study period in 1800 by which time a modest recovery is evident. This stands in contrast to cod prices in Barcelona, where the prices held reasonably steady for the first decades following 1650 and (despite a decrease in the opening decades of the eighteenth century) has increased over the long term to a record decadal high just before 1800. One (demand-side) interpretation of these trends suggests that in southern European regions, such as Barcelona, marine fish continued to increase in popularity, whereas in northern European regions, as represented by Gdańsk, decreasing prices for marine produce indicate it was becoming a less popular, lower priced option. This contrasting response in prices also reinforces the hypothesis advanced by Poul Holm and

others that there was a shifting preference toward increased fish consumption in southern Europe that was not matched in northern Europe.²¹⁴

Concerning potential inter-regional market integration, the two series shared only a limited amount of common price variation in the medium term (i.e., based on the decadal price averages). One such example was a decrease in prices for both commodities in the early 1700s up to the 1730s, however, bacalao prices began to increase again in the 1740s while herring continued to decline in price. The evidence here for any inter-regional integration is therefore suggestive at best.

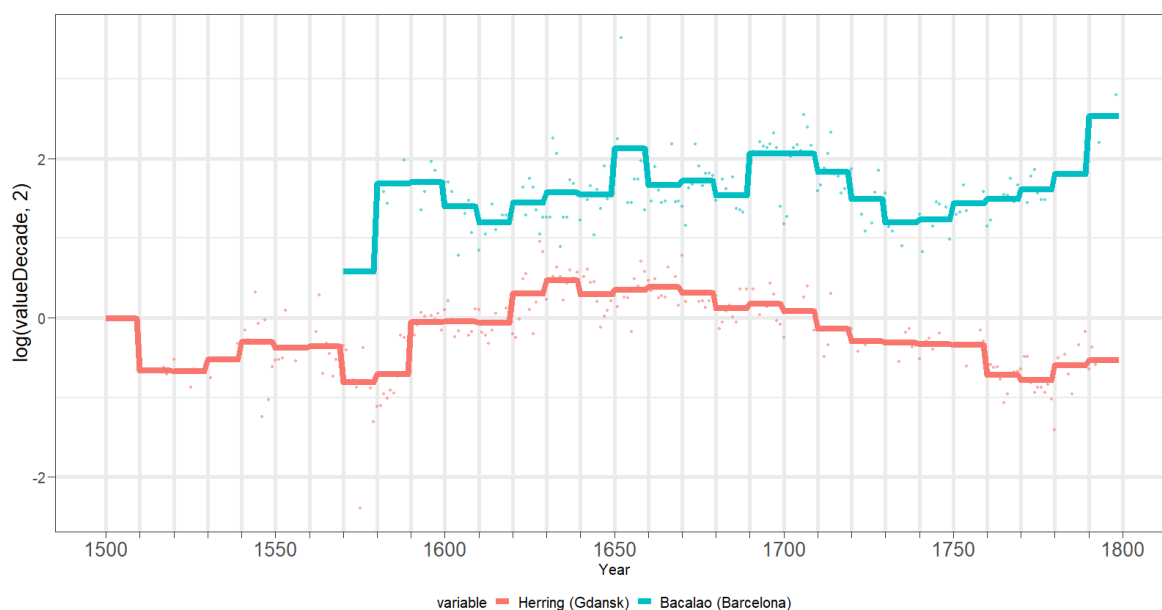


Figure 5.10. Bacalao from Barcelona and Gdańsk herring prices.

Price volatility for these two markets is shown in Figure 5.11. It is immediately clear that prices became distinctly volatile in Barcelona in the 1650s (discussed earlier), while this is not the case for the Gdańsk herring prices. The series mostly display different and apparently unrelated volatility over the study period, suggesting that these two markets were indeed insulated from one another and any volatility, or lack thereof, was not clearly driven by common underlying factors.

²¹⁴ Holm et al, "The North Atlantic Fish Revolution."

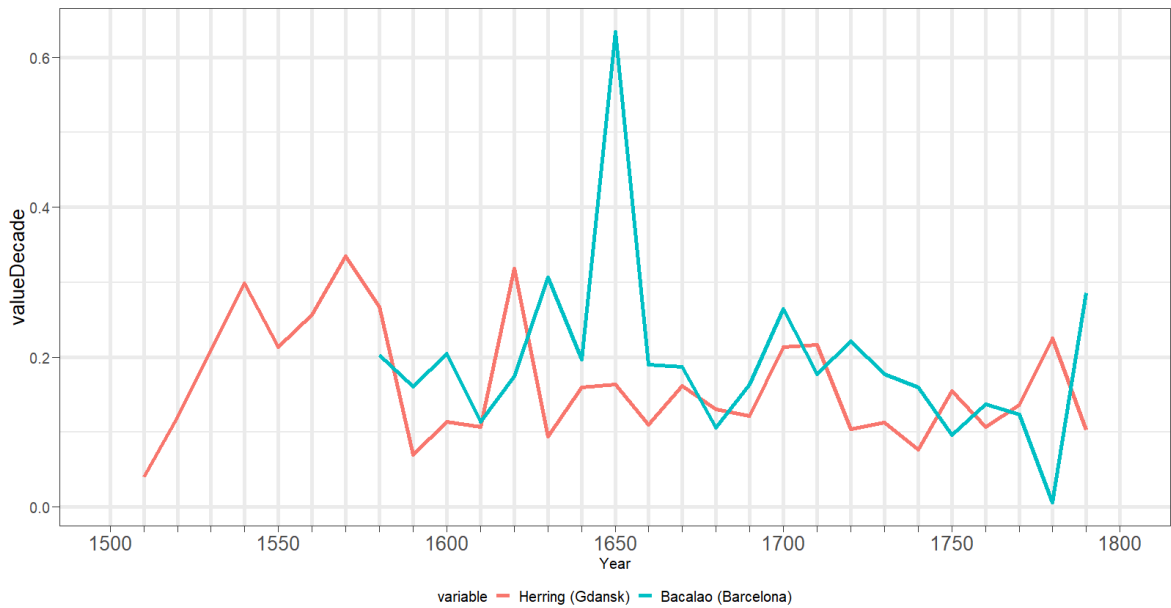


Figure 5.11. Decadal Coefficient of Variation values for case study. Northern European herring in Gdańsk and Southern European bacalao in Barcelona.

5.2.4. French and Spanish Cod

Both the French and the Spanish fishing industries returned Newfoundland cod. Both nations had different preferences, with the French preferring the salted “green cod” and the Spanish preferring the salted and dried bacalao. Bacalao sold in Barcelona was more expensive than the cod sold in Paris (Figure 5.12). They shared a trend of similar price changes, though they were not always the same. Following the large price increases from 1650 to 1652, prices returned to a level in Barcelona in the following decade. In the case of Paris, they remained high for an additional decade. This delayed, or slower, response in Paris suggests the Paris market was more integrated and better able to deal with disaster, thus smoothing out price shocks over a longer period of time.²¹⁵

²¹⁵ Cook and 56 others, ‘Old World megadroughts’.

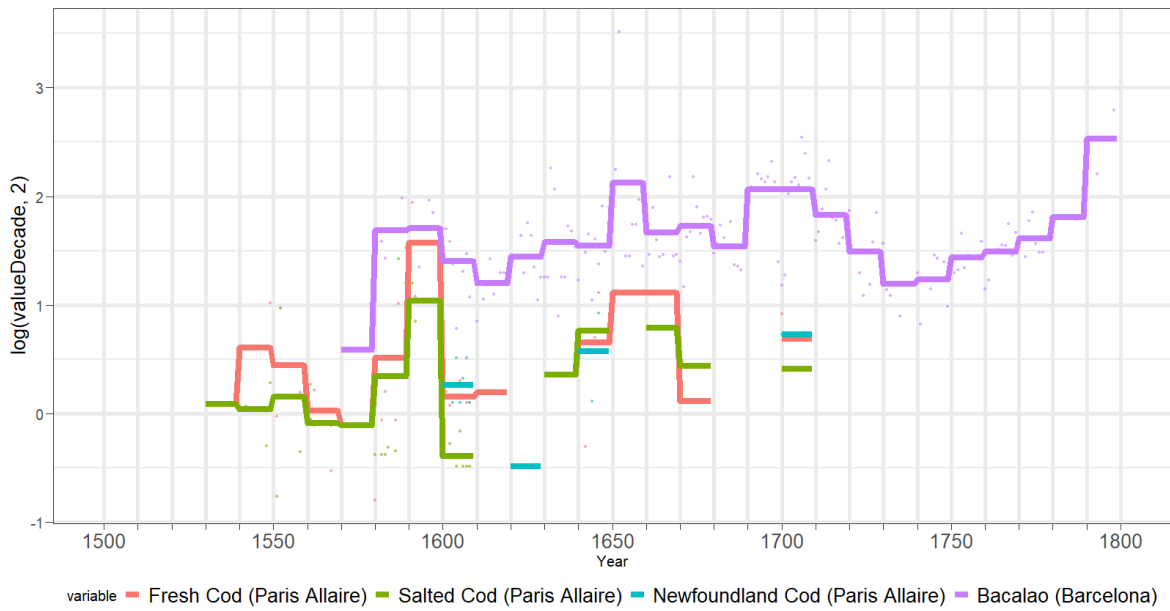


Figure 5.12. Cod prices in Paris and Barcelona.

Analysis of CV values for these two series are included below (Figure 5.13). Price information is available for the three commodities for a relatively short period of three decades from the 1580s to 1600. In the 1580s, Paris prices were very volatile, and decreased in the 1590s and were quite stable for the 1600s. Contrasting this, the prices in Barcelona were relatively stable in that period.



Figure 5.13. CV of cod prices in Paris and Barcelona.

5.2.5. Conclusions

The extent, or degree, of integration for cod and herring markets evolved during the study period, ending this period at similar levels as it started. Common to almost all products and locations was the prominent drop in levels of the integration of markets (as indicated by higher CV values) that occurred during the mid-17th century. This coincided with the build-up and aftermath of the Thirty Years' War (1618 to 1648) and was coincident with the broader "General Crisis" of the same century. The association between market prices and conflict clearly merits additional examination, which will be presented in Chapter 6. Relatively speaking, cod markets displaced similar levels of integrated herring, beef, and wheat by the conclusion of the study period. Regina Grafe observes that cod and beef prices began moving together after the 1650s.²¹⁶ This supports beef and cod markets developing a price relationship with one another. Bacalao prices emerged during the 16th century and quickly began to display similar CV trends to these other products. For example, in Barcelona in Spain. Herring markets may have been more integrated than cod, based on CV evidence. Though not by a large amount.

Integration levels varied between locations, and there may have been a differing behaviour between northern and southern European regions. Barcelona displayed high CV values for bacalao, relative to northern European regions, during the mid-17th century. On the other hand, CV values in northern Europe do not show much variability in common with southern Europe. Thus, markets throughout Europe were not influenced by the same events or had considerably different responses. The data also suggest that herring was a comparatively "reliable" food in Gdańsk, more resilient to external factors than bacalao in Barcelona, or simply did not experience the same "problems". Where the same problems were nominally faced (such as spatially extensive drought), a greater integration of markets (with commodity substitution) within northern Europe may have helped prevent price spikes of the sort observed for bacalao in Barcelona in the 1650s.

²¹⁶ Regina Grafe. "Popish Habits vs. Nutritional Need: Fasting and Fish Consumption in Iberia in the Early Modern Period," *Discussion Papers in Economic and Social History* No. 55 (University of Oxford, Department of Economics, 2004), 30.

5.3. Conclusions

Over the long term, most prices, and locations experienced three periods of price change. The first period related to the Price Revolution. It extended from 1500 to the early 1600s and was marked by a gradual long-term increase in all studied commodities prices and locations. This was followed by a period often referred to as the General Crisis, when price inflation halted and even deflation occurred in places. More specifically, change in prices occurred during or in the aftermath of the Thirty Years' War (1618 to 1618), depending on the region. In the final period, inflation returned in many locations, and larger price differentials began to emerge between commodities.

The ratios of lowest to highest prices between all locations and all 50-year periods indicate the levels of price volatility for each commodity. Higher values indicate higher price volatility. The ratio for wheat was highest (see Section 5.1), then herring, followed by cod, and finally beef showed the lowest. Prices need to be studied on a shorter term to understand how market integration evolved (Section 5.2). Studying the prices on the medium term suggests market integration may have been at the same level or slightly higher in well-established commodity markets such as beef and herring, particularly at the start of the study period. Newfoundland cod was a less established market earlier in the study period, it may have been slightly less integrated when price information became available to study in the late 16th century, however, this product quickly began to display similar CV values to the beef and herring markets. This suggests the markets for cod produce became quickly established and integrated over the course of the study period.

Levels of price change over the study period reveal northern and southern locations in Europe experienced a shift in the value of marine fish, with fish becoming lower priced in the north, while becoming higher priced in the south. Gdańsk is a prominent example, it displayed a trend of decreasing value of herring in the mid-1600s that continued to the end of the study period. In contrast, in the southern European region of Barcelona, bacalao displayed increasing prices for much of the same period. In summary, the increasing price for cod, along with the increasing supplies during the study period, suggests a larger demand for cod in southern Europe. On the other hand, the decreasing prices for herring in Gdańsk, contrasting increasing beef prices, would have made herring a progressively lower-priced option. Thus, this is evidence in support of a hypothesis that preferences for

marine fish produce were diverging between northern and southern regions from the late 17th century and continuing through the 18th century.

6. Conflict

Conflict can devastate the operation of market economies, which in turn may be observable through the dynamics of commodity prices. Rarely were there periods of complete peace in Europe during the early modern period. Civil wars occurred, not least the French Wars of Religion from the mid to late 16th century.²¹⁷ Conflict levels were broadly elevated during the 17th and early 18th centuries, in a period often referred to as the “General Crisis”.²¹⁸ The Thirty Years’ War (1618 to 1648) was one particularly notable highlight of this. It was an intense multi-decade conflict into which many European nations were drawn. Conflict often led to a disruption of trade between nations.²¹⁹ This could impact the ability of merchants to supply particular commodities (increasing costs if not making trade outright impossible), in turn impacting prices. A further knock-on was the (at least temporary) dis-integration of markets, which disrupted progress towards integration. Food security was also consequently at times reduced. For example, the Thirty Years’ War (1618 to 1648) had a major effect on trade in Poland.²²⁰ Some battles even bore the name of food produce, for example, the Battle of the Herrings in France (1429 CE), won by the English against the French²²¹ (Figure 6.1, below). The battle was not waged over herring. Kelly DeVries observes that villagers profited from the herring(s) left following the battle, and hence gave it the name it has today.²²² This example is given for more reason than simply airing its name, as it also highlights how the provisioning of armies involved fish products of concern to this thesis.²²³

²¹⁷ Robert Jean Knecht. *The French Religious Wars 1562–1598* (Oxford, Osprey Publishing, 2002).

²¹⁸ Geoffrey Parker. “Crisis and Catastrophe: The Global Crisis of the Seventeenth Century Reconsidered,” *The American Historical Review* 113, no. 4 (2008): 1053-1079, 1053.

²¹⁹ Such disruptions are described in an abundant literature for the period. See, for examples: Sam White. *The Climate of Rebellion in the Early Modern Ottoman Empire* (Cambridge: Cambridge University Press, 2011); Geoffrey Parker. *Global Crisis: War, Climate Change and Catastrophe in the Seventeenth Century* (New Haven and London: Yale University Press, 2013). For a perspective on the vulnerability of contemporary trade and food supply, see: Michael Puma et al. “Assessing the Evolving Fragility of the Global Food System,” *Environmental Research Letters* 10, no. 2 (2015): 024007.

²²⁰ Victoria Bateman. *Markets and Growth in Early Modern Europe* (Routledge, 2015), 27.

²²¹ Kelly DeVries. *Joan of Arc: A Military Leader* (The History Press, 2011), 67.

²²² *Ibid*, 66.

²²³ Some merchants made considerable profit serving the supply needs of armies in this period. The increased demand from such provisioning can be seen as another potentially significant influence on prices. See: Jeff Fynn-Paul. *War, Entrepreneurs, and the State in Europe and the Mediterranean, 1300-1800* (Brill, 2014); David Parrott. *The Business of War: Military Enterprise and Military Revolution in Early Modern Europe* (Cambridge University Press, 2012).



Figure 6.1. The Battle of the Herrings. Journée des Harengs. (From *Les Vigiles de Charles VII* by Martial d'Auvergne, written c. 1477–84, held by Bibliothèque Nationale, Paris). In the image there are herrings in the baskets.²²⁴

6.1. Measuring Conflict

This chapter will compare commodity prices to a chronology of conflict events to examine the relationship between them. The basis of the chronology of conflicts studied in this section is a database compiled by Peter Brecke.²²⁵ Brecke's chronology quantifies a large number of conflict events over the period 1400 CE to 2000 CE. His database was last updated in 1999, when presented at a meeting of the Peace Science Society. It would be preferable if this was a peer-reviewed dataset, but at this time, this is not the case. Brecke's catalogue has, however, facilitated credible studies of historical conflict levels. For example, it acted as the foundation of Max Roser's study entitled "War and Peace from Our

²²⁴ Accessible online: <https://gallica.bnf.fr/ark:/12148/btv1b105380390/f118>.

²²⁵ Peter Brecke. "Violent Conflicts 1400 AD to the Present in Different Regions of the World," in *1999 Meeting of the Peace Science Society* (unpublished manuscript, 1999). <http://www.cgeh.nl/data#conflict>, <http://www.cgeh.nl/sites/default/files/Conflict%20Catalog%2018%20vars.xls>.

World in Data”, which examined global conflict levels from 1500 to around 2000 CE.²²⁶ In this section, rather than simply stating if conflict was active in a particular year (i.e., using the data to create a presence-absence, 0,1 series), the *level* of conflict for each country in a given year was instead calculated. This provides a picture of the relative frequency of conflict across time and space. To validate and check the accuracy of Brecke’s catalogue, Tony Jaques’ *Dictionary of Battles and Sieges* has been compared to a selection of years and events, as well as Jonathan Dewald’s *Encyclopaedia of the Early Modern World* has also been explored.²²⁷ To “cross validate” between these sources, events were chosen from each. They were checked to confirm they corresponded between each source. The date range (in years) was also checked.

It should be noted that the *level (or magnitude)* of conflict is not captured by the above measure alone. Other measures can thus be proposed to attempt to quantify this, for example by recourse to records or estimates of the number of deaths that may have been directly caused by any given conflict. Large or prominent conflicts are, however, distinguished over the course of this chapter. For example, the Thirty Years’ War (1618 to 1648). Also, Table 6.1 (below) is a list of events associated with one location, the Netherlands, as extracted from Brecke’s database. This includes large events such as the Anglo-Dutch Wars and the Thirty Years’ War, all of which occurred over the course of the 17th century.

²²⁶ Max Roser. “War and Peace” (2019). Published online at OurWorldInData.org. Retrieved from: <https://ourworldindata.org/war-and-peace> [Online Resource]

²²⁷ Tony Jaques. *Dictionary of Battles and Sieges*. 3 Vols (Greenwood Publishing Group, 2007); Jonathan Dewald, ed. *Europe 1450 to 1789: Encyclopaedia of the Early Modern World*. 5 Vols (New York, Charles Scribner's Sons, 2004).

Table 6.1. Conflict Events for the Netherlands within the period from 1500 to 1800. (In some cases, there is a formatting issue, with dates appearing twice).

Name	Name
Netherlands (Friesland), 1522-24, 1522 - 1524	Dutch-Portuguese War, 1640 - 1641
Denmark (succession, with intervention by Lubeck and Netherlands), 1531-32, 1531 - 1532	Dutch-Portuguese War in West Africa, 1641 - 1641
Dutch War of Independence (Eighty Years War), 1566 - 1609	Dutch-Portuguese War in West Africa, 1648 - 1648
First Phase of Eighty Years War, 1566 - 1568	First Anglo-Dutch War, 1652 - 1653
Insurrection of the Beggars (Eighty Years War), 1569 - 1572	First Northern War, 1655 - 1661
Spain-Netherlands, 1572-1576, 1572 - 1576	Dutch War with Portugal, 1657 - 1661
Spain-Netherlands (with intervention from France and England), 1578-1587, 1578 - 1587	Second Anglo-Dutch War, 1665 - 1667
Spain-Netherlands, 1589-1607, 1589 - 1607	War of the Devolution, 1667 - 1668
Netherlands-Mauritius, 1598, 1598 - 1598	Third Anglo-Dutch War, 1672 - 1674
Thirty Years' War, 1618 - 1648	Dutch War of Louis XIV, 1672 - 1678
Dutch-Spanish War (Eighty Years War), 1621 - 1648	English, Dutch-Brandenburgers (Germans) (Ghana), 1711, 1711 - 1711
Dutch-Portuguese War, 1622 - 1622	Britain-Dutch (Bengal), 1759, 1759 - 1759
Dutch-Portuguese War, 1624 - 1629	Brabant Revolt, 1789 - 1790
Spanish Netherlands (Brussels), 1633, 1633 - 1633	Ceylon War, 1795 - 1796
Dutch-Portuguese War, 1638 - 1640	Netherlands (Friesland), 1522-24, 1522 - 1524

Indices have been developed for each location included in this chapter (such as the example for the Netherlands above). They were developed from Brecke’s catalogue by applying data analysis techniques in Excel and further development in the R statistics package. These R scripts, which comprise a useful resource for similar work in future, can be found in Appendix D. (Conflict Analysis section). Brecke’s database comprises one large table. A row in this table corresponds to a single conflict and includes information on the regions involved and the time-period in which it occurred. For this thesis, code was written in the R package to extract locational chronologies. This included applying computer programming techniques (such as “loops” and advanced “map/reduce” techniques). More specifically, each regional index was developed by searching the catalogue for conflicts that had names that related to locations, and references in the catalogue to what countries were involved. As for what Brecke considered a conflict, his catalogue is based on the “Richardson’s Magnitude” measure. He has included events that measured 1.5 or greater on this scale, which he states equates to 32 or more deaths having occurred.²²⁸ Thus, to an extent these indices may not capture every conflict in a location. From inspection, though, the trends of conflict levels do correspond to what would be expected for each location as

²²⁸ Brecke, (1999), 1.

based upon consultation of military and political histories of the period.²²⁹ For example, the Thirty Years' War is evident in all locations under consideration, being active over a large spatial scale covering much of what is modern-day Europe.

The following graph (Figure 6.2) displays a time series that is annual in resolution. This time series is an index with a single value per year, based on the number of active conflicts and the number of regions involved. It is based on the sum of the regional indices for locations that are studied in this chapter and for which price information is also available. These locations are France, Germany, the Netherlands, Sweden, Belgium, Poland, Spain, England, and Austria. Thus, "weight" is added to a conflict that involves more than one location by counting it for each region it was active in for a given year. This is beneficial for indicating the potential magnitude, or influence, of a conflict. That is, if more countries were involved, then the level of the conflict is graded as higher. As an example, if a particular conflict is active in five regions in a given year, a value of five will be included for that conflict's contribution to the index in that year.

This overall regionally aggregated index displays greater levels of conflict in the first half of the 17th century. This occurs in the lead up to and during the Thirty Years' War (1618 to 1648), reaching a peak at the end of this major conflict, which involved most European countries at some point over its 30-year course. Another significant contributor to this index in the years prior to the Thirty Years' War was the Eighty Years' War (1568 to 1648). Many nations were involved, such as the Dutch, French, Spanish, and English. In the aftermath of the Thirty Years' War, with the Treaty of Utrecht in 1648, a period of relative peace began and persisted for the rest of the 17th century. However, conflict levels again rapidly increased in the first quarter of the 18th century, including the War of Spanish Succession (1701 to 1714) and the Great Northern War (1700 to 1721). Following this, conflict levels remained comparatively low, including some of the lowest values observed

²²⁹ Useful examples, of which there are very many, include: Iosias Jody. *Franco-Spanish War (1635-1659)* (Cred Press, 2011); Robert Jean Knecht. *The French Wars of Religion 1559-1598* (Routledge, 2014); James C. Riley. *The Seven Years War and the Old Regime in France: The Economic and Financial Toll* (Princeton University Press, 1986); Ronald G. Asch. *The Thirty Years War* (Macmillan Publishers Limited, 1997); Robert I. Frost. *The Northern Wars: War, State and Society in Northeastern Europe, 1558-1721* (Routledge, 2014); Brian J. Davies. *Warfare in Eastern Europe, 1500-1800* (Brill, 2012); Christine Shaw, and Michael Mallett. *The Italian Wars 1494-1559: War, State and Society in Early Modern Europe* (Routledge, 2007, 2nd Ed). Further examples include large encyclopaedias of early modern European history, that include lists of conflict: e.g., Jonathan Dewald, ed. *Europe 1450 to 1789: Encyclopaedia of the Early Modern World*. 5 Vols. (2004).

for the entire study period, until the onset of an upward trend from the 1780s, prior to the Napoleonic Wars of 1803 to 1815.

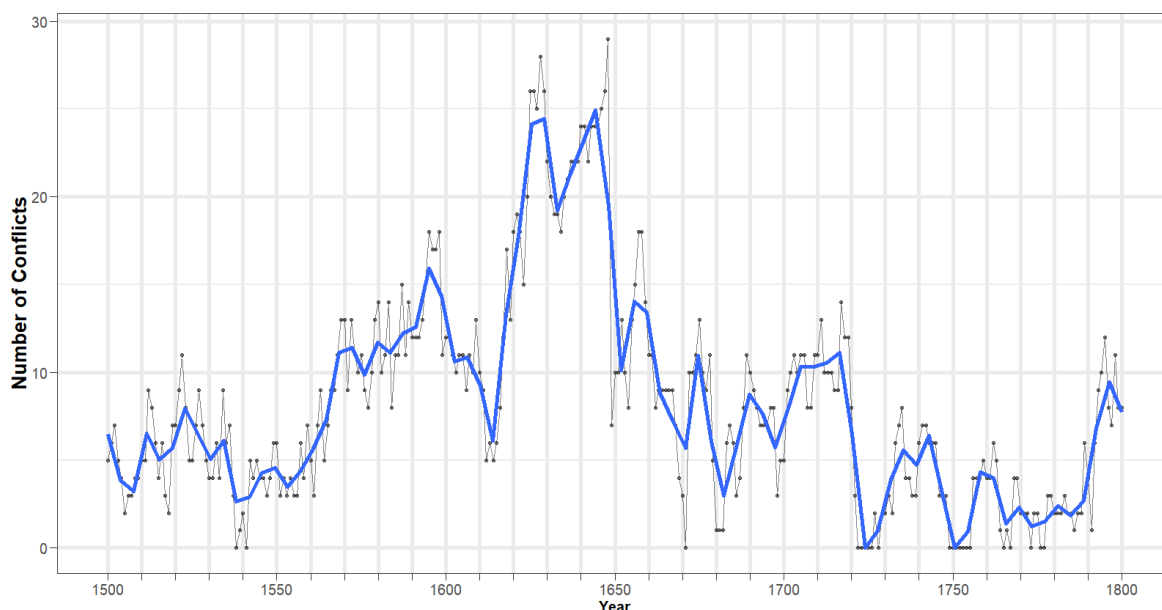


Figure 6.2. Conflict levels in Europe. Based on an aggregated count of conflicts across all involved countries per year. A loess trend-line has been added to emphasise longer-term trends.²³⁰

Subdividing the total index presented in Figure 6.2 into its regional components leads to Figure 6.3 (below). In this graph, the total conflict level for each country under consideration is displayed individually. Conflict levels for France and England share similar trends, largely a result of both nations being involved in many of the same conflicts, even if they were often antagonistic, as per the Thirty Years' War. The Netherlands experienced relatively high conflict levels, with these events listed earlier in Table 6.1. At least in part, this is due to numerous conflicts the Dutch Republic was involved in with competing nations during its rise in economic power.²³¹ In contrast, some countries display notably low levels of conflict, such as the region labelled "Belgium" in the dataset. In the case of Belgium, it was not an independent region during the study period, with the modern nation state boundaries not yet in existence, hence the absence of conflicts recorded in the index beyond the Thirty Years' War (1618 to 1648).

²³⁰ This is a "Loess" trendline with a span of 0.05.

²³¹ Jonathan Israel. *The Dutch Republic: Its Rise, Greatness and Fall, 1477-1806* (Oxford University Press, 1995). There are various examples of conflicts such as wars and revolts that occurred as it gained power.

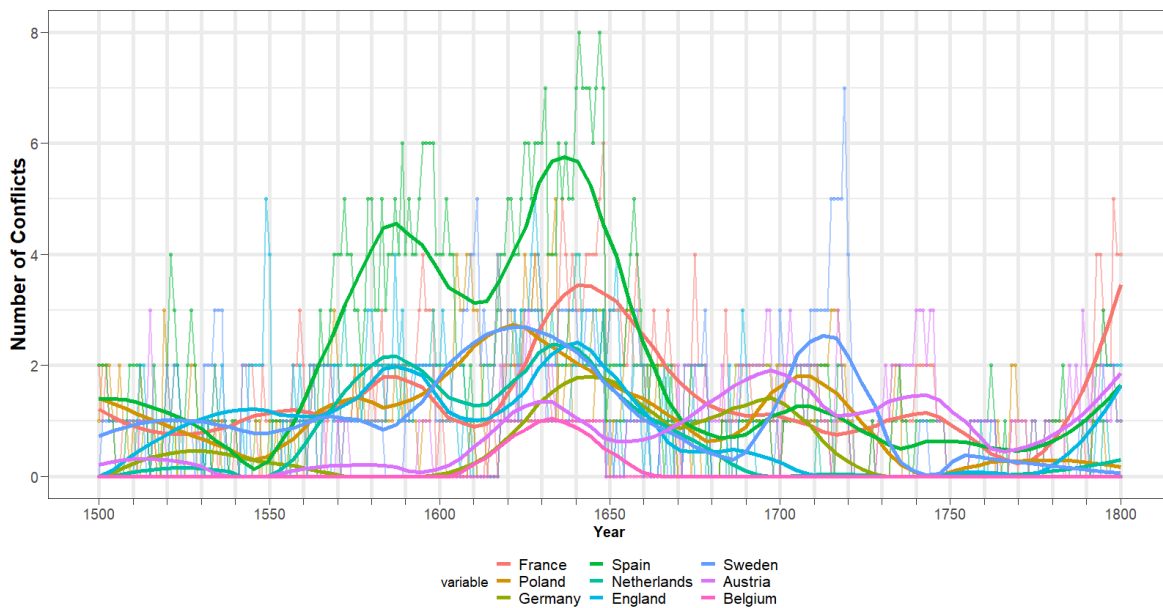


Figure 6.3. Total conflict levels for different territories in Europe. A loess trendline has been included for each country.²³²

Due to the large amounts of available conflict and price information, it becomes difficult to distinguish these when they are included on the same graph. For this reason, the conflict levels are presented in a different manner below (Figure 6.4), with different degrees of grey shading applied to indicate the number of conflicts for each year, based on the sum of the nine regional indices. Thus, this grading matches the values in Figure 6.3. White indicates a year when no conflicts occurred and gradually darker shades of grey for higher levels of conflict. In subsequent sections, price data will be overlain to facilitate various comparisons with conflict.

²³² Loess trendline span has been set at 0.25.

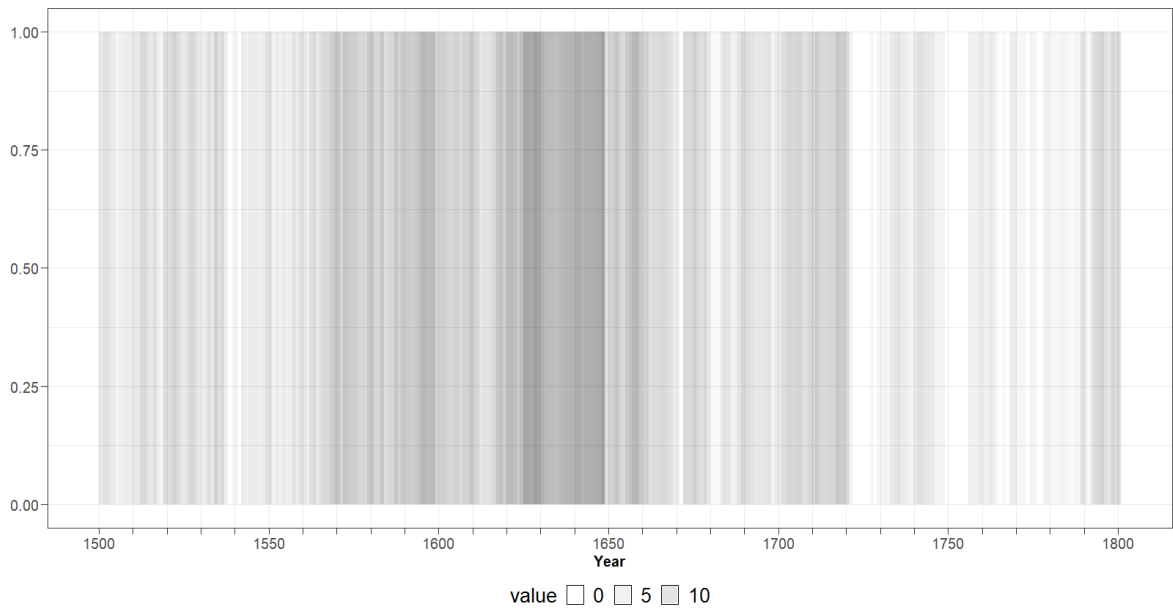


Figure 6.4. Total conflict levels in Europe as represented by a grey scale to represent conflict levels. White represents no recorded conflict in any country considered, while a year with just one conflict in one country would receive the lightest shading available, becoming progressively darker grey as a year experienced greater conflict counts across countries.

6.2. Changing Nation States and Institutions

Changes of ruling empires and monarchies are often associated with (acting as a potential product and/or cause of) societal conflicts, and in some cases, environmental events.²³³ Even without violent conflict, such changes may be associated with significant changes in economic and foreign policy and may thus have impacted markets and trade, potentially registering through price movements. Nation states and empires in Europe during the early modern period included the Kalmar Union, British, French, Habsburg Monarchy, Holy Roman Empire, Kingdom of Prussia. A partial list of years associated with changes in control has been tabulated (Table 6.2, below). This includes the Habsburg Netherlands shifting to the Holy Roman Empire in 1581, and the Kalmar Union to Sweden in 1524. Given its great importance to many parts of the European economy, one example of a change in trading company is also examined for its potential price impact, that is the removal of the Hanseatic League from London in 1598, which was one of the four main Hansa Kontors.²³⁴

²³³ White, *The Climate of Rebellion*; Parker, *Global Crisis*; Jared Diamond. *Upheaval: Turning Points for Nations in Crisis* (Little, Brown & Co., 2019).

²³⁴ Arnvéd Nedkvitne. *The German Hansa and Bergen 1100-1600* (Köln: Böhlau Verlag, 2014), 581; Philippe Dollinger. *The German Hansa* (Bristol: Western Printing Services Ltd, 1964), 343.

Table 6.2. Examples of changes in ruling Empires and influential trading companies.

Location	Event	Country	Type	Year
Amsterdam	From: Habsburg Netherlands to: The Holy Roman Empire	Netherlands	Empire	1581
Amsterdam	From: The Holy Roman Empire to: The Dutch Republic	Netherlands	Empire	1648
Amsterdam	From: The Dutch Republic to: France	Netherlands	Empire	1796
Antwerp	From: House of Habsburg to: Austrian Netherlands	Belgium	Empire	1713
Antwerp	From: Austrian Netherlands to: France	Belgium	Empire	1795
Munich	From: Holy Roman Empire to: Habsburg family	Germany	Empire	1705
Gdansk	From: Kingdom of Poland to: Kingdom of Prussia	Poland	Empire	1794
Barcelona	From: Spain to: Habsburg Spain	Spain	Empire	1516
Barcelona	From: Habsburg Spain to: Spanish Bourbons	Spain	Empire	1700
Madrid	From: Spain to: Habsburg Spain	Spain	Empire	1516
Madrid	From: Habsburg Spain to: Spanish Bourbons	Spain	Empire	1700
West Sweden	From: Kalmar Union to: Sweden	Sweden	Empire	1524
Stockholm	From: Kalmar Union to: Sweden	Sweden	Empire	1524
Barcelona?	From: Spain to: Habsburg Spain	Spain	Empire	1516
Barcelona?	From: Habsburg Spain to: Spanish Bourbons	Spain	Empire	1700
London	From: Hanseatic League to: London Merchants	England	Company	1598

Figure 6.5 (below) builds on the previous chart and includes these events. The blue vertical lines represent a year when there was a change of ruling empire in any location in this chapter. The orange vertical line represents a change in trading company. In this example, there is only one such example, when the Hanseatic League were expelled from London in 1598.

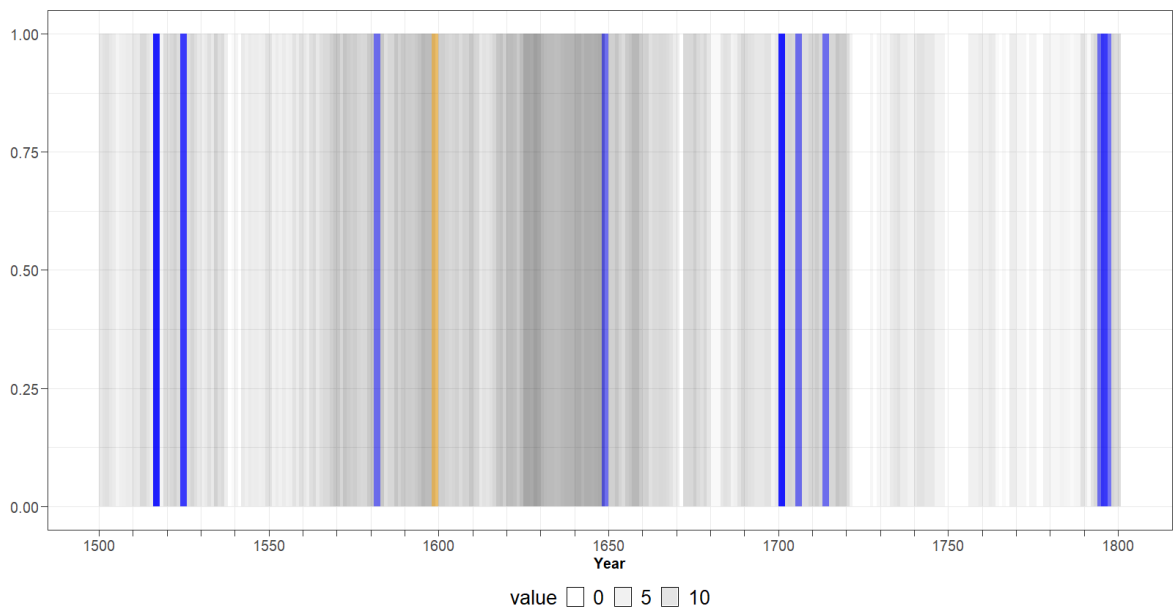


Figure 6.5. A representation of cases of years when a country saw a change of ruling entity or change in company. That is empire, monarchy, etc.

6.3. Herring

Herring prices are presented below (Figure 6.6). The prices are log-transformed to allow for clearer visualisation of change over time by limiting the influence of large price changes. An overall trendline (in red) has been included and is based on all herring prices available in each year. This trendline can be thought of as a “herring price index”, representing average prices in Europe, though one that is limited by the information that is available for each year.²³⁵ The prices are set against the backdrop of conflict levels for Europe, the intensity of which is represented by the gradient of the grey background. As stated earlier, the vertical blue lines indicate times when there was a major change in the political entity (e.g., empire) ruling a given nation.

²³⁵ The index is based on an average of the herring prices available for each country in a given year. Potential bias can exist due to the changing coverage of the price series at each location. To understand the specifics of each location, Appendix 4 includes an extensive analysis that studies each location, and their respective conflict levels and prices series.

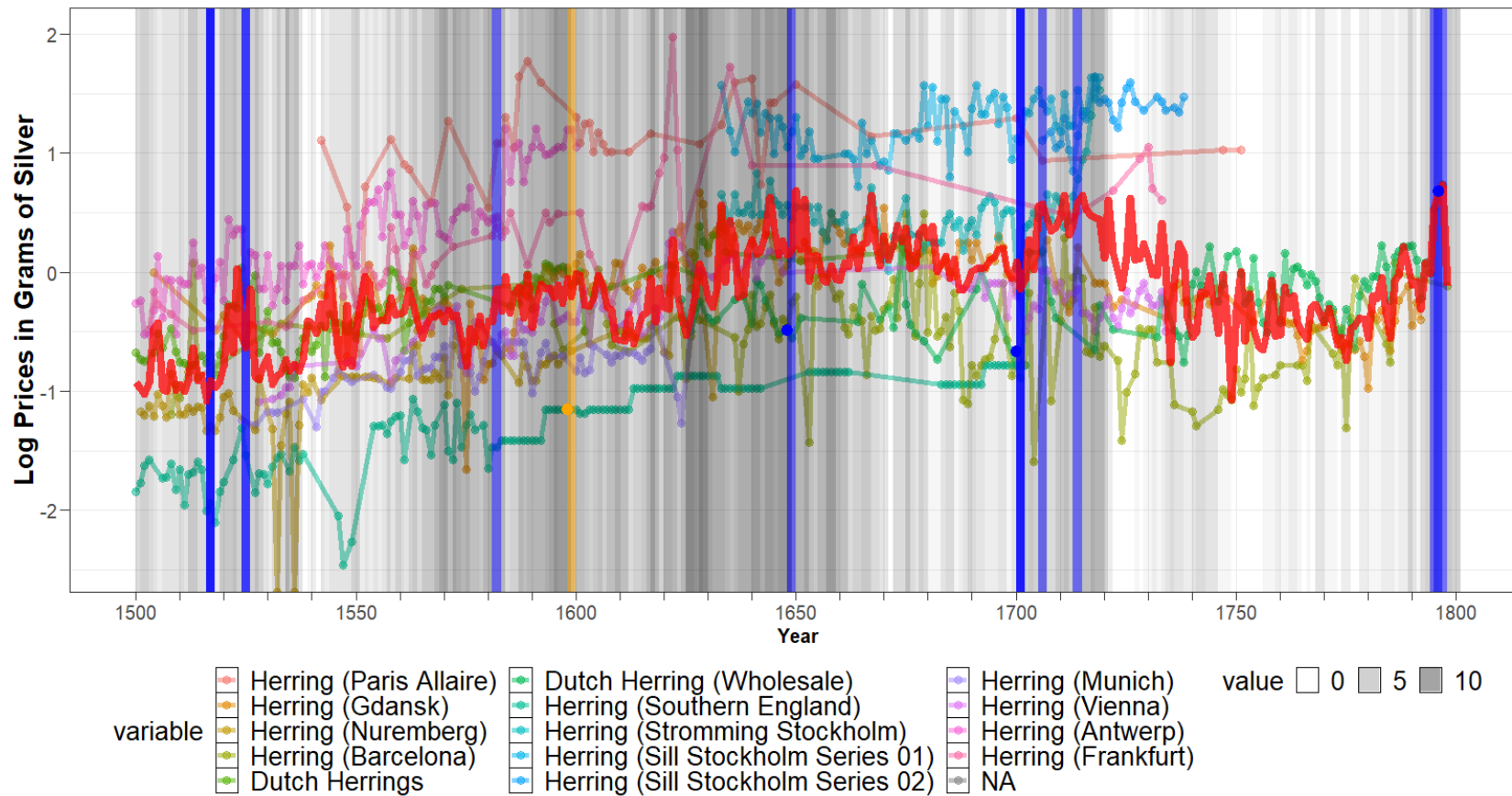


Figure 6.6. Herring prices (log transformed) and compared to conflict. The blue lines indicate a change in ruling entity (empire, monarchy, etc.). Orange represents a change in trading company in a location. Grey indicates the level of conflict, with darker shade indicating more conflict. Missing years are estimated by the linear trend between known data points. The red trendline is based on an average for each year, which is limited to the values available in each year.

Prices, as represented by the index, follow a gradual long-term increase from 1500 to around 1650, in keeping with the Price Revolution (discussed in Chapters 1 and 5, and occurring from the late-16th and into most of the 17th century). Thereafter, in the context of the General Crisis, including the Thirty Years' War (1618 to 1648), herring prices saw little to no inflation during the remainder of the 17th century. Then, during the 18th century, there is a long period of herring price decline that is followed by a period of recovery in the latter quarter of the century. Broadly speaking, most herring price series follow the same long-term trend as marked by the herring index trendline. This sharing of common trends suggests the operation of long-term forces acting in common on the herring markets, including patterns of conflict, though a universal relationship is not in evidence. Nonetheless, there exist some apparent multi-decadal trends in common, most strikingly the downward trajectory of prices from the (approximately) 1730s to 1770s, following the steep fall in conflict levels in the period relative to that preceding. Here, the reduction in conflict may have allowed for increased market integration (evidence for which was noted in Chapter 5), hence driving an average price decrease. That said, the number of price series under consideration drops in this period, and thus caution must be exercised in uncritically accepting this interpretation.

Over the shorter term, conflict bears a clearer relationship with prices, with abrupt changes in the index often seen to occur during periods of heightened levels of conflict. For example, herring prices for Paris follow a trend of higher values during periods of higher conflict, including the dramatic events of the Siege of Paris in 1590.²³⁶ A further prominent example occurred during the 1620s and 1630s. Prices had seen a notable drop preceding the heightened conflict levels in the 1620s. This was followed by increased volatility in the 1630s, evident as several increases and decreases. By the 1650s, prices peaked. A more detailed correlation analysis has been completed in Chapter 8.

An association between prices and changes in governing entities, institutions and possibly the removal of the Hanseatic Kontor in London in 1598 is also apparent. For example, in

²³⁶ Here the herring prices are matched by well-known sharp increases in other commodities (e.g., bread) during the siege: Philipp Blom. *Nature's Mutiny: How the Little Ice Age of the Long Seventeenth Century Transformed the West and Shaped the Present* (Picador, 2019), 39-40, 52-53.

1516 there was a change in Habsburg rule in Spain, and in 1524 the Kalmar Union dissolved, and Sweden became independent. Herring prices experienced a large increase on average after 1516, with a peak in 1524. It is plausible that these events, situated at distant and opposing ends of Europe, caused pressure on herring prices. Conflict in that time was reasonably high, including conflict between the Kalmar Union (controlled by Denmark) and Sweden. Also particularly notable are prices which began a period of marked increase in the early 1700s, starting and continuing during a cluster of these conflict events (shown above, Figure 6.6).²³⁷

In conclusion, the available evidence points to a correspondence between elevated levels of conflict in Europe and periods of price change for herring. Further, there are price changes that occurred in parallel with changes in leadership of nations. These changes in leadership, however, often coincide with periods of elevated conflict, thus it is possible that change in leadership was symptomatic, rather than causal, with it came to price changes during conflict.²³⁸

6.4. Cod

As observed for herring, cod prices can be seen to respond to increasing conflict levels. The cod prices are shown below in Figure 6.7, for which an overall “cod price index” is also generated (thick red line). Regarding the influence of conflict, the 1620s provide a notable example of a period of high conflict, during which time cod prices display a dramatic decrease, followed shortly by a prominent spike in the 1630s to the highest levels yet observed by that time. Thus, it is volatility that often marks the apparent price response to conflict, rather than strict movements in any one direction.²³⁹ For example, prices may have

²³⁷ For example, from the period from 1700 to 1720, this includes the following events: Sweden-Denmark 1699-1700, Second Northern War 1700 - 1721, Saxony, Poland-Sweden 1700-06, War of Spanish Succession 1701-14, Austria-Sardinia 1701-03, Insurrection of Camisards 1702-06, Hungarian Insurrection 1703-11, Catalanian Rebellion 1705-15, Sweden-Saxony Poland 1709-19, Sweden-Denmark 1709-20, English Dutch-Brandenburgers (Germans) (Ghana) (1711), British-Swedish War 1715-19, Prussia-Sweden, 1715-20, Revolt of the Tarnograd Confederation 1715-17, Austria-Turkey War 1716-8, Spain-Austria (Sardinia) 1717, War of Quadruple Alliance 1717-20, Spain-Savoy (Sicily), 1718, Swedish-Hanoverian War, 1719-21, Sweden (succession), 1719.

²³⁸ For more discussion on this topic see, for example, Linda Darling. “Political change and political discourse in the Early Modern Mediterranean world,” *Journal of Interdisciplinary History* 38, no. 4 (2008).

²³⁹ As was the case for herring, volatility in the index can be caused by the differing data availability in the time series. Such changes in data availability are also symptomatic of the influence of conflict on the markets, indicating some products may have not been available during conflicts, for example.

increased during conflict due to problems along supply chains. It is also possible that prices decreased or remained the same for other products. For example, price-fixing of grain in Spain by central governments.²⁴⁰ Further examples include the price increase observed in the latter half of the 1500s, becoming more pronounced in the final decade of that century. This, it may be hypothesized, related at least in part to the French Wars of Religion that spanned most of the second half of this century, and the many conflicts in which the Netherlands were embroiled through this time such as the Eighty Years' War (1568 - 1648).

²⁴⁰ Regina Grafe, *Distant Tyranny*, 43.

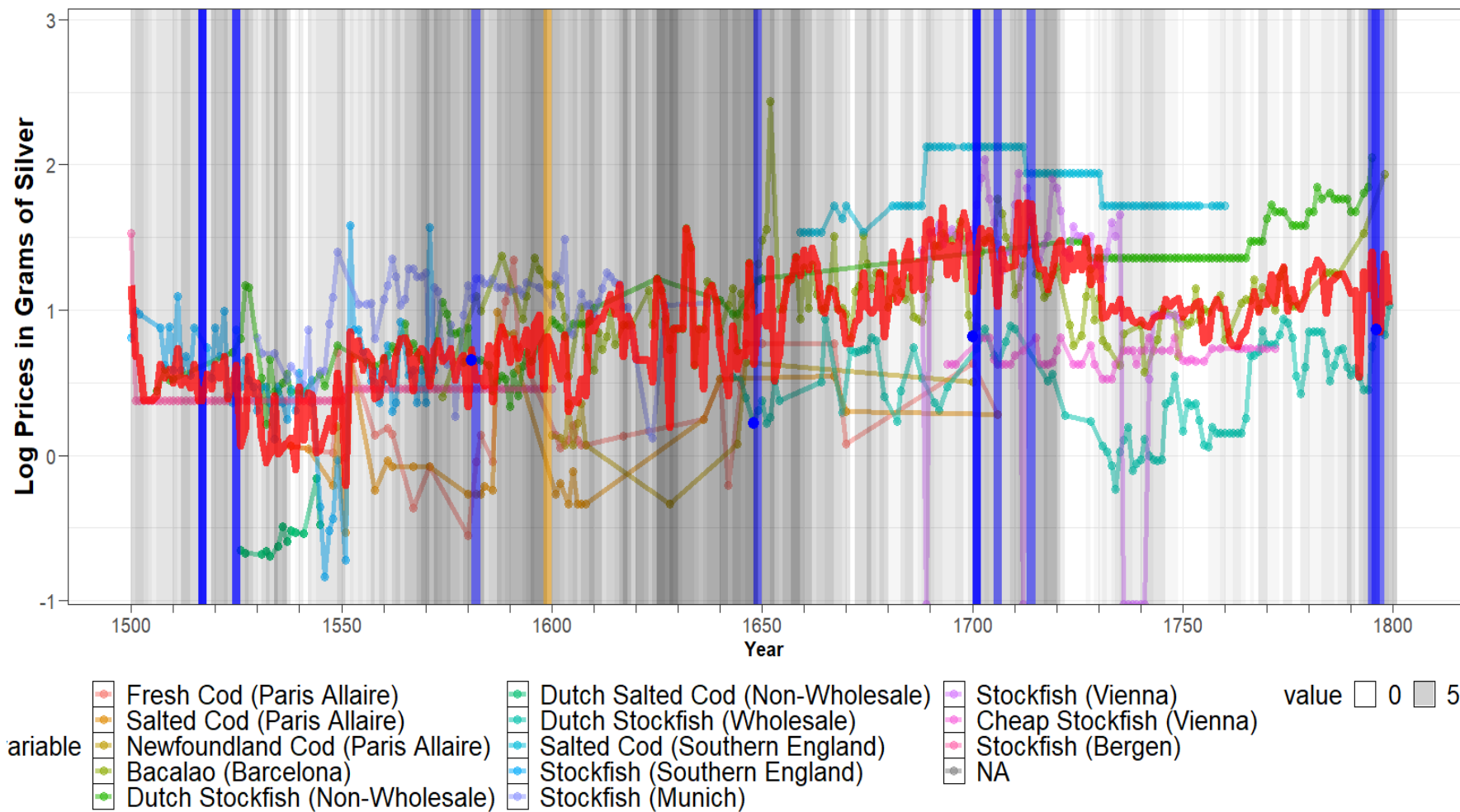


Figure 6.7. Cod Prices (log-transformed) and compared to conflict levels. Conflict levels are represented by gradients of grey. Blue lines represent changes in ruling political entities for a given territory, while orange represents when the Hanseatic League lost its privileges in London in 1598.

The flow of products returning from the east and west Atlantic fishing grounds will have both experienced different conflicts, and the same conflicts differently; thus, it can be expected that the effect of conflict on the prices of these products will have differed. As is well known, the supply of Newfoundland produce was dominated by Iberian fishers for the most in the 1500s and part of the 1600s before the French and English became the larger forces.²⁴¹ The English cod fishery began expanding in the mid-16th century, in particular following the destruction of the Iberian fisheries at Newfoundland.²⁴² Prices in Spain for bacalao show a remarkable increase in the 1650s, during the Franco-Spanish War (1635 to 1659). By that time, the Spanish did not have a meaningful fishing presence in Newfoundland to ensure their own supply without recourse to fishers of other nationalities.²⁴³ Grafe notes anecdotal evidence from before the 1630s that imports to Bilbo in Spain had been low at that time and increased in the following years as English merchants increased their presence.²⁴⁴ Cod series from other European locations do not display such a prominent increase at any time, suggesting a confluence of events unique to Barcelona, and possibly other regions of Spain, may have driven this unusual price increase. These other series are often not as complete as the information for Barcelona (Chapter 2), however, making it difficult to infer the extent of the differences.

One particularly important event during the study period was the shutting down of the Hanseatic League Kontor in London around 1598.²⁴⁵ The League was heavily involved in the trade of cod in Northern Europe, and hence the potential price impact of this event is of interest. In the very immediate aftermath, however, it is not possible to study price changes for cod due to the lack of available price information, however salted cod prices become available for the second half of the 17th century for Southern England. It may have been the case that English fishing expeditions were bringing salted cod back to England directly by this time, replacing previous supplies of stockfish from the Hanseatic League. Although only indirect evidence, this is further supported by the cessation of stockfish price series in

²⁴¹ Regina Grafe. *Popish Habits vs. Nutritional need: Fasting and Fish Consumption in Iberia in the Early Modern Period. No. 055* (University of Oxford, Department of Economics, 2004), 7.

²⁴² William H. Lear. "History of Fisheries in the Northwest Atlantic: The 500-Year Perspective," *Journal of Northwest Atlantic Fishery Science* 23 (1998), 44.

²⁴³ This may have compounded the price impact of the notable and widespread European drought in the 1650s or vice versa (Chapter 5).

²⁴⁴ Regina Grafe, *Popish Habits*, 10.

²⁴⁵ Arved Nedkvitne. *The German Hansa and Bergen 1100-1600* (Köln: Böhlau Verlag, 2014), 581.

Southern England, later being replaced by salted cod (See Section 2.1.3 and Appendix A.) Even though it is not yet possible to be certain that this is a result of a change of cod supply from the Hanseatic League to London merchants, it is a possibility.

The red trend-line in the previous figure is an index of cod prices, indicating the average changes across all locations and types of cod product, based on the available price information, derived in a similar manner to the herring index in Section 6.3. This cod price index is more volatile than the herring price index, as can be observed by the large price see-saws on the chart. This may in part be influenced by the less available information for cod, which in a statistical sense can lead to more uncertainty about the position of the true average, thereby leading to greater apparent volatility. Nonetheless, the index is conspicuous in exhibiting high volatility at times during periods for high conflict, as per the early to mid-1600s period already mentioned. Conflict and other conditions (e.g., extreme weather) that caused supply shortages through normal channels could at times help forge new market linkages.²⁴⁶ The net result of conflict, however, appears to have been a disintegration (or delay in ongoing integration) between locations and market levels. Another especially noteworthy feature of these cod prices is how the price increases and decreases in contrast to herring in some instances, and this point will be returned to in the conclusions.

6.5. Beef

In many regards, the long-term price movements are similar for beef, herring, and cod. In particular during the earlier part of the study period. Figure 6.8 (below) displays the long-term trends for beef compared to conflict. Information for pork has also been included on a limited basis to understand how it compared. The differences between beef and marine fish prices are more prominent in the last century (the 1700s) of the study period. Instead of decline early in the century, beef prices exhibited a gradual long-term increase until the final decade of the century. In this final decade, the price increase in beef rapidly

²⁴⁶ As noted by Milja van Tielhof. "In the last decade of the sixteenth century grain shortages in Southern Europe, especially Italy, caused a structural expansion of the Dutch trade network. Shipmasters and merchants from Holland ventured into the Mediterranean, got to know the navigation routes, the ports and local customs, and managed to develop an extensive shipping and trading network within a limited period of time". Milja van Tielhof. "The Rise and Decline of the Amsterdam Grain Trade," in *Food Supply, Demand and Trade: Aspects of the Economic Relationship between Town and Countryside (Middle Ages - 19th Century)*, eds. Piet van Crujning, and Erik Thoen (Brepols, 2012), 85-99, 89.

accelerates, displaying a similar trend to that seen for herring (and which was not evident in the case of cod).

It is clear that beef prices in some cases behaved differently when conflicts occurred. For example, as was the case with cod and herring, prices stopped increasing in the aftermath of the Thirty Years' War (1618 to 1648). Also, when the Hanseatic League lost much influence in London to the hands of local merchants in 1598,²⁴⁷ prices experienced an increase following this. The increases began before the merchants were expelled, thus a more complex set of events was at play, which may have influenced both price changes and the expulsion of the League.

²⁴⁷ Arved Nedkvitne. *The German Hansa and Bergen 1100-1600* (Köln: Böhlau Verlag, 2014), 581; Philippe Dollinger. *The German Hansa* (Bristol: Western Printing Services Ltd, 1964), 343.

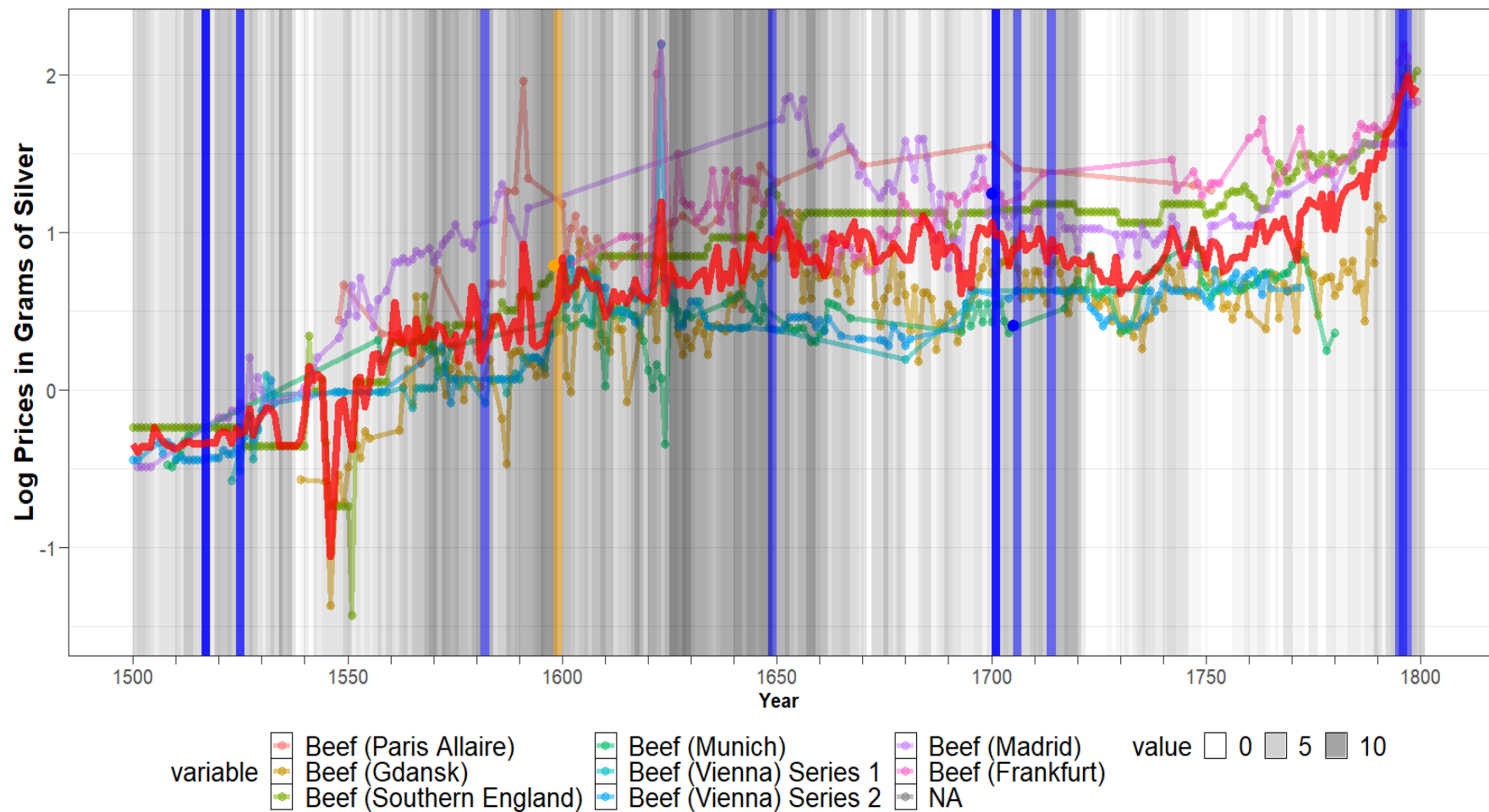


Figure 6.8. Beef prices. (Log transformed and indexed) and compared to conflict (shown in gradations of grey), alongside changes in ruling political entity in blue and the removal of the Hanseatic League Kontor from London in 1598 in orange. (The first beef series was derived from prices from Wien Bürgerspital and the second are from Stift Klosterneuburg; more detail can be found in Appendix C.)

6.6. Wheat

The prices for wheat are shown below (Figure 6.9). Examples of rye and barley price series are also included for additional context. It can be observed, to begin, that these prices nominally cover a larger range than herring and cod; values in the log scale range from around -3 to +2.75, while herring ranges from around -2 to 2 and cod from -1 to 2.²⁴⁸ This large range of prices for grains is, however, at least in part driven by very large values early in the period for Dutch wheat. Whether this indicates that further conversion adjustments (for which see Chapter 3) are required is unclear, but when these potentially suspect values are removed, values in the log scale can now be seen to vary less, ranging from less than -1 to over +2. Once more, broadly in common with the fish and meat products examined above, the long-term trendline (in red) shows a march toward higher prices during the 18th century, at a time of generally (if certainly not completely) diminished conflict. This was more regular and continuous than any of the products studied thus far, also lacking much of the sudden increase seen in the final decade of the century in other products.

The evidence presented here supports an interpretation of grain as a relatively well-established market, with more constrained price increases over the long term, when compared to cod and herring. Over the shorter term, there is considerable similarity between the grain prices, meat, cod, and herring. For example, in the 1650s, the price increases associated with the Price Revolution had come to a standstill, initiating a period with a largely flat long-term trend into the early 1700s.

²⁴⁸ These log values are based on logs to the base of the exponential number (i.e., approximately 2.718). Thus, the range of -3 to +2 is equivalent to silver values of 0.05 to over 15, while the range of -2 to +2 is equivalent to 0.14 to 7.39. And -1 to 2 is equivalent to 0.37 to 7.39.

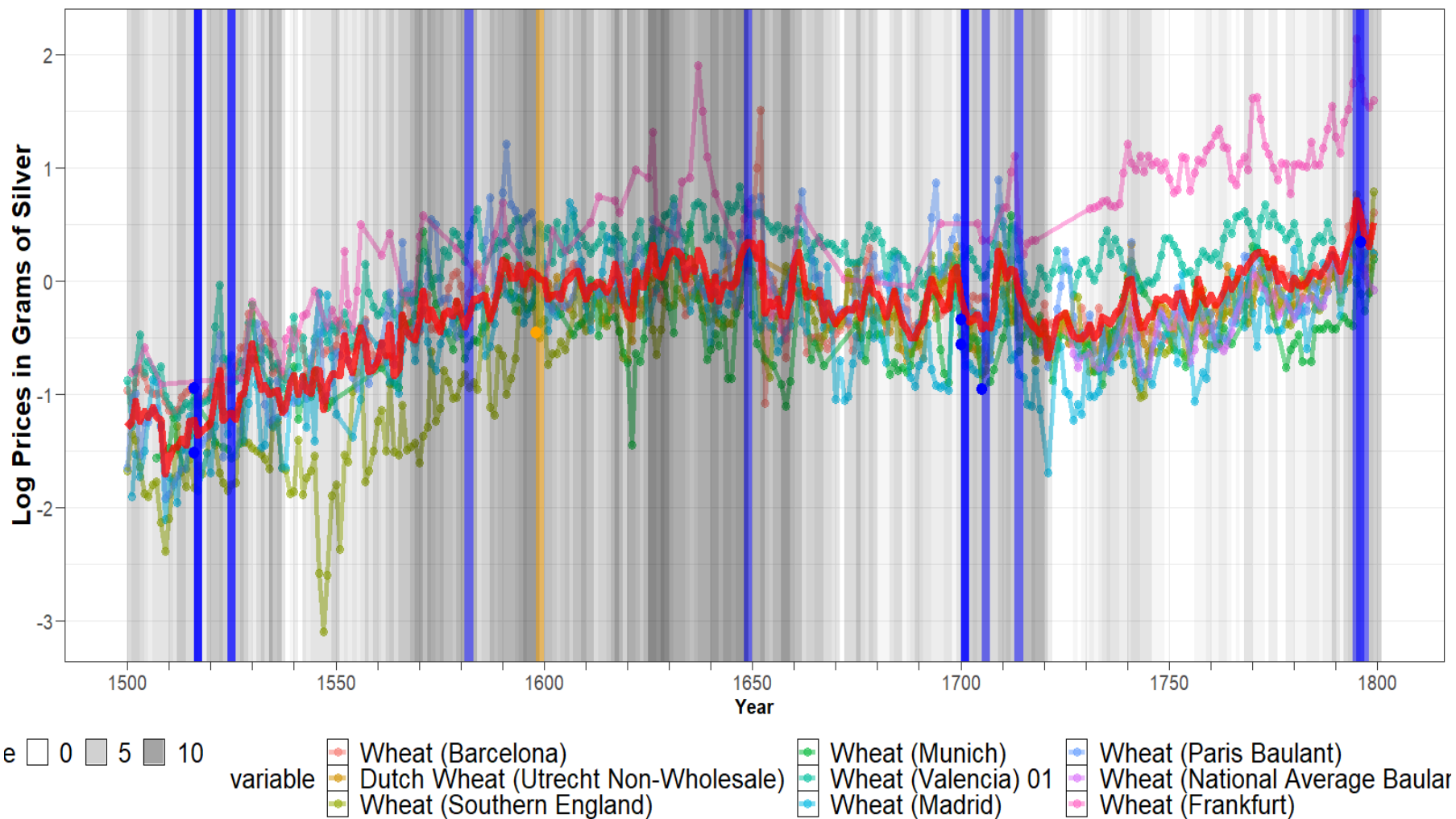


Figure 6.9. Wheat prices. (Log transformed) compared to conflict, alongside changes in ruling political entities in blue and the removal of the Hanseatic League Kontor from London in 1598 in orange.

6.7. Conclusions

Conflict often appears to occur alongside notably large price changes; however, a systematic study of this relationship has been left to Chapter 8. Many regions display similar price movements, however there was a degree of regional variation. (A more extensive regional analyses of the influence of conflict can be found in Appendix F. In the long term, the Thirty Years' War (1618 to 1648) was a major conflict and stood out as dominating the study period, with many locations displaying extremely high levels of conflict. During this conflict, the long-term creep of inflation that increased all prices over the last century came to a stop. In the aftermath of this conflict, prices displayed different behaviour and no longer shared the common long-term trend that was evident during the Price Revolution in the 16th century and early 17th century. Specifically, price increases resumed in locations, such as in the Netherlands, while other price-series decreased, e.g., herring in Gdansk. Cod and herring prices changed at different rates than each other and those of beef and wheat. Wheat prices began to increase in the first half of the 18th century. This was also the case for beef, with even more pronounced increases. Herring prices began to increase also though not to the same degree as wheat and beef. Cod saw the smallest levels of increase. This suggests that during the 19th century, cod and herring become better positioned to act as lower-priced commodity substitutes when compared to beef and wheat.

In the shorter and medium term, conflicts also coincided with price fluctuations; localised conflicts, playing out over shorter durations, often induced more localised price fluctuations. Major events such as changes in empires and trading companies are influential, though it is difficult, or impossible, to untie these events from the elevated levels of conflict they generally occur within.

Locations with prices that were more stable than others, or that were displaying regular and gradual prices increase over time, were possibly more resilient to stressors such as conflict. For example, Dutch prices during the 16th to 18th centuries were quite stable and came with gradual price increases. This indicates the Dutch markets may have been quite resilient. In addition to the likes of conflict, the Dutch prices may also have been influenced

by climate conditions.²⁴⁹ Dutch prices displayed changes that were the most regular and gradual of all locations. This was not only for marine fish, but for wheat and beef also, suggesting the marine fish prices were subject to similar influences as other foods

²⁴⁹ Dagomar Degroot. *The Frigid Golden Age: Climate Change, The Little Ice Age, and the Dutch Republic, 1560–1720* (Cambridge University Press, 2018), 300-9.

7. Environment and Climate

A connection between environmental changes (often particularly involving climate) and human history (from the health of populations to the functioning of economies) has been established in countless studies. For a wide-ranging review, see John Brooke.²⁵⁰ Also, Alex Alvarez provides a broad overview of how climate has changed in the past and the impacts of these changes on human societies.²⁵¹ Similarly useful is Anthony McMichael, Alistair Woodward, and Cameron Muir 2017's publication.²⁵² The extent of this influence relative to other factors, not least internal social dynamics, has sometimes been overemphasized. Overly environmentally deterministic attributions of the role of environment in human affairs is an ongoing concern in history.²⁵³ Yet the absence from consideration of any role for the environment (or the simplistic characterisation of such as "determinism") is equally considered a problem.²⁵⁴ Major climatic (and linked marine environmental) changes have occurred within the study period. For example, the Little Ice Age (LIA) is thought to have occurred from approximately the fourteenth to nineteenth centuries, though there remains some scepticism regarding the utility of a single term like the "Little Ice Age" (LIA) in covering a phase of climatic change that was regionally variable in its timing and severity.²⁵⁵ In essence, the LIA encompassed the early modern period.²⁵⁶ Its existence is largely accepted and visible in multiple climate proxies, particularly for the study region of Europe and the North Atlantic.²⁵⁷ The social impacts of the LIA have already been heavily studied, including with conflict levels in mind. Geoffrey Parker has thus examined how the

²⁵⁰ John L. Brooke. *Climate Change and the Course of Global History: A Rough Journey* (Cambridge University Press, 2014).

²⁵¹ Alex Alvarez. *Unstable Ground: Climate Change, Conflict, and Genocide* (London: Rowman & Littlefield, 2017), especially Chapter 1, 9-34, "Making sense of climate change".

²⁵² Anthony J. McMichael, Alistair Woodward, and Cameron Muir. *Climate Change and the Health of Nations: Famines, Fevers, and the Fate of Populations* (Oxford University Press, 2017). In particular, see especially the Introduction, 1-21, Chapter 1, 22-50, "A Restless Climate," and Chapter 10, "Humans throughout the Holocene," 227-253.

²⁵³ Gabriel Judkins, Marissa Smith, and Eric Keys. "Determinism within Human-Environment Research and the Rediscovery of Environmental Causation," *The Geographical Journal*, 174 (2008), 17-29.

²⁵⁴ Francis Ludlow, and Arlene Crampsie. "Environmental History of Ireland, 1550-1730" in *Cambridge History of Ireland: Volume 2, Early Modern Ireland, 1550-1730*, ed. Jane Ohlmeyer (Cambridge University Press, 2018), 608-637.

²⁵⁵ See, e.g., Astrid E. J. Ogilvie. "Historical Climatology, Climatic Change, and Implications for Climate Science in the 21st Century," *Climatic Change* 100 (2010), 33-47

²⁵⁶ Bruce M. S. Campbell. *The Great Transition, Climate, Disease and Society in the Late-Medieval World* (Cambridge University Press, 2016), 52.

²⁵⁷ See also John A. Matthews and Keith R. Briffa. "The 'Little Ice Age': Re-evaluation of an evolving concept," *Geografiska Annaler* 87 (2005), 17-36.

LIA may have influenced major revolts and revolutions between 1635 and 1666.²⁵⁸ To this end, the analyses presented in the remainder of this chapter advances the understanding of the extent to which environmental factors and climate may have influenced European fish market dynamics. As part of this, the analysis also compares selected price series to long-term temporal and spatial reconstructions of climate conditions, to complement the study of the impact of conflict (Chapter 5).

7.1. Comparing Prices to Climate

In recent decades, concerted efforts have been made to develop long-term climate reconstructions.²⁵⁹ In the absence of direct knowledge of historical climate from instrumental or other written records,²⁶⁰ environmental “proxies” (or “natural archives”) are often studied to develop these reconstructions. The proxies (comprising tree-rings, ice-cores, and more) provide an array of indirect indicators of features of historical climate. In 2019, Dana Riechelmann and Marjolein Gouw-Bouman reviewed reconstructions that covered Europe for the first millennium CE.²⁶¹ Their paper concluded that there were remarkably similar trends in many of the reconstructions that they studied (17 single records and 1 composite record). This highlights the great advance in our knowledge of past climate over the past several decades, with anything beyond the past four to five centuries poorly known until recently.²⁶² These reconstructions also increasingly come in the form of annual resolution time-series that are also spatially resolved (i.e., supplying information about climate across space as well as time).

The paleoclimatic time series analysed below were chosen to give coverage of ocean temperature dynamics (potentially influencing the supply of available fish via its effect on

²⁵⁸ Geoffrey Parker. *Global Crisis: War, Climate Change and Catastrophe in the Seventeenth Century* (Yale University Press, 2013); Geoffrey Parker. “Crisis and Catastrophe: The Global Crisis of the Seventeenth Century Reconsidered,” *The American Historical Review* 113, no. 4 (2008).

²⁵⁹ For a review: Raymond S. Bradley. *Paleoclimatology: Reconstructing Climates of the Quaternary*. 3rd Edition (Amsterdam: Elsevier, 2015).

²⁶⁰ As reviewed by Christian Pfister, Rudolf Brázdil and Marianus Barriendos. “Reconstructing Past Climate and Natural Disasters in Europe Using Documentary Evidence,” *PAGES News*, 10 (2002), 6-8, and at greater length by Rudolf Brázdil et al. “Historical Climatology in Europe - The State of the Art,” *Climatic Change*, 70 (2005), 363-430.

²⁶¹ Dana F. C. Riechelmann and Marjolein T. I. J. Gouw-Bouman. “A Review of Climate Reconstructions from Terrestrial Climate Archives Covering the First Millennium AD in Northwestern Europe,” *Quaternary Research* 91, no. 1 (2019).

²⁶² Hubert H. Lamb. *Climate, History, and the Modern World*. 2nd ed. (Routledge, 1995); Raymond Bradley and Phil Jones. *Climate Since A.D. 1500*. Revised ed. (Routledge, 1995).

primary ocean productivity), temperature and soil moistures on land (potentially influencing terrestrial agricultural output, for which marine food sources may act as a substitute), and abrupt climatic changes wrought by volcanic activity. Such time series will be compared against price information in this chapter. A relationship, or lack of one, can signal if climate did indeed influence market prices and further, can help quantify the extent of this influence; this will be studied in Chapter 8. As an example, identifying and characterising any relationship between climate dynamics and prices, as well as its constancy through time and space, can be used to infer how favourable market conditions were for commodity substitution, or whether market integration may have changed through time and space.

The mechanisms through which dynamics of climate ultimately influence prices can be complex, and always also partly dependent on other factors such as the efficiency of market arbitrage and integration (which can be co-determined by political, military, and other conditions), the availability of substitute commodities, and more.²⁶³ They are not, however, the direct focus of this analysis, though the following briefly outlines hypothetically how these factors could lead to price changes. Environmental factors are external or exogenous influences on the markets that influence prices paid by affecting both supply and demand. Climate (via weather) is a more or less indirect influence on price, with its effect working through various “pathways” that eventually register in price changes. Examples of supply-side pathways by which climate can ultimately influence price include the devastation of grain yields and wasting (even mass mortality) of animals during drought, leading to a constricted or poorer quality supply that ultimately drives up prices if alternative supplies cannot be readily sourced or substitutes found.

Such scarcity may also promote conflict through intensified resource competition when supplies are diminished, and conflict can in turn further affect supply.²⁶⁴ This can arise from additional transportation and transaction costs (in cases of blockades, imposition of new tariffs, export bans between warring regions, and more) or when armies are provisioned directly from local landscapes or markets, further driving up prices. Conflict is, thus, a

²⁶³ For an insightful case study, see Charles Gibson. “An Historical Event and Its Interpretation: The Castilian Grain Crisis of 1506-1507,” *Social Science History*, 2(2) (1978).

²⁶⁴ Joseph G. Manning et al. “Volcanic Suppression of Nile Summer Flooding Triggers Revolt and Constraints Interstate Conflict in Ancient Egypt,” *Nature Communications* 8, no. 1 (2017).

particularly important link in the chain of causality that can often lead from a climatic stress to price increase. The relative positions of climate and conflict can also certainly change, with climatic stress occurring at a time of already heightened conflict perhaps being associated with some of the more notable price escalations in the study period.²⁶⁵ In 2005, Paul Erdkamp discussed the grain market in the Roman Empire, and noted how prices tended to be volatile in pre-industrial societies, with small disruption to supply and demand causing prices to multiply.²⁶⁶ Markets can become less integrated in these scenarios, which can be observed in higher Coefficient of Variation (CV) values.²⁶⁷ Commodity substitution might occur, if one product can no longer satisfy demand at a reasonable price, resulting in another product stepping in to take its place.

7.2. Ocean Temperature

Phytoplankton occupy the base of the marine food web and their production is termed “primary production”.²⁶⁸ Research from Gregory Beaugrand et al. has suggested there is a link between this primary production and ocean temperatures.²⁶⁹ Beaugrand developed a “Plankton Index (PI)”, using data from what is known as the “Continuous Plankton Recorder (CPR)”. Specifically, the PI is the first component of the Principal Component Analysis of the abundances of types of plankton measured by the CPR.²⁷⁰ In 2016, Riina Klais reported a correlation between the Atlantic Multidecadal Oscillation (AMO) and Beaugrand’s Plankton Index.²⁷¹ More specifically, a negative linear correlation is seen in the case of the Northeast

²⁶⁵ Prices in Paris during the French Wars of Religion provide one example, 1562-1598. The conflict itself almost certainly contributed to increased prices, not least during the Siege of Paris in 1590. But the situation was already bad before this date, and in 1585 a major tropical volcanic eruption occurred (registering in ice-core-based volcanic climate forcing reconstructions: Michael Sigl et al. “Timing and Climate Forcing of Volcanic Eruptions during the Past 2,500 years,” *Nature* 523 (2015), 543-549). This can be plausibly associated with deteriorating conditions in 1586, which saw “a sharp rise in the price of bread and an increase in beggars on the [Parisian] streets...” (Nancy Lyman Roelker. *One King, One Faith: The Parliament of Paris and the Religious Reformations of the Sixteenth Century* (University of California, 1996), 342).

²⁶⁶ Paul Erdkamp. *The Grain Market in the Roman Empire: A Social, Political and Economic Study* (Cambridge University Press, 2005): Ch 4.

²⁶⁷ Victoria Bateman. *Markets and Growth in Early Modern Europe* (Routledge, 2015), 47.

²⁶⁸ Philip C. Reid et al. “Impacts of the oceans on climate change,” *Advances in marine biology* 56 (2009), 27-8.

²⁶⁹ Grégory Beaugrand et al. “Plankton effect on cod recruitment in the North Sea,” *Nature* 426, no. 6967 (2003).

²⁷⁰ *Ibid*, 1.

²⁷¹ Riina Klais. “Hindcasting North Atlantic plankton production,” (Unpublished internal NorFish report, 2016).

Atlantic (the Northwest displayed a positive correlation but requires further research). As a PI does not exist for the period from 1500 to 1800, instead ocean temperatures are used in the following analysis to estimate the PI. The AMO measures variability in sea surface temperature (SST). In this analysis, the Atlantic Multidecadal Variability (AMV)²⁷² has been used on the basis that it became available following Klais' analysis. The AMV overlaps with the PI for a 50-year period from 1958 to 2007. They correlate with a r value of -0.683, thus indicating a strong negative association between them. (The r^2 value is 0.466 and the p -value is a fraction of a percentage at $4.701e-08$). The AMV and AMO follow similar trends, though the AMV captures more variability in past ocean temperatures, and hence can possibly explain more of the variation in ocean productivity, catch, and hence price movements. The negative correlation between the AMV and the PI indicates higher AMV values related to lower ocean productivity and fish supplies. Thus, commodity prices could be driven up in such a scenario, and vice versa.

The AMV index is presented below for the period 1500 to 1800 (Figure 7.1). The mid-1600s were a turning point that was marked by the start of a gradual long-term decline. This occurred alongside the General Crisis (discussed previously in Chapter 6).

²⁷² Jianglin Wang et al. "Internal and external forcing of multidecadal Atlantic climate variability over the past 1,200 years," *Nature Geoscience* 10, no. 7 (2017): 512-517, 513.

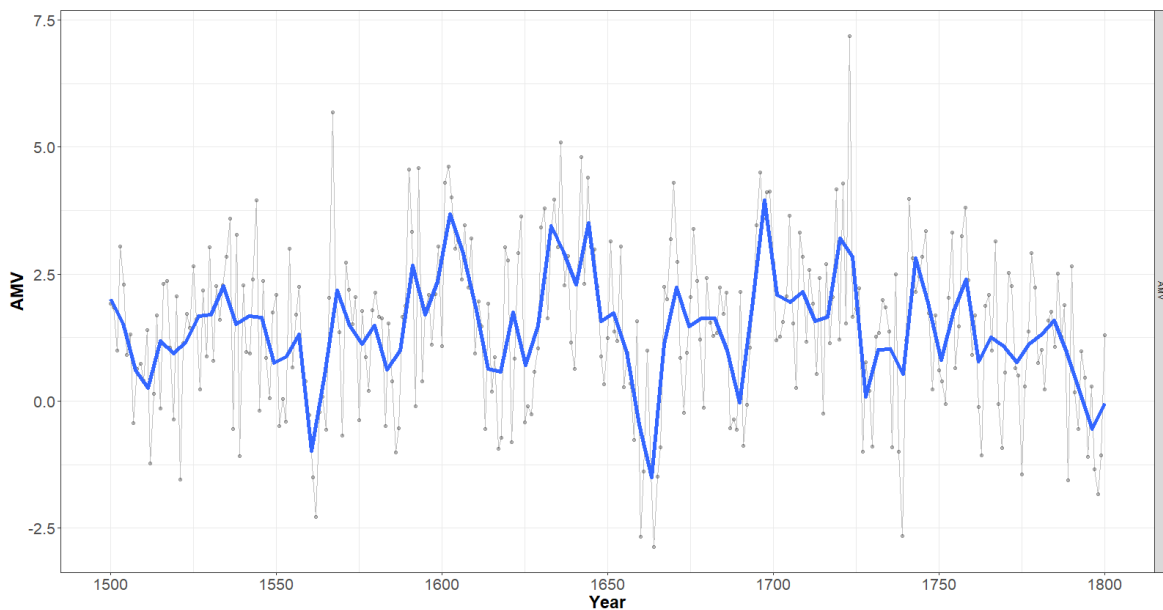


Figure 7.1. Atlantic Multidecadal Variability (AMV) for the study period of 1500 to 1800. The blue trendline is a loess curve and represents long-term change. The index is measure in degrees Celsius.²⁷³

Cod and herring price information (from wholesale and consumer markets - as was also the case in previous chapters) is compared with the AMV (Figure 7.2). Trendlines have been included for both fish. These trendlines are averages for the cod and herring prices for all series available in each year. They are smoothed to a degree, thus more so indicating long-term price changes over all series. The trendlines are influenced by price information availability for each year, i.e., each annual value is based on the average of available price series in that particular year (similar to Chapter 6). Thus, years with more price information may be more representative of the true average, while less would be less accurate. There are examples of price changes that conspicuously occurred following periods of higher AMV volatility. The most significant example occurred in the lead up to and following the mid-1600s, the AMV fluctuates from a relatively high value for the 300-year study period to a record decadal-scale low (with the long-term trend indicated by the blue trendline). The multi-decadal price inflation that occurred during the Thirty Years' War (1618 to 1648) effectively stopped at this point. Following this, a divergence in cod and herring prices occurs up to the end of the century, with herring becoming cheaper than cod. As noted earlier, heightened AMV values correspond with lower ocean productivity in the Northeast Atlantic and vice versa. Total quantities of fish caught, hypothesised by Holm, declined in

²⁷³ Visit National Centres for Environmental information for further information on the units: <https://www.ncdc.noaa.gov/paleo-search/study/22031>.

the second half of the 17th century, before beginning to increase again around 1725.²⁷⁴ Thus, volatile SSTs in the mid-1600s may have contributed to changes in herring supplies and price decline. There were significant levels of conflict at play during the mid-17th century and again in the early 18th century. This occurred at the same time or after heightened AMV activity. A correlation between AMV activity and fish prices, however, is by no means implying a direct causal link. Possibly AMV activity influenced conflict levels, which in turn would cause price changes. The following chapter will analyse this in further detail.

²⁷⁴ Poul Holm et al. "A revolution in fish supplies. The Scale of the Cod and Herring Fisheries, c. 1500-1800," (Unpublished).

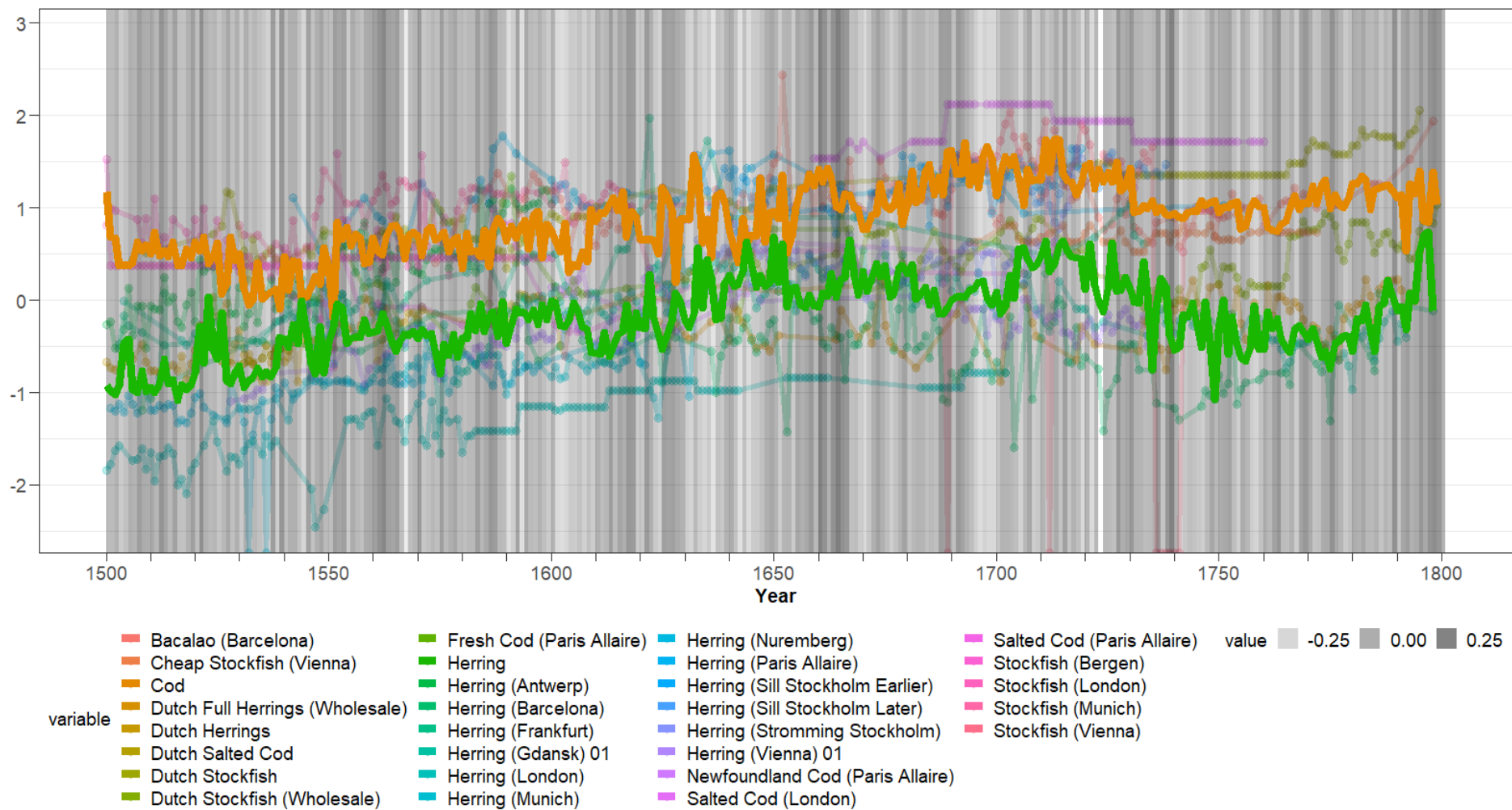


Figure 7.2. Cod and herring prices compared to AMV. Cod (orange trendline) and herring (green trendline) prices in Europe compared to the Atlantic Multidecadal Variability (AMV).

7.3. Drought and Land Temperature

On land the Old World Drought Atlas (OWDA) reconstruction measures the intensity of historical droughts and pluvials throughout Europe and the surrounding region.²⁷⁵ This index is a measure of years with higher or lower drought levels from an overall view of Europe and the surrounding regions. It was developed from precipitation-sensitive temperate such as tree ring chronologies, and the units are based on the Palmer Drought Severity Index (PDSI), which reflects soil moisture availability for June, July, and August (JJA). The PDSI was first proposed in 1965 by Wayne Palmer.²⁷⁶ A variant of this (used in the OWDA) is the “self-calibrating Palmer Drought Severity Index” (scPDSI). The self-calibrating feature removes certain empirically calculated values and replaces them with calculations that are dependent upon the particular location each component of the index relates to.²⁷⁷ Possibly the self-calibration can be described as using a type of “mean” value for each location, rather than an overall mean for all areas combined. The AMV cannot be decomposed into regions for land-based locations. This is, however, possible for measurement of soil moisture. The OWDA is a reconstruction developed from 106 tree-ring chronologies.²⁷⁸ This index is not simply one value per year, instead it comes with the benefit of a spatial resolution that consists of a grid of 0.5° latitude/longitude points. They cover Europe, North Africa, and the Middle East from 0000 to 2012 CE.²⁷⁹ In keeping with PDSI indices, the values of the index are negative for years that experience a level of drought while positive values are wetter. The more extreme the value, the more extreme the drought or pluvial within that year.

It is difficult, if not impossible, to know the precise “mechanism(s)” by which drought might work its way through the economic system (or more precisely, the coupled human-natural system prevailing in this broad region and period) to influence herring and cod prices.

²⁷⁵ Edward Cook et al. “Old World megadroughts and pluvials during the Common Era,” *Science advances* 1, no. 10 (2015), 2.

²⁷⁶ Wayne C. Palmer. *Meteorological drought*. Vol. 30. US Department of Commerce (Weather Bureau, 1965).

²⁷⁷ Nathan Wells, Steve Goddard, and Michael J. Hayes. “A Self-Calibrating Palmer Drought Severity Index,” *Journal of Climate* 17, no. 12 (2004), 2337.

²⁷⁸ Edward R. Cook et al. “Old World megadroughts and Pluvials during the Common Era,” *Science Advances* 1, no. 10 (2015).

²⁷⁹ Year “0000 CE” is referring to 1 BCE.

Plausible scenarios can, however, be hypothesised. For example, drought may have led to crop failures; these in turn could cause a demand-driven increase in prices for the likes of wheat. The effect of drought is likely to have a more direct or significant impact on terrestrial agricultural production than on fish supply. However, fish prices (for a given supply level) may still be increased if fish acts as a commodity substitute for grain, especially if grain prices rise to such a degree as to become prohibitively expensive.

Figure 7.3 presents one value per year for all of Europe. This is based on an average of all grid values in each specific year. To achieve this, first the OWDA information was uploaded to R. The OWDA database comes in the form of a NetCDF file. Following the upload to R, the single value per year was calculated by designing a “script” to sum all available grid points per year and performing an average of these values. This required study to understand the NetCDF data structure. The NetCDF datatype is becoming a standard for multidimensional data storage. It is complicated to use for those not familiar with how it works. For this thesis, R scripts were designed and coded to extract information from such datasets (more information on the R scripts can be found in Appendix D under “OWDA Analysis”). The resulting values range from approximately -1.26 to +1.41. There is a degree of “smoothing” in the OWDA index when the value in each year is averaged over all grid-points. That is, the averaging leads to higher and lower values from certain locations in each year cancelling one another out. Also, for comparison, the range of values for the entire period from 1 BCE to 2012 CE is -2.37 to 2.91.

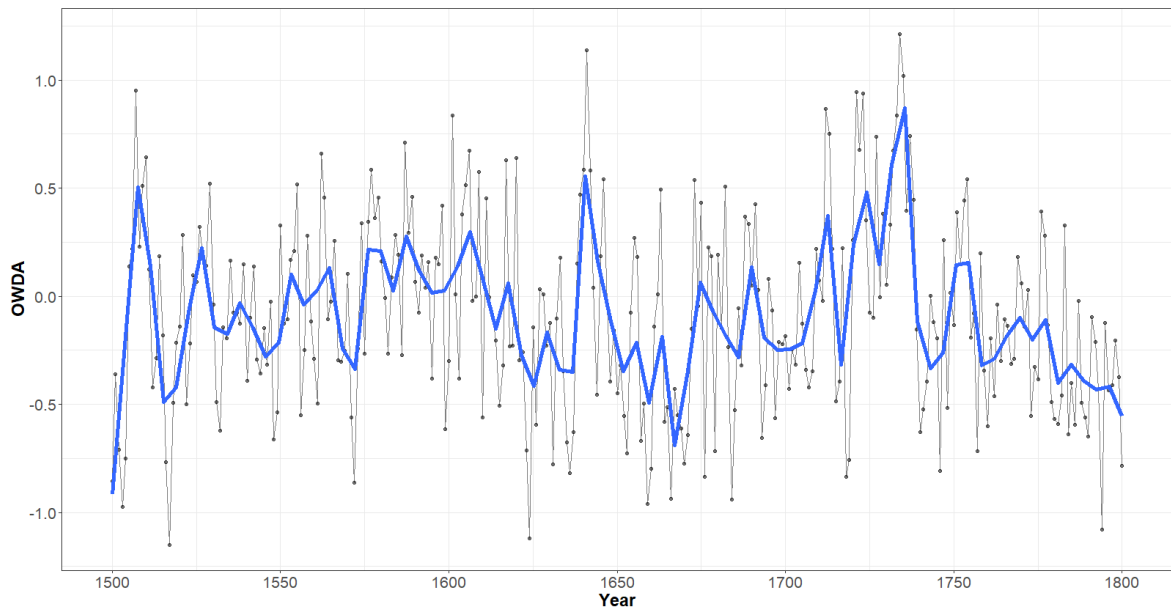


Figure 7.3. The Old World Drought Atlas (OWDA) Index. An annual average index value over the entire European region and surrounding areas.

As drought levels were not uniform throughout Europe, regional indices were extracted for this section, also achieved by developing scripts for the R programming language. Each of the extracted regional OWDA indices are based on a mean for all grid options in a country for each year (Figure 7.4). There is more volatility and extreme values in these individual series than there was in the overall index. This is the case as there is less averaging and smoothing of the data occurring when studying smaller regions. Many of the locations share trends, however this is not always the case. A more extreme example is Spain, which often displays quite different values to most other locations. The OWDA indicates that Spain experienced relatively more pluvials during the study period than many of the other locations. A climate divide (or seesaw) between northwest and south-southeast Europe is known and is related to phenomena known as the North Atlantic Oscillation (NAO) and the East Atlantic Pattern (EAP).²⁸⁰ There was also a divide in price behaviour between northern and southern European regions, which was discussed in Chapter 5. Thus, it is necessary to understand if the regional differences within the OWDA corresponded with and potentially contributed to regional price differences.

²⁸⁰ Mukund Palat Rao et al. "European and Mediterranean Hydroclimate Responses to Tropical Volcanic Forcing over the last Millennium," *Geophysical Research Letters* 44, no. 10 (2017): 5104-5112, 5105. Figure 5a displays how conditions between northwest and southeast contrast. This figure covers the more modern period from 1950 to 1978, however the trend also existed in earlier periods.

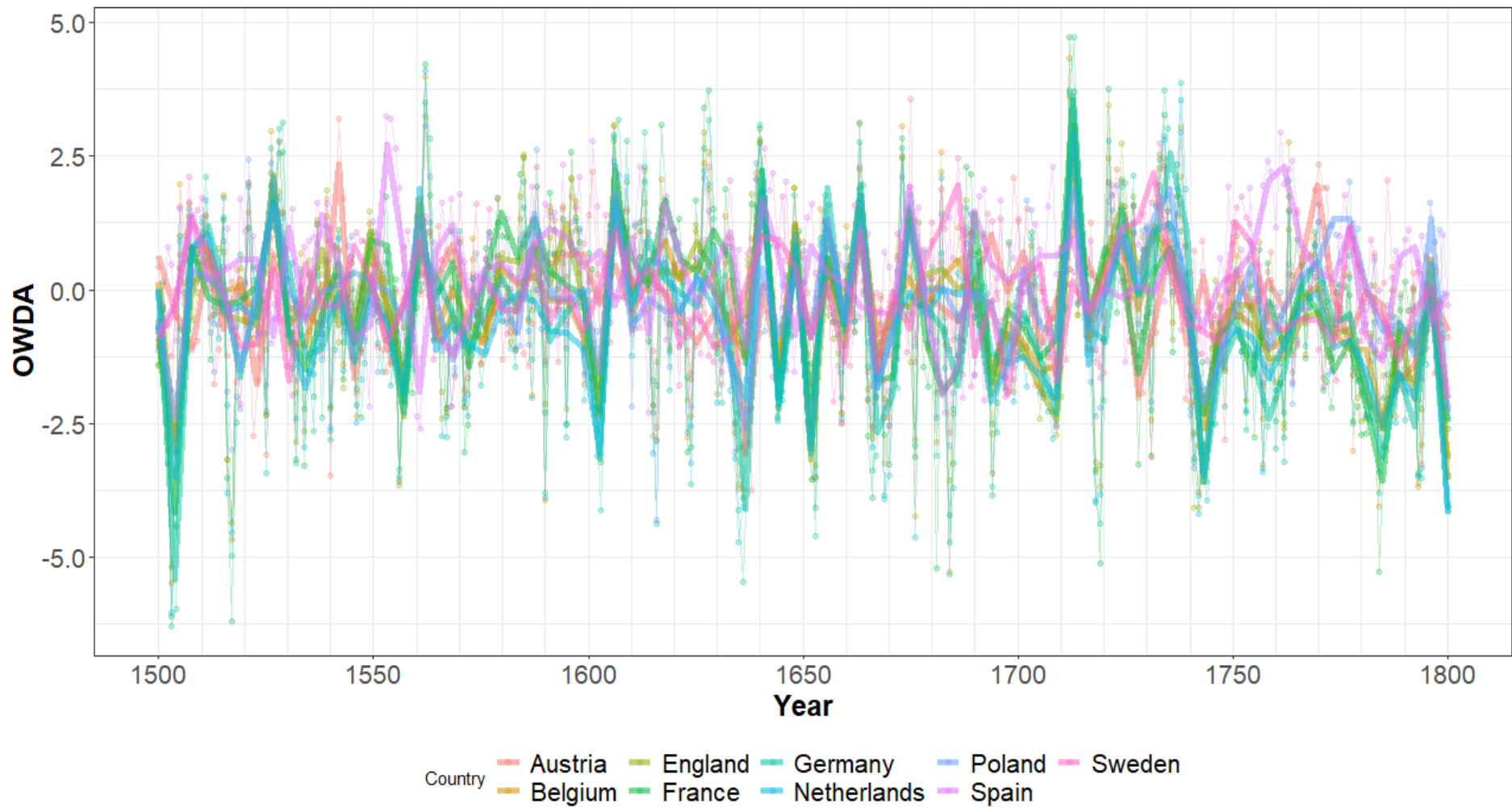


Figure 7.4. The OWDA index for each country. A smoothing trendline has been included to present the longer-term trend for each location.

The OWDA locational indices for Paris, Amsterdam, Gdańsk, and Spain are compared to cod and herring prices in the respective locations. This selection of locations provides a broad geographic coverage of Europe. In each case, the extracted OWDA data is limited to the creation of an averaged index that covers the geographical span of the country that each city sat within.²⁸¹ Trendlines for cod and herring have been included in each case (Figure 7.5). These trendlines are an average of all price information available each year. The trendlines display the now familiar trend of long-term price change that was discussed in Chapter 5.

Before studying the locations specified above, the following figures compare OWDA activity to cod and herring. The style of chart is similar to that used in Chapter 6, though conflict levels have been replaced by OWDA levels (Figure 7.5). For example, during the 2nd quarter of the 17th century, soil moisture levels were elevated in several years during the Thirty Years' War. This trend then reverses in the following quarter, with a number of years experiencing relatively wet years. As another example, there was a decrease in cod prices that occurred towards the end of the first quarter of the 17th century. Herring was similar, but the decline began earlier. This was in contrast with wheat prices, which were increasing in that time (see Figure 6.9 for the trend in wheat prices). Chapter 8 undertakes a more extensive and systematic analysis of how the OWDA interacts with conflict and price levels.

²⁸¹ This is based on the modern definition of the country boundaries, which are broadly similar to those of the study period.

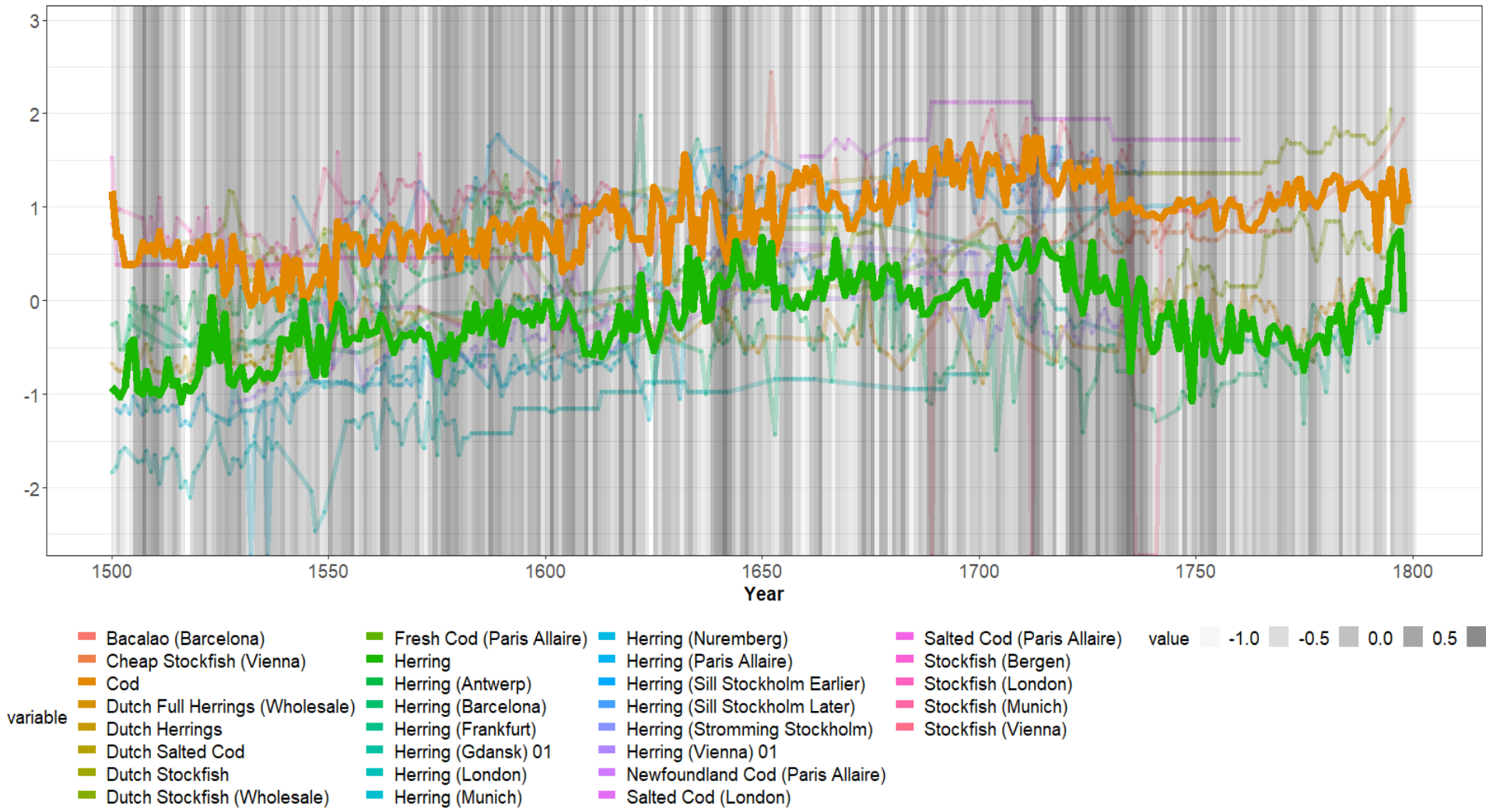


Figure 7.5. Cod and Herring Prices compared to the OWDA. Cod (orange trendline) and herring (green trendline) prices compared to the OWDA index (grey shading).

In the case of Paris, the OWDA index restricted to the region of France, displays more annual variation than was displayed annually for the averaged index over all of Europe. This is often the case for regional indices, as less averaging will often lead to more variability (Figure 7.6). The OWDA indicates elevated levels of drought during the late 1630s into the early 1640s. Drought may have been influencing both conflict levels and the commodity prices, and it is not possible to completely untangle them. High drought levels do not always correspond to elevated levels of conflict, however.

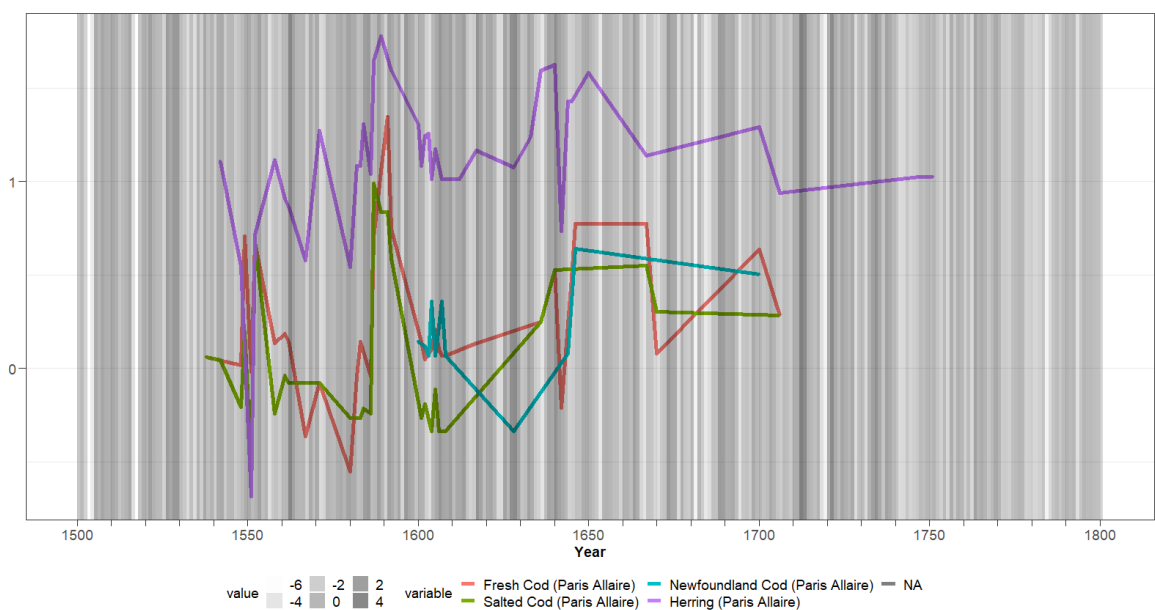


Figure 7.6. Prices in Paris compared to the OWDA index for France.

For Amsterdam (Figure 7.7), the long term trendline displays lower volatility than France, or more specifically the price changes are more of a consistent gradual increase over the study period. One of the largest drought values occurred in the early 1560s. Herring prices had seen a large price drop in the years prior to this, which recovered during the drought years. This large drop in herring prices would have set it up to act as a lower-priced commodity substitute if wheat was in less supply. Prior to this though, in the late 1550s, there was a very wet period (as represented by the light grey years), which coincides with price increases for both cod and herring. Cod and herring experienced different price changes in the lead up to the mid-1700s. In the early decades of the 1700s, there was a degree of volatility, with soil moisture varying between wet and dry conditions. In the years that followed, from the 1710s to 1750s, wheat prices declined. It is possible that wheat

production was adversely affected in that time. There were also conflicts in that period, Poulsen discussed these conflicts as an influence on herring production.²⁸² The analysis in Chapter 8 deals more extensively with these interactions (i.e., between conflict, climate, and prices).

²⁸² Poulsen, *Dutch Herring*, 226.

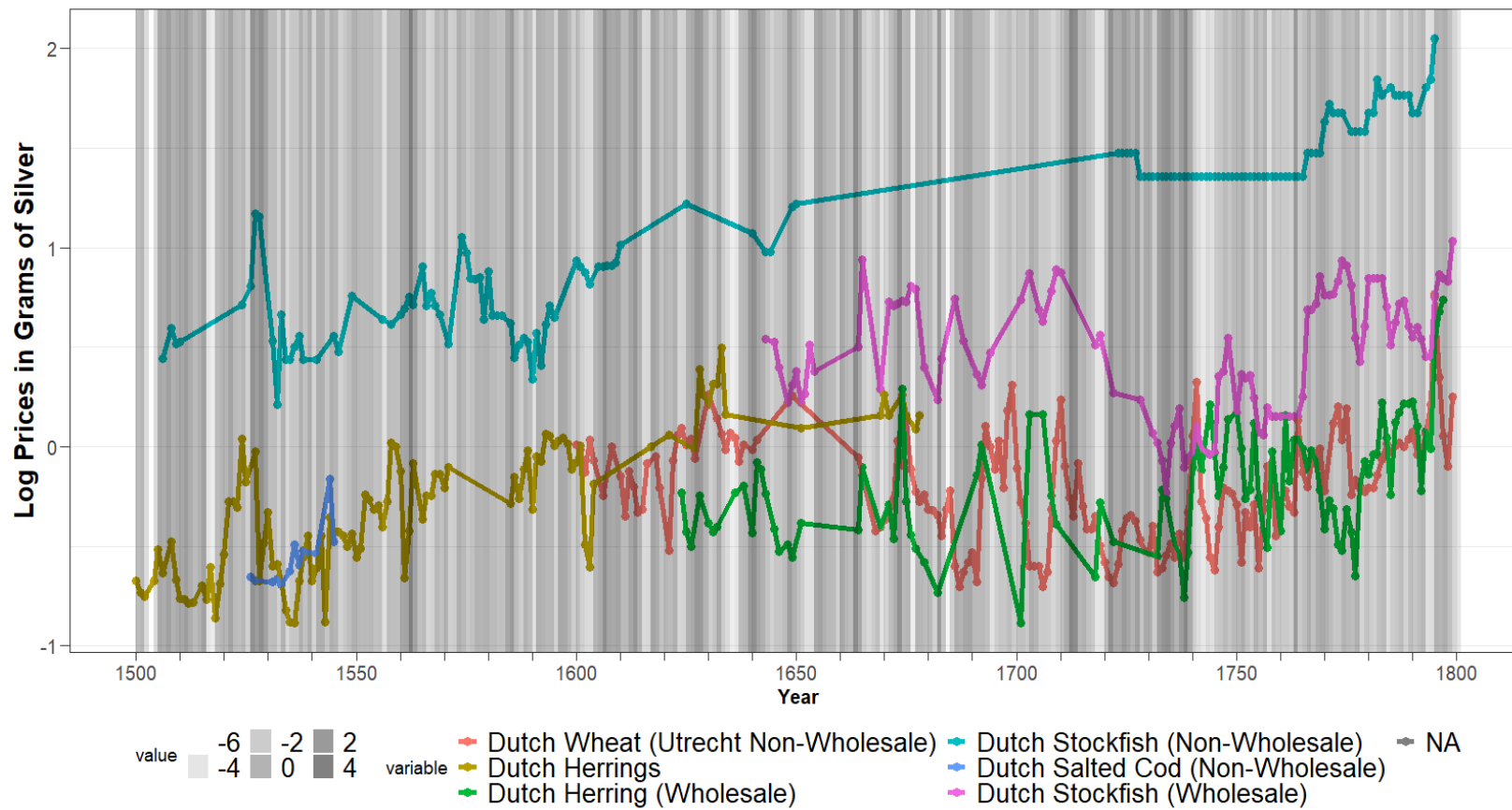


Figure 7.7. Prices in Amsterdam for cod and herring compared to the OWDA.²⁸³

²⁸³ Wheat prices for the 16th century have been excluded as they are disproportionately high relative to the following two centuries. There may be a conversion rate issue relating to the sources.

In Gdańsk, the OWDA indicates the occurrence of a particularly dry year in 1623 (Figure 7.8). This was in the early years of the Thirty Years' War (1618 to 1648). The dry year was also prominent in the Netherlands. Herring prices were decreasing in the lead up to and during this period, before beginning to increase in the final years when the drought conditions were peaking, thus there may have been a higher demand due to the effects of this unusually dry year, which would have led to lower grain-harvest yields encouraging commodity substitution. Beef followed a similar trend in that time, thus may also have been in higher demand.

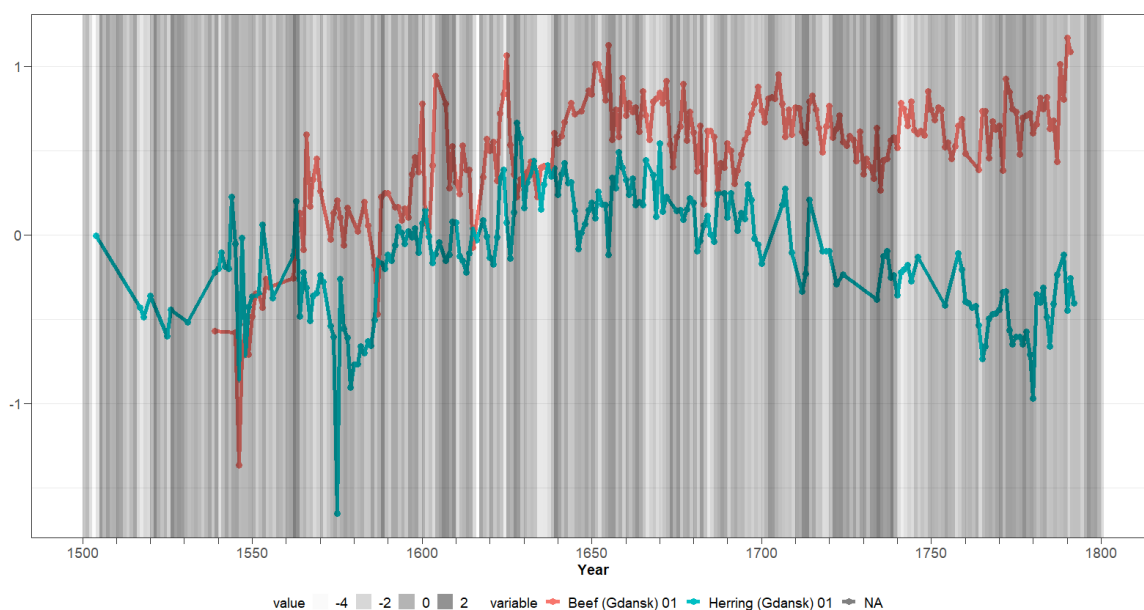


Figure 7.8. Beef and Herring Prices in Gdańsk compared to the OWDA activity.

Spain provides an important southern European perspective (Figure 7.9). In this example, prices come from Barcelona. The OWDA indicates that Spain experienced somewhat different trends to that of France, the Netherlands, and Gdańsk. For example, there were very wet spells in the 1550s, followed by a dramatic drop to very dry years in the following decade, which was not evident in the Netherlands or Gdańsk. Based on the limited price information available for that period, wheat prices displayed a temporary increase in the years following 1550, this may have been due to wet periods leading to poor harvests. On the longer term, wheat prices continued a gradual price incline until the end of the century. The available herring prices are less complete in that time, but they are following a similar trend in that time as wheat. They are also similar in price (when measured in grams of silver per kilogram of produce). In the 1650s, a dramatic OWDA change occurred from high values

to low. Wheat prices were declining in that time. Unfortunately, at this time sufficient information on fish prices is not available to better understand how they behaved. Drought levels in the early 1700s were also different in Spain when computed to Paris, Amsterdam, and Gdańsk, with Spain experiencing drier conditions. Though there is no clear evidence that the price trends in Spain behaved differently from these locations during that time, i.e., the price trends were similar elsewhere despite the different climate behaviour. Prices experienced a decline in the first half of the 18th century. Thus, conflict in Spain may have been influenced by or was even an influence upon price changes in other locations. In such a scenario, any price integration that existed between these regions may have mitigated, to a degree, the differing climate conditions between locations. At least prior 1730s and 1740s. Following this, beef prices began to diverge from herring, a trend not evident in Spain.

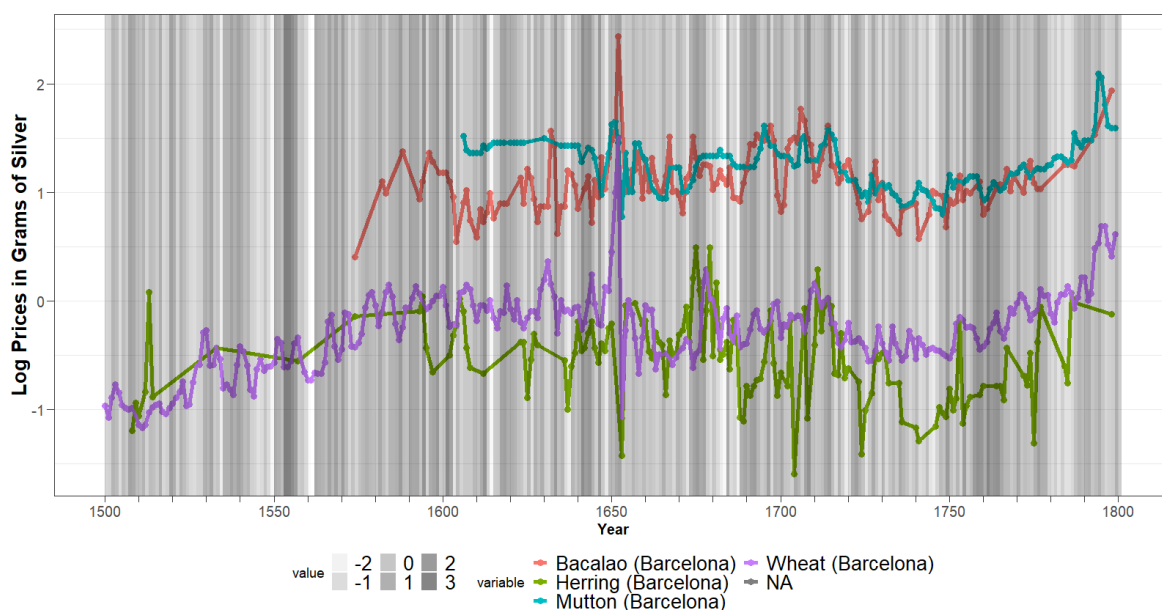


Figure 7.9. Commodity prices in Barcelona, Spain, for cod and herring.

Land temperature is another measure that can be studied as an alternative to gauging drought levels. A reconstruction has been developed by Luterbacher et al. which is a 1,200-year temperature anomaly reconstruction for Europe.²⁸⁴ This reconstruction is based on estimates for temperatures each year in June, July, and August (JJA). The reconstruction covers a period from 755 to 2003. For the purposes of this chapter, study will be limited to

²⁸⁴ Jörg Luterbacher et al. "European Summer Temperatures since Roman Times," *Environmental Research Letters* 11, no. 2 (2016). Online access to database: <https://www.ncdc.noaa.gov/paleo-search/study/19600>.

the early modern period. The reconstruction is based on nine annually resolved tree-ring width chronologies (Figure 7.10). The resolution is not as high as the OWDA reconstruction. Therefore, as the resolution for this reconstruction is based on 5 by 5-degree spatial grids, some countries have been excluded and their neighbours' reconstruction is instead studied. This was also studied in R (the R code can be found in Appendix 2).

This index gives annual values that represent temperature anomalies, rather than absolute temperatures. This means that the values of the index represent variations from expected average temperatures for the JJA time, with more extreme values indicating larger variations from expected values. The values of the index range from -3 to +3. In this regard it is similar to the OWDA, in that it measures activity that is different from what is considered normal, rather than absolute values. On average the entire early modern period tended to be somewhat cooler, as indicated by the general trend of negative values. More specifically, 0 is the average for the entire period the reconstruction was developed for, and negative values indicate cooler temperatures than what might be expected. Thus, this indicates the occurrence of the Little Ice Age, and the generally cooler temperatures that it came with. The long-term trends over the indices for the various locations, as represented by the trendlines, do indicate that for most locations, the temperature anomalies were similar in the different locations. In this instance, Spain is not behaving notably different from the other locations.

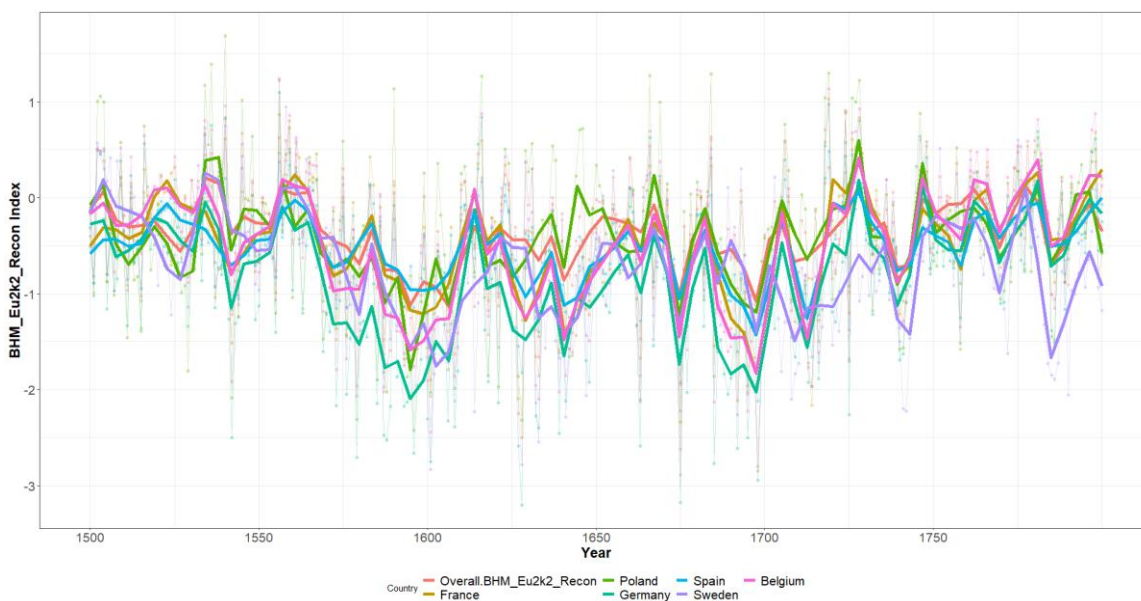


Figure 7.10. Estimated European summer temperatures anomalies. Based on 5 by 5 degree grids. Based on the work of Jörg Luterbacher et al.

Broadly speaking, there are similar trends between Luterbacher's temperature reconstruction and the OWDA reconstruction. As the OWDA offers higher resolution information, it was studied for this thesis. Beyond the scope of this chapter, it does offer the opportunity for a more extensive analysis than with the OWDA alone. This would require a comparison of the indices to understand at what times and locations they display similarities, as well as when they diverge from one another. There are commonalities between both this reconstruction and the OWDA over the long term. For example, the final two decades of both the 16th and 17th century were experiencing colder temperatures, with a turning point in both cases moving into the 17th and 18th centuries respectively. These periods of cold surrounded heightened drought levels in the 17th century. Thus, the combination of drought and temperature conditions that occurred in the 17th century created environmental conditions that may have contributed to commodity supply and price changes.

In conclusion, the OWDA does display variation between locations. Over the long term, heightened OWDA activity may have been an influence on price changes in the 17th century. When prices in particular locations are compared to the OWDA indices tailored to these locations, there are instances when notable price changes occur following heightened levels of drought or wet conditions. During the 17th century, many locations displayed higher levels of OWDA activity. Along with other environmental activity, such as lower temperature on land, this created a complex interaction of climate events. The outcome of this may have contributed to levels of conflict and higher commodity prices. Some evidence suggests Spain experienced markedly different drought conditions than other locations. For example, drought levels were high in the 1720s and 1730s when this was not the case in other locations. Shifts in prices, that were discussed in the preceding chapter as being related to conflict, may also have been influenced by these elevated environmental conditions. Such different behaviour between northern and southern regions of Europe may have contributed to both regions producing different food consumption patterns.

7.4. Conclusions

It is the case that ocean temperature, drought levels on land, and volcanic eruptions correlate with price changes for different commodities. Of much prominence, the AMV and

OWDA display heightened activity during the General Crisis, in particular during the Thirty Years' War (1618 to 1848). The different environmental proxies often follow similar trends, thus precisely what environmental activity influenced prices is difficult to ascertain.

Towards the end of the 17th century, prices for beef and herring diverged. With high values for the AMV occurring during that time as well as increased OWDA volatility, there may have been a complex interaction occurring with environmental variability, influencing conflict levels, food supplies and prices. Thus, relatively extreme environmental activity corresponded with contrasting price behaviours between commodities. For example, herring and cod progressively lost value relative to beef and wheat in the early 18th century.

Prices in northern and southern European regions did not always follow the same trends. In fact, there are indications that different products shifted in relative value during heightened environmental activity. This corresponds with differing OWDA activity in northern and southern European locations. Periods of heightened environmental activity indicate that there may have been a shift towards marine fish in the south, with Spain as an example. This was in contrast with the North, with beef in Gdańsk becoming more expensive. In the case of Spain, drought leading to lower crop yields would have encouraged increased reliance on consumption of products such as marine fish. Gdańsk did not experience the same difficulties, thus leading to different behaviour in the two locations.

8. Discussion

In the previous chapters, the combined interactions of conflict, climate, and prices dynamics were alluded to but not extensively studied. Advanced quantitative techniques are an important aid to untangle these complex interactions. To this end, in what follows, Superposed Epoch Analyses (SEA)s have been applied to understand the influence of extreme climate events on conflict levels. Next, autoregression techniques have been applied to explore if it is likely that a genuine causal correlation existed between conflicts, climate, and prices. Prior to this, however, a review of results from previous scholars has been conducted and compared the results presented in this thesis thus far.

8.1. Comparison with Previous Research

Analysis of cod and herring price over a large geographical spread of Europe is novel. Previous scholars often studied one product, usually grain, or fish prices within individual countries. The question arises, how do the new results presented in this thesis compare to those of previous scholars, such as Regina Grafe, Victoria Bateman, Kevin O'Rourke, and Giovanni Federico? Overall, there is a broad consensus that European market integration began in the late 15th century and continued rapidly until the early 17th century when it stalled, before resuming after the Thirty Years' War (1618 to 1648) and continuing until the early 19th century, when it stalled again during the Napoleonic Wars.

Each scholar has contributed to the understanding of market integration. Giovanni Federico and co-authors' recent publication covers wheat in a comprehensive manner, from the mid-14th to the early 20th centuries.²⁸⁵ Their research, as the authors themselves note, further supports the concept of the "Little Divergence" from the beginning of the 17th century between a rapidly advancing Northwest Europe and the rest of mainland Europe. Such a divergence is consistent with what has been shown in this thesis (for example, see section 5.1.1).

Victoria Bateman's research focuses on wheat markets in Europe. Her research from 2011 employs methods such as the Coefficient of Variation (CV) to determine market

²⁸⁵ Giovanni Federico, Max-Stephan Schulze, and Oliver Volckart. "European Goods Market Integration in the Very Long Run: From the Black Death to the First World War," *The Journal of Economic History* 81, no. 1 (2021): 276-308.

integration.²⁸⁶ Bateman concluded that a degree of integration existed in the 1500s, that it lessened in the 1600s, then partially recovered in the 1700s. Bateman notes conflict, such as the Thirty Years War (1618 to 1648), may have been a reason for some of the loss of integration that occurred during the 1600s.²⁸⁷

Findlay and O'Rourke's *Power and Plenty* describes the years from 1500 to 1780 as being composed of two distinct periods.²⁸⁸ From 1500 to 1650 there was "old world trade" and was under the influence of the influx of silver, during a time when new trade routes were being established following European discovery of North America. The period that followed, from 1650 to 1780, is described as the "Age of Mercantilism", which was marked by the growth of empires in Europe and commercial entities such as trading companies.

Kevin O'Rourke and Jeffrey Williamson analysed globalisation (in terms of integration) and its temporal evolution.²⁸⁹ For this, levels of increasing price convergence between regions were used as an indicator of increasing market integration and vice versa.²⁹⁰ They argue that price convergence did not occur before the 1800s.²⁹¹ This is broadly in keeping with the results of this thesis, which showed levels of integration were similar by the end of the study period as they had been at the start, (having gone through a period of less integration within the study period). Ronald Findlay and Kevin O'Rourke present evidence that clove markets became less integrated during the early 1600s, returning to levels seen before this time by the late 1700s.²⁹² This observation aligns with trends discussed in previous chapters for cod, herring, beef, and wheat markets.

There has been limited comparable research on integration in fish markets. Major contributions have come from Regina Grafe, who advanced our knowledge of bacalao in Spain, including how its price dynamics compared to those of wheat.²⁹³ Grafe's research

²⁸⁶ Victoria Bateman. "The Evolution of Markets in early modern Europe, 1350-1800: A Study of Wheat Prices 1," *The Economic History Review* 64, no. 2 (2011).

²⁸⁷ *Ibid*, 459, for example.

²⁸⁸ Ronald Findlay, and Kevin H. O'Rourke. *Power and Plenty: Trade, War, and the World Economy in the Second Millennium*. Vol. 30 (Princeton University Press, 2009).

²⁸⁹ Kevin O'Rourke, and Jeffrey G. Williamson. "When Did Globalisation Begin?" *European Review of Economic History* 6, no. 1 (2002): 23-50.

²⁹⁰ *ibid*, 26.

²⁹¹ *ibid*, 28.

²⁹² Ronald Findlay, and Kevin H. O'Rourke. "Commodity Market Integration, 1500-2000," in *Globalization in Historical Perspective*, 13-64 (National Bureau of Economic Research, 2003), 25.

²⁹³ Regina Grafe. *Distant Tyranny: Markets, Power, and Backwardness in Spain, 1650-1800* (Princeton University Press, 2011).

not only makes a novel addition to the understanding of market integration, but also to commodity substitution, which she discusses for the Iberian Peninsula.²⁹⁴

Less information is available on the state of fish market integration in Northern Europe. For example, in Gdańsk, levels of market integration for rye were termed “good” in the 16th century, before disintegrating in the 17th century, according to Mikołaj Malinowski. They remained as such during the 18th century, more so than Western European nations.²⁹⁵ This was also the case for herring, as discussed in Section 5.2.1.

The consensus across previous research is that from 1500 to 1800 CE, wheat, cod, beef, and herring followed similar long-term price trends as well as shared periods of price volatility. The evidence suggests cod and herring were slightly more integrated than the wheat market, however.

Table 8.1. Views of selected previous scholars.

Author	Products or Regions	Market Integration Views
Bateman	Wheat in Europe	A degree of integration in the 1500s, less in the 1600s and partial recovery in the 1700s
O'Rourke	Various, regions and products. Includes wheat and pepper	No observed price convergence before 1800.
Grafe	Bacalao in Spain	Responds to previous research focused on wheat that suggested market integration in Spain was less than in much of Europe. By instead studying Bacalao, shows there was a higher degree of such integration.
Unger²⁹⁶	Wheat (mostly) in Europe	MI had been low during the 15th century (i.e., before the study period) and it had increased by the 16th century.
Federico	Mostly wheat and Europe	Points out that methods and techniques used to study MI are diverse and confusing, as well as the results and questions.
Malinowski	Rye in Poland	Decrease integration in the 17th century compared to the previous century. Remaining disintegrated in the 18th century, more so than Western Europe.

²⁹⁴ Regina Grafe. *Popish Habits vs. Nutritional Need: Fasting and Fish Consumption in Iberia in the Early Modern Period*. No. 055. (University of Oxford, Department of Economics, 2004).

²⁹⁵ Mikołaj Malinowski. “Market conditions in preindustrial Poland, 1500–1772,” *Economic History of Developing Regions* 31, no. 2-3 (2016): 253-276.

²⁹⁶ Richard W Unger. “Thresholds for market integration in the Low Countries and England in the fifteenth century,” in *Money, Markets and Trade in Late Medieval Europe: Essays in Honour of John HA Munro* (2007): 349-380.

Commodity substitution is often indicated by changing relative prices of commodities. The value of fish was changing at a different pace depending on the location within Europe, and this indicates the degree of commodity substitution that occurred in different locations. For example, in Gdańsk, herring prices began decreasing in the mid-17th century, which was in contrast with the increasing prices seen in many locations such as the Netherlands.²⁹⁷ Poulsen also notes that the herring price decrease in the decade 1575-85 coincided with a substantial increase in supply of herring from Bohuslän. This was in contrast with the increasing cod prices seen in Barcelona, i.e., giving a Southern European perspective. (See Section 5.1.2.)

8.2. Influence of Conflict and Climate on Prices

In the previous chapters, the interactions between conflict, climate and prices dynamics were alluded to but not extensively studied. In what follows, Superposed Epoch Analyses (SEA)s have been applied to understand the influence of extreme climate events on conflict levels. Also, autoregression techniques have been applied to explain if it was likely that a correlation existed between conflicts, climate, and prices.

8.2.1. Influence of Climate on Conflict

The following analysis of the influence of climate on conflict is “unidirectional” in the sense that we posit climate as an influence on conflict. While conflict can potentially influence regional climate through landcover changes, it is unlikely that it has had a significant influence on climate in this time period. The complex relationship between conflict and climate in the early modern period is presently an active area of research. Much of this was discussed in Chapter 6. For example, Poulsen notes the influence of conflict and climate on Dutch herring fisheries.²⁹⁸ The Thirty Years’ War (1618 to 1648) is often referred to as occurring during a period of tougher environmental conditions that encompassed the 17th century.²⁹⁹ In the more distant past, Joseph Manning and Francis Ludlow discuss these

²⁹⁷ Poulsen, *Dutch herring*, 95-6.

²⁹⁸ *Ibid*, 233.

²⁹⁹ Geoffrey Parker. “Crisis and Catastrophe: The Global Crisis of the Seventeenth Century Reconsidered,” *The American Historical Review* 113, no. 4 (2008): 1053-1079, 1053.

interactions in the context of ancient Egypt.³⁰⁰ (See Chapter 7 for further discussion of environmental factors.)

Conflict during Climate Extremes

The following SEA analyses examine how conflict levels responded following years of elevated climate stress. The conflict data are based on the overall index that was studied in Chapter 6.

The first SEA (Figure 8.1 below) compares conflict against climate by studying sea surface temperature, which are represented by a reconstruction of the Atlantic Multidecadal Variability (AMV).³⁰¹ Years of extreme sea surface temperature are based on the more outlying values within the AMV distribution. Here “outlying” refers to two groups of values: the highest 10 and lowest 10 within the period from 1500 to 1800. The lowest (i.e., Coldest) 10 generate statistically significant results (which are shown in Figure 8.1), while the highest 10 do not (figure not shown). Statistical significance is tested at the 90% level. That is, years relative to extreme AMV activity that led to the highest 10% of conflict values are considered significant, and the 10% lowest for the second test. The values in Years 4 and 8 suggest that within a number of years following the extreme AMV values, conflict levels became significantly higher (p-values are 0.07 and 0.095 respectively). Thus, for years displaying extreme cold AMV activity, the years from 4 to 8 are all higher, even if not all values are statistically significant. Thus, unusually lower sea surface temperatures often occur before elevated levels of conflict. Such a result indicates it is possible that the lower sea surface temperatures indirectly contributed to disruption, “knocking” societies out of periods of stability (i.e., low conflict levels) or contributing further to periods of instability. The value in Year -2 suggests that conflict levels tended to be low prior to unusually lower sea surface temperature years. There is a high degree of variability displayed on the chart, thus these lower levels of conflict prior to the cold AMV years could be by chance causing statistical significance.

³⁰⁰ Joseph G. Manning et al. “Volcanic Suppression of Nile Summer Flooding Triggers Revolt and Constraints Interstate Conflict in Ancient Egypt,” *Nature Communications* 8, no. 1 (2017).

³⁰¹ Jianglin Wang et al. “Internal and external forcing of multidecadal Atlantic climate variability over the past 1,200 years,” *Nature Geoscience* 10, no. 7 (2017): 512-517.

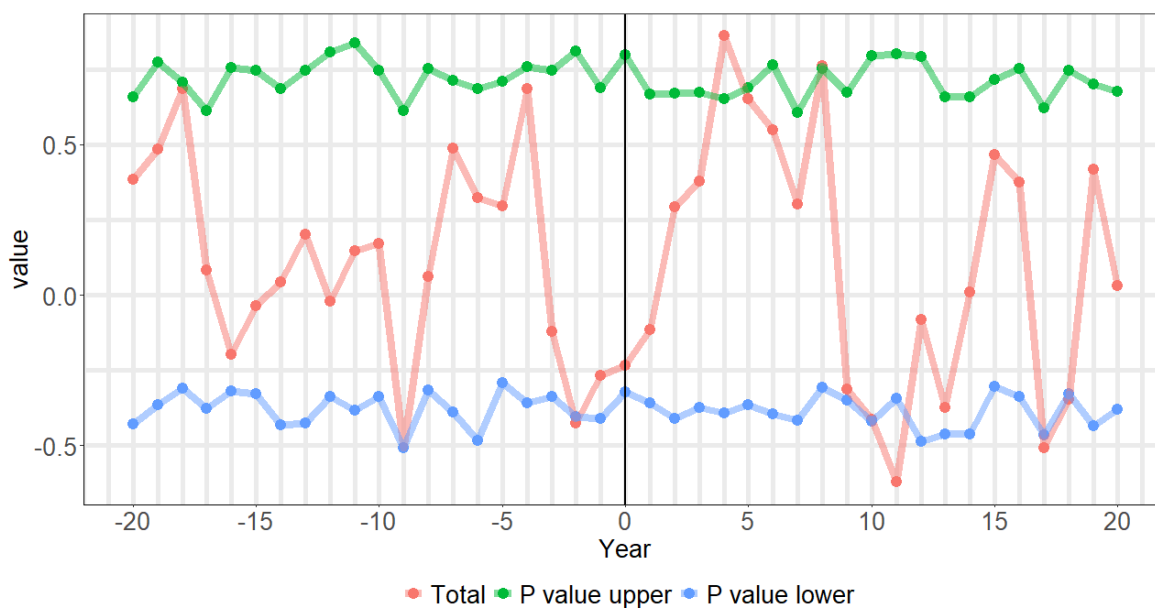


Figure 8.1 SEA comparing conflict to the ten years of lowest SST temperatures (based on reconstructed AMV relative to the preceding 10 years).

The second SEA moves from the oceans to land, and compares conflict to drought levels, which are represented by the Old World Drought Atlas (OWDA).³⁰² The highest and lowest 25 (i.e., most extreme) soil moisture values are again tested, representing unusually wet and dry years, respectively. The results suggest conflict levels decrease in the years following drought. Years 1 to 4, 7 and 14 following the extreme droughts produce statistically significantly lower levels of conflict (again 90% level). This indicates that conflict levels were initially lower after droughts, possibly due to a lack of resources to focus on conflict. There is a “swing”, however, that follows with statistically significantly elevated levels of conflict in year 17. Such a distant change may occur simply by chance, however, it occurs following a trend of increasing values over previous years. Even though these values were not statistically significant when considered individually, they reinforce the likelihood that the trend is indicative of a long-term increase in conflict levels following drought years.

³⁰² Edward Cook et al. “Old World megadroughts and pluvials during the Common Era,” *Science advances* 1, no. 10 (2015).

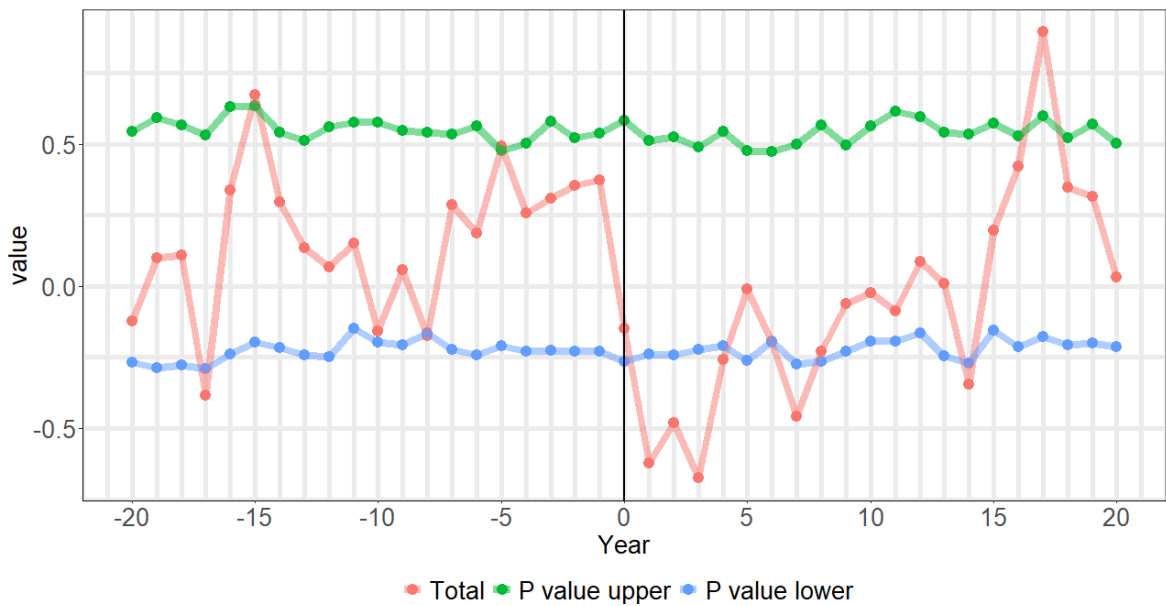


Figure 8.2 SEA comparing conflict to drought levels. Based on OWDA normalised relative to the preceding 10 years.

Both SEAs thus reveal statistically significant changes in conflict levels in years starting immediately or shortly after the examined climate extremes. They also provide evidence that these extreme events influenced conflict levels for up to two decades after they occurred. Also, while there are apparent significant years in the minus range, they are not as frequent, sustained, or significant as what is observed in the post-extreme years. This is consistent with a hypothesis that statistically significant pre-extreme years may have occurred due to chance, while the post-extreme years may have contained a genuine response signal.

Conflict and Climate Linear Correlation

To understand the association between conflict levels over the entire range of all values for each (rather than just the extremes) the data have been compared using linear regression models. Such models establish the strength of any linear association between variables. Multiple linear regression models simultaneously facilitate the study of more than two sets of data (i.e., variables) at once. Thus, they allow analysis of the combined contributions of conflict and climate on prices in one model. One output of these models is a value known as the “ r^2 ” value. These r^2 values measure the strength of the associations within the models. They range between 0 and 1 (or, in other terms, 0% and 100% with 0% meaning

the same as 0 and 100% as 1). In the following, they represent the extent that conflict and climate variables contribute to the overall price change. The models that follow also study values in previous years (referred to as “lags”), as well as the values in each year. The most prominent lags (i.e., those with the largest statistically significant r^2 value) are the focus. While the SEA analyses indicate meaningful delays between the hypothesised stressor (i.e., climate and conflict) and outcome (i.e., conflict and prices), the lags indicate the extent of the association between the variable across all values rather than the extreme events alone. These lags are studied as economic systems may be affected not only in the same year as a climate or conflict event, but also in years afterwards, possibly multiple years. For example, this can be the case if a state had sufficient stored grain reserves to compensate in the short term for failed or destroyed harvests.

The first linear regression example analyses sea surface temperatures and drought levels (Equation 8.1 below). These time series in their initial “raw” state are biased (for the purpose of the analysis) by long-term trends. The time series used below have therefore been “normalised” relative to the (mean and standard deviation of) values from the same time series over the previous ten years. The normalisation reduces the influence of long-term trends, thus allowing a clearer focus on the shorter-term associations between the variables under study. The regression model relates conflict to sea surface temperatures (SSTs, as reconstructed in the AMV) and drought levels for the current year and 15 previous years. Several statistically significant lags are identified and included in Equation 8.1. Statistical significance has been set at 0.9. These lags are the AMV in years 0 and 6 and OWDA in years 6 and 7. Both occurring with a negative association, meaning that lower conflict levels were associated with higher AMV values and vice versa. These results generate an r^2 value of 7.2%, thus this indicates that the climate conditions, from the perspective of the linear regression model, explains approximately 7.2% of variability.

Equation 8.1. Conflict compared to climate.

$$\text{Conflict} \sim \text{AMV} + \text{AMV_lag6} + \text{OWDA_lag6} + \text{OWDA_lag7}.$$

To further understand the association of each variable, the correlation matrix (Table 8.1 below) highlights the level of association between each pair of series. These values are

related to the “r” value generated in linear regression models. As mentioned above, the AMV association in Year 0 with conflict is statistically significant. The r value is -0.07, which indicates a negative association. The next significant AMV value occurred in Year 6. Indicating that AMV activity 6 years prior was associated with conflict levels. With a negative r value of -0.16, it suggests that higher ocean temperatures lead to lower conflict levels and vice versa. Or in other terms, conflict levels rose after drops in SST (and vice versa). Such an association is indicative that changing ocean temperatures influenced changes to food supplies from the oceans, which in turn led to a change in the likelihood of conflict occurring. Another possibly more direct reason for such an association could be if SSTs mirror air temperatures over land, leading to terrestrial agricultural stresses that led to higher levels of conflict. Alternatively, in the case of marine food supplies, colder temperatures might be associated with more abundant supplies of food. The OWDA displays association with conflict in years 6 and 7, both of which are positive. In this case, the model is suggesting that wetter conditions led to higher conflict levels several years later (and vice versa).

In summary, both the AMV and OWDA bear an association with the prices in this model. By taking the squared value of each entry in the matrix, the result is analogous to the r^2 value between each pair of variables. These values are approximately 3% from the AMV in years 6 and over 1% from OWDA in each of years 6 and 7. This gives a total similar to the aforementioned total r^2 value of 7.2%.

Table 8.2 Correlation matrix comparing conflict and environment. All series were normalised relative to the previous ten years prior calculating correlations.

		Conflict	AMV		OWDA	
	Lag	0	0	6	6	7
Conflict	0	1	-0.07	-0.16	0.11	0.11
AMV	0	-0.07	1	0.04	-0.1	-0.1
	6	-0.16	0.04	1	0.09	0.06
OWDA	6	0.11	-0.1	0.09	1	0.41
	7	0.11	-0.1	0.06	0.41	1

8.2.2. Influence of Conflict and Climate on Prices Examined Separately

Cross-correlation analyses have been developed to understand the association of price with conflict and climate individually, before later moving to a combined model for both variables and their association with prices. Firstly, overall price indices were created for each of cod, herring, beef, and wheat, (similar to those studied in Chapter 7). These indices are indicators of the average trend of price movement throughout Europe.

Conflict and Prices Correlation/Regression

As observed earlier, notable statistically significant associations tend not to occur immediately (i.e., in the same year), thus cross-correlation models are applied here to reveal significant lags. The results vary for each of herring, cod, wheat, and beef versus conflict (Figure 8.3 below). For herring, in Year 4, there is a statistically significant correlation at the 0.95% level (two-tailed). The correlation is positive, thus indicating that elevated fish prices occurred in years following conflict and in turn, it is likely that conflict led to elevated herring prices. In the case of cod, such a statistically significant value occurred in Year 6. Thus, any influence of conflict on cod prices emerged later than was the case for herring.³⁰³ There is also a statistically significant correlation in Year -3, indicating the possibility that lower cod prices were followed by periods of conflict. Such a correlation, if genuine, indicates an unusual set of market behaviour. Rather than being read as lower cod prices somehow promoting (directly or indirectly) increased conflict, we may posit that these lower prices were symptomatic of changes occurring in years that lead to elevated levels of conflict.

To understand how these marine fish markets behaved relative to other foods, beef and wheat have also been studied. Beef prices reveal numerous notable positive correlations with conflict, with statistically significant prices in years -7 to -3 i.e., before increased levels of conflict. They are also significant following conflicts, specifically in Year 5. It is possible that high beef prices were symptomatic of economic stress, which may have been part of the process that led to conflict. This would suggest that conflicts themselves can be

³⁰³ Possibly differing transport times introduce a different response timing in the models. It is difficult to specify a convincing mechanism for this.

generative of economic stress (and price increases, e.g., by disrupting agriculture). Such a scenario would be an example of a positive feedback loop.

Beef appears to exhibit a stronger association with conflict than either herring or cod. This suggests beef markets were more affected by conflict. Wheat, by contrast, does not show statistically significant correlations. However, they are near the threshold of statistical significance, indicating a positive association may have existed. Here, a greater ability to store grain could have protected the markets from year-on-year problems associated with elevated levels of conflict.

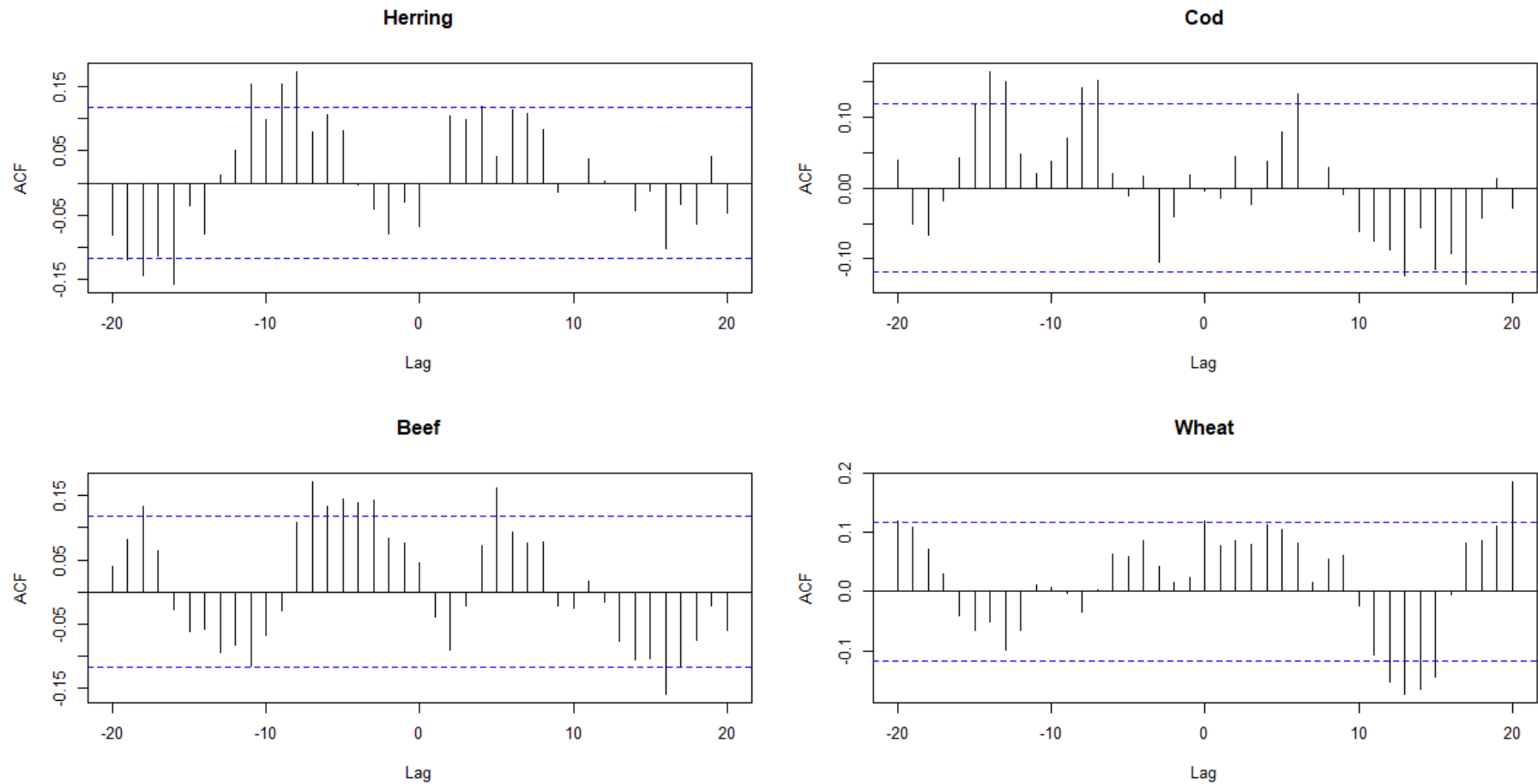


Figure 8.3 Cross-correlation of conflict levels per year against herring, cod, beef, and wheat logged prices. Positive lag values represent the association of prices with conflict. Correlation coefficients at lag 0 represent the correlation between prices and conflict levels in the same years, while positive lags represent the correlation between conflict levels and prices in each of the individual twenty years following. The negative lags show the association with conflict and prices for each of the previous 20 years. Prices and conflict both include a 10-year normalisation relative to the previous 10 years. Any lag years that breach the blue lines are significant at the 95% level (two-tailed).

Climate and Prices

Drought levels, as indicated by the OWDA, display statistically significant correlations when compared with normalised prices. (See below Figure 8.4). Herring prices are negatively correlated in years 1 and 7, thus suggesting that dry conditions lead to price increases and vice versa (i.e., that wet conditions lead to decreases). Cod, beef, and wheat exhibit statistically significant negative correlations in years -1 and -3. A positive correlation is noted for cod in Year 10. The correlation is positive in this case, suggesting that drier periods were related to decreased prices and vice versa.

Thus, for both cod and herring, soil moisture levels correlated with price movements. The associations were different, however, with herring prices increased during dry conditions while cod prices decreased (and vice versa), dependent on the lags under consideration.³⁰⁴ Such an association set up conditions for commodity substitution, that is, for cod to become a cheaper alternative to herring during drought periods and herring as a cheaper alternative to cod during wet periods. Beef exhibits a stronger association with conflict than either herring or cod, suggesting beef markets were more affected by conflict. In such times, cod and herring may have acted as substitutes. Wheat, however, was resilient during conflict and would have continued to be in supply.

³⁰⁴ Further analysis could reveal that some form of non-linear association exists. Or that the relationship depends more on how extreme condition were, rather than the distinction of dry or wet.

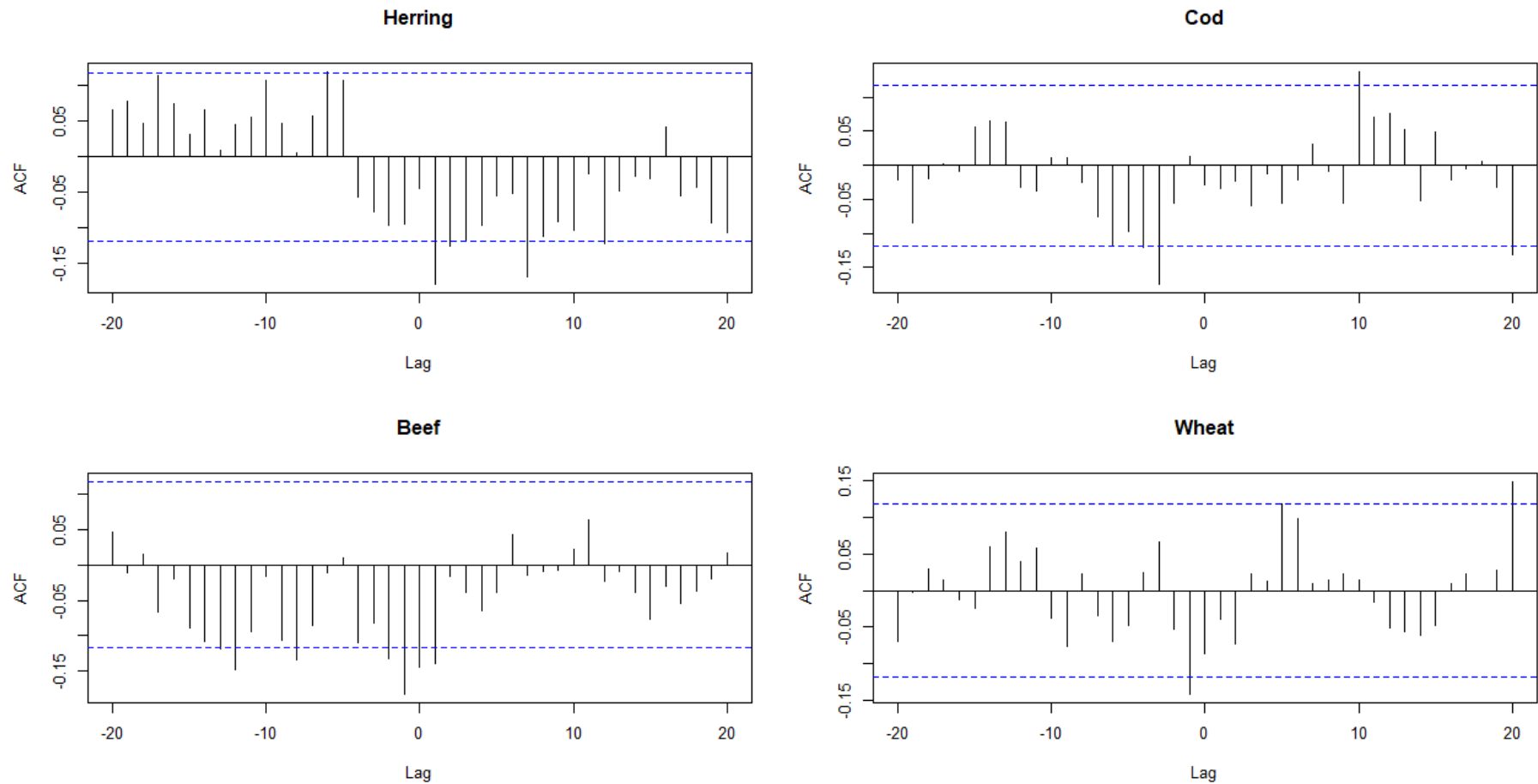


Figure 8.4 Cross-correlation of drought levels against herring, cod, beef, and wheat logged prices. Positive lag values represent the association of prices correlation with OWDA. Prices again normalised by ten years. Correlation coefficients at lag 0 represent the correlation between prices and the OWDA in the same years, while positive lags represent the correlation between the OWDA and prices in each of the individual twenty years following. The negative lags show the association with the OWDA and prices for each of the previous 20 years. Any lag years that breach the blue lines are significant at the 95% level (two-tailed).

Ocean temperatures display a statistically significant association with prices (Figure 8.5 below), some of which are positive and others negative. Herring prices are statistically significant in Year 6. This was not the case for cod, however, possibly due to a significant source of cod coming from a distant location, i.e., from North America, where the Atlantic Multidecadal Variability would not necessarily have had the same influence. Beef prices show statistically significant years too, i.e., in years 8 and 9. These significant years were different from cod though somewhat similar to herring. It is difficult to interpret how ocean temperature would have influenced beef prices. It is possible that a complex interaction with marine products may have influenced other products, which in turn would have caused beef prices to change.³⁰⁵ Wheat is again not displaying significant values, possibly due to being isolated by a better ability to be stored leading to reduced price changes. Unlike wheat, markets for herring and beef were not able to insulate price changes over time in the manner that wheat storage allowed. The negative price correlation for herring in Year -4, suggest prices tended to decrease in advance of higher temperatures (and vice versa). This hints at the possibility that herring prices tended to be lower in the years prior to warmer temperatures (and vice versa).³⁰⁶

³⁰⁵ For example, if ocean temperatures were mirrored largely by air temperatures, severe cold waters in a given year may have been accompanied by severe air temperatures that could kill cattle.

³⁰⁶ Herring productivity can be greater in cold waters, thus if colder waters tended to precede warmer waters, then it would be possible that in year -4 the prices would have been lower due to larger supplies of herring.

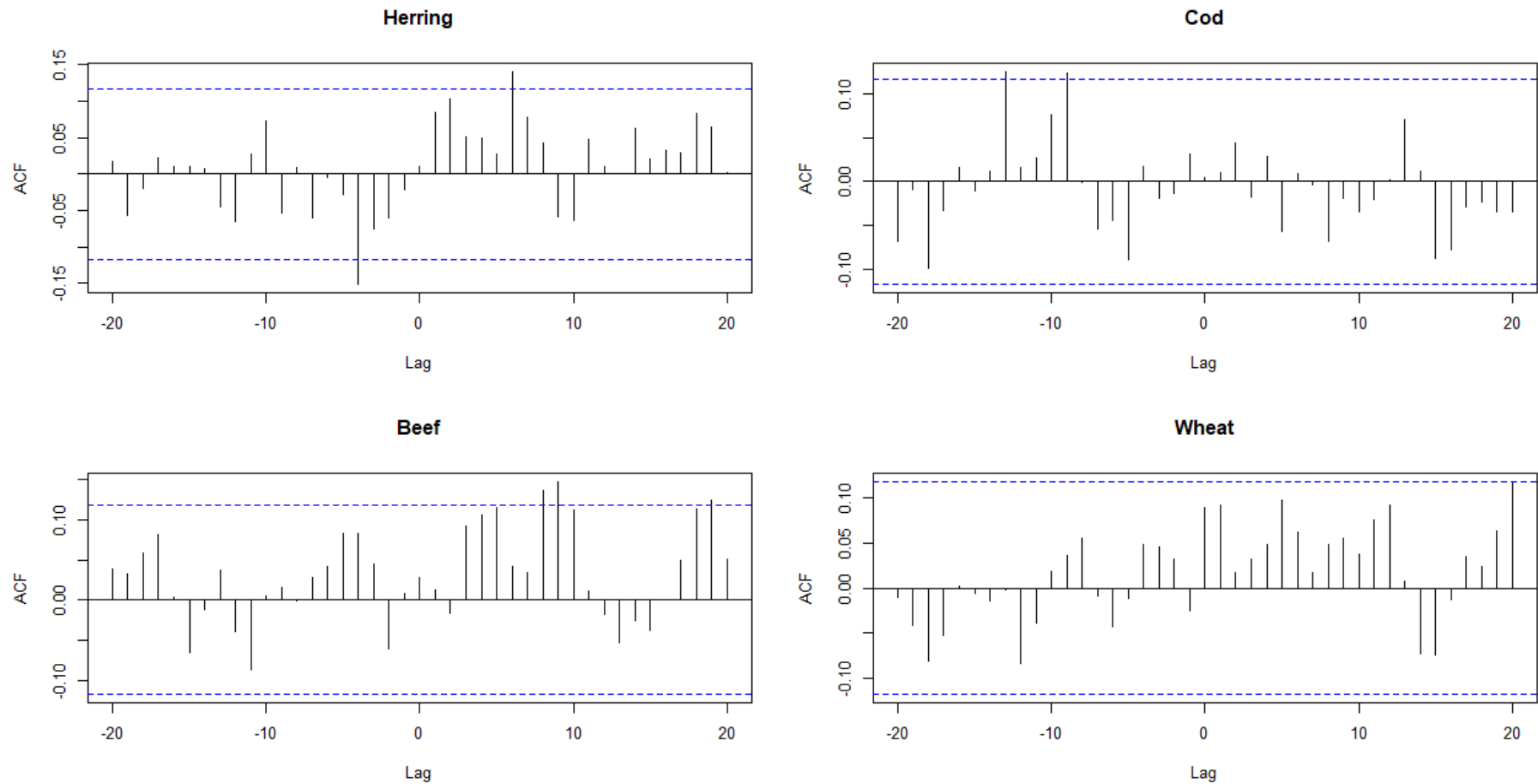


Figure 8.5 Cross-correlation of ocean temperature variability against herring, cod, beef, and wheat logged prices with conflict levels per year. Positive lag values represent the association of prices are associated with the AMV. Prices are treated with a ten-year normalisation. Correlation coefficients at lag 0 represent the correlation between prices and the AMV in the same years, while positive lags represent the correlation between the AMV and prices in each of the individual twenty years following. The negative lags show the association with the AMV and prices for each of the previous 20 years. Any lag years that breach the blue lines are significant at the 95% level (two-tailed).

In conclusion, it is evident that both conflict and climate correlate with (normalised) commodity prices. The frequently delayed nature of the correlations suggest it took time for their influence to materialise on the markets. The influence upon cod prices was more delayed than that of herring, which may in part reflect cod coming from more distant fishing grounds in many cases. The influence of climate may have indirectly resulted in herring prices increasing following periods of elevated conflict levels. On the other hand, cod prices decrease. Such an association indicates that the cod market was performing well during elevated conflict in the sense that prices were not pushed up. This scenario would have encouraged commodity substitution, with cod substituting herring in times of elevated conflict as its value decreased more than was the case for herring, while the converse may also have occurred during times of less conflict.

8.2.3. Combined Influence of Conflict and Climate

It remains to understand how conflict and climate, including their association with one another, contributed to price movements. To this end, multivariate linear regressions have been applied. These models have again been developed to focus on statistically significant associations that occurred for up to 15 years beforehand. Lag terms are included in the model below if they achieve statistical significance at a level of 10%.

In the case of herring (Equation 8.2 below), the r^2 value implies that up to 61.25% of price movement (or “variance”) can be explained by a combination of the price from the previous year, as well as conflict and climate. That is, conflict two and three years prior, ocean temperature variability nine years prior as well as soil moisture levels (indicated by the OWDA) in years 0, 1, 7 and 12.

Equation 8.2. Linear Model Equation for herring.

(R-sq.(adj) = 0.6125, 256 degrees of freedom):

$$\log_price \sim \log_price_lag1 + Conflict_lag2 + Conflict_lag3 + AMV_lag9 + OWDA + OWDA_lag1 + OWDA_lag7 + OWDA_lag12.$$

To untangle the extent each variable contributes to the observed 61% of explainable price variance, the correlation matrix below displays the extent to which each variable is linearly correlated with each other. The square of each of these variables is the coefficient of

determination, i.e., the r^2 for the association between a particular pair. Thus, the price correlated to the previous year with a value of 76%, which indicates an r^2 of 58% (i.e., $0.76^2 = 0.58$). This indicates the majority of the association of price comes from the previous year's price. The conflict r value is .22 in year 2 and year 3 before price changes. As the r value is positive, this indicates that increased conflict occurs before increased prices (and vice versa). The r^2 of these variables is 4.9%. Both of these variables strongly correlate with one another (i.e., they have a high level of cross-correlation), thus their individual contribution to the price association should not be double-counted.³⁰⁷ Thus, their combined influence is little more than 5%. Ocean temperature variability in Year -9 contributes about 2%. Much of this association contributes directly towards price as the correlation with conflict is low. The OWDA in years 7 and 12 each contributed about 1%. Thus, the combined efforts of environmental variables also account for approximately 4-5%. The association between the AMV and OWDA displays about 1% overlap. In total conflict and climate appear to contribute almost 10% to the price variance.

Table 8.3. Correlation Matrix for logged herring prices, conflict levels and environment.

		Log Price		Conflict		AMV	OWDA			
		0	1	2	3	9	0	1	7	12
Log Price	0	1	0.76	0.22	0.22	-0.15	0.15	0.05	-0.12	-0.11
	1	0.76	1	0.18	0.22	-0.07	0.09	0.14	-0.04	-0.01
Conflict	2	0.22	0.18	1	0.85	-0.11	0.04	0.02	0.06	0.02
	3	0.22	0.22	0.85	1	-0.16	0.06	0.04	0.01	0.04
AMV	9	-0.15	-0.07	-0.11	-0.16	1	-0.17	-0.11	0	-0.06
OWDA	0	0.15	0.09	0.04	0.06	-0.17	1	0.38	0.02	-0.03
	1	0.05	0.14	0.02	0.04	-0.11	0.38	1	-0.08	-0.01
	7	-0.12	-0.04	0.06	0.01	0	0.02	-0.08	1	0.06
	12	-0.11	-0.01	0.02	0.04	-0.06	-0.03	-0.01	0.06	1

³⁰⁷ Further information on this topic can be found under the topic of "multilinearity" or "collinearity".

Completing a similar analysis for cod prices again reveals statistically significant lag terms. These lags occur with a larger delay than they did with herring. Conflict is statistically significantly associated with price in years 8, 14 and 15, ocean temperature variability in years 5, 8 and 15, and soil moisture levels (as per the OWDA) are statistically significantly associated with prices in years 10, 11, 14 and 15. The delay is again evidence that cod markets reacted later than herring to external influences.

Equation 8.3. Linear Model Equation for cod.

(R-sq.(adj) = 0.555, n = 261.)

$$\log_price \sim \log_price_lag1 + Conflict_lag8 + Conflict_lag14 + Conflict_lag15 + AMV_lag5 + AMV_lag8 + AMV_lag15 + OWDA_lag10 + OWDA_lag11 + OWDA_lag14 + OWDA_lag15.$$

The overall r^2 value for cod is similar to that of herring, with a value of 0.628. Again, the previous years' prices have the largest influence on the current year's price, with $r = 0.76$ and giving $r^2 = 0.58$. Thus, much of the r^2 value is driven by the price in the previous year. Conflict was significant, in this case, in years 8, 14 and 15, contributing 2%, 2% and 3%, respectively. This gives a figure of 7%. Some of this can, however, be explained by "internal" associations between the three conflict lag terms. Accounting for this could reduce the contribution of conflict to around 5%. The AMV in years 8 and 15 contributes 1% and 1%, respectively. This implies a contribution of 2%.³⁰⁸ The OWDA at lag 14 contributed approximately 1%. This implies a cumulative contribution from conflict and climate of around 10%. Such a result is similar to that of herring.

Table 8.4. Correlation matrix for logged cod prices, conflict levels and environment.

		Log Price		Conflict			AMV			OWDA			
	Lag	0	1	8	14	15	5	8	15	10	11	14	15
Log Price	0	1	0.76	-0.15	-0.14	-0.16	-0.04	-0.09	-0.11	-0.02	-0.04	-0.1	-0.03
	1	0.76	1	-0.15	-0.16	-0.14	0	-0.02	-0.05	-0.14	-0.01	-0.04	-0.09
Conflict	8	-0.15	-0.15	1	0.62	0.61	-0.11	-0.07	-0.1	0.01	0.03	0.11	0.1

³⁰⁸ In this case, both terms did not display a high level of correlation, thus each contributed about 1% to the model.

	14	-0.14	-0.16	0.62	1	0.85	-0.15	-0.12	-0.1	0.02	0.01	0	-0.02
	15	-0.16	-0.14	0.61	0.85	1	-0.17	-0.14	-0.07	-0.02	0.01	-0.03	0
AMV	5	-0.04	0	-0.11	-0.15	-0.17	1	0.15	0.05	-0.04	-0.04	-0.01	0.03
	8	-0.09	-0.02	-0.07	-0.12	-0.14	0.15	1	-0.01	0.03	-0.04	-0.04	-0.06
	15	-0.11	-0.05	-0.1	-0.1	-0.07	0.05	-0.01	1	-0.09	-0.12	0.03	0.1
OWDA	10	-0.02	-0.14	0.01	0.02	-0.02	-0.04	0.03	-0.09	1	0.37	0.07	0.06
	11	-0.04	-0.01	0.03	0.01	0.01	-0.04	-0.04	-0.12	0.37	1	0.11	0.08
	14	-0.1	-0.04	0.11	0	-0.03	-0.01	-0.04	0.03	0.07	0.11	1	0.38
	15	-0.03	-0.09	0.1	-0.02	0	0.03	-0.06	0.1	0.06	0.08	0.38	1

To understand how the above results for cod and herring may have influenced another important food, beef has been analysed. In addition to correlating with the previous years' prices, beef prices correlate with conflict in the preceding years 5 and 13. Sea surface temperatures, again indicated by the AMV, are associated with the prices that followed 6 and 8 years later. The combined influence gives an r^2 value of 0.914, which is notably higher than for either cod or herring. The majority of the value is, however, driven by the previous year's price (as with cod and herring) with an r^2 of 95%. Such a strong association to the price in the previous year is evidence of a relatively well-integrated market, with a comparatively stable year-on-year price association. Drought levels do not correlate significantly with prices in this case.

Equation 8.4. Beef Adjusted R-squared: 0.9144.

$$\log_price \sim \log_price_lag1 + Conflict_lag5 + Conflict_lag7 + AMV_lag6 + AMV_lag8.$$

Table 8.5. Correlation Matrix for logged beef prices, conflict levels and environmental activity.

		Log Price			Conflict			AMV	
	Lag	0	1	4	5	13	6	7	
Log Price	0	1	0.95	-0.07	-0.06	-0.08	-0.05	-0.06	
	1	0.95	1	-0.08	-0.07	-0.06	-0.02	-0.05	
Conflict	4	-0.07	-0.08	1	0.85	0.56	-0.13	-0.11	

	5	-0.06	-0.07	0.85	1	0.59	-0.1	-0.13
	13	-0.08	-0.06	0.56	0.59	1	-0.16	-0.14
AMV	6	-0.05	-0.02	-0.13	-0.1	-0.16	1	0.33
	7	-0.06	-0.05	-0.11	-0.13	-0.14	0.33	1

Wheat was also tested. Significant correlations are not apparent up to lag 15 for any of the variables. The lack of a correlation with conflict, drought and sea surface temperatures implies that the wheat market performed differently from the marine fish markets, possibly due to the ability to store food to stabilise supply and demand during different conditions. Thus, markets for cod and herring were more vulnerable or exposed to changing conflict and climate conditions than those of wheat and beef.

8.2.4. Relationship with Market Integration

The association prices maintained with conflict and climate was also related to price volatility, rather than simply price increases or decreases. The Coefficient of Variation (CV) was used in previous chapters to study price volatility. It was computed for each decade. In this chapter, a moving CV has been calculated for each year based on the previous ten years in each case. This measure of price volatility again is an indicator of levels of market integration.

In the case of herring, numerous years illustrate that climate was an influence on prices, as well as land wetness levels.³⁰⁹ Ocean temperature variability in this case does not act as an influence. Unlike the previous section, it has not been necessary to include the CV of logged prices for previous years. Thus, prices in this model indicate that the ten-year cv of prices is influenced by levels of conflict and land drought. The influence of conflict is to decrease herring price volatility. This would have made it a more stable commodity following conflict and more desirable as a commodity substitute for some, due to price stability. However, this influence is small with r^2 values of around 0.01% in each of the 4 statistically significant years. (see Table 8.6 below.) Drought levels brought both increased and decreased price stability, thus this would have brought uncertainty to the markets.

³⁰⁹ A number of extremely large values were also removed as they were artificially distorting the analysis.

Equation 8.5. Model of CV compared to conflict and environment.

$$\log_mean_price.moving.10.year.cv \sim \text{Conflict} + \text{Conflict_lag2} + \text{Conflict_lag6} + \text{Conflict_lag8} + \text{OWDA_lag5} + \text{OWDA_lag8} + \text{OWDA_lag14} + \text{OWDA_lag15}$$

Table 8.6. Correlation Matrix for the CV of herring prices, conflict levels and environment.

		Log Price	Conflict				OWDA			
	Lag	CV	0	2	6	8	5	8	14	15
Log Price	CV	1	-0.08	-0.05	-0.03	-0.03	-0.05	0.01	0.05	-0.11
Conflict	0	-0.08	1	0.76	0.61	0.59	0.06	0.05	0.02	0.05
	2	-0.05	0.76	1	0.68	0.61	0.04	0.1	0.03	0.03
	6	-0.03	0.61	0.68	1	0.76	0.01	0.03	0.05	0.04
	8	-0.03	0.59	0.61	0.76	1	0.04	0.02	0.1	0.1
OWDA	5	-0.05	0.06	0.04	0.01	0.04	1	0.13	0.06	-0.06
	8	0.01	0.05	0.1	0.03	0.02	0.13	1	-0.12	-0.03
	14	0.05	0.02	0.03	0.05	0.1	0.06	-0.12	1	0.4
	15	-0.11	0.05	0.03	0.04	0.1	-0.06	-0.03	0.4	1

In the case of cod prices, the ten-year moving CV from the previous year is statistically significant. Thus, unlike herring, it has been included in the regression model. This association with the previous year's prices is an indicator that it may have been more integrated than the herring market. Drought levels are not significant. It is possible this was due to cod arriving from distant shores and being isolated from European land drought levels. Ocean temperatures produce significant results. The negative correlation suggests that higher temperatures lead to more price stability as well as vice-versa.

Equation 8.6. Moving CV compared to conflict.

$$\text{moving.cv}(\log_mean_price, 10, 0) \sim \text{moving.cv}(\log_mean_price_lag1, 10, 0) + \text{TotalConflict_lag4} + \text{TotalConflict_lag13} + \text{TotalConflict_lag14} + \text{AMV_lag13}$$

From studying the correlation matrix, it is apparent that the CVs strong correlation with the previous year produces the majority of the r^2 value. The positive association with conflict indicates it leads to increased price volatility. This in contrast with herring, thus indicates that a more stable herring market during conflict may have led to herring replacing cod. However, other scenarios are possible, for example, less stable cod prices may have occurred if cod was replacing herring. This is in keeping with a hypothesis that cod replaced herring during times of elevated conflict.

Table 8.7. Correlation Matrix for the CV of cod prices, conflict levels and environment.

		Log Price CV		Conflict			AMV
	Lag	0	1	4	13	14	13
Log Price CV	0	1	0.97	0.12	0.16	0.16	-0.06
	1	0.97	1	0.1	0.16	0.16	-0.1
Conflict	4	0.12	0.1	1	0.55	0.54	-0.08
	13	0.16	0.16	0.55	1	0.85	-0.07
	14	0.16	0.16	0.54	0.85	1	-0.12
AMV	13	-0.06	-0.1	-0.08	-0.07	-0.12	1

Wheat has again been included for comparison. This analysis produced results similar to that of cod, though the lags are significant in different years. This indicates that the cod market was behaving similar to that of wheat as indicated by their price movements in association with conflict and ocean temperatures.

Equation 8.7. Moving price average compared to the previous year, conflict, and climate.

$$\log_mean_price.moving.10.year.cv \sim \log_mean_price_lag1.moving.10.year.cv + TotalConflict_lag15 + AMV_lag7 + AMV_lag11 + OWDA_lag11$$

The wheat associations are shown below (Table 8.8). They were similar to those displayed earlier for cod. Thus, these similar values indicate the two markets may have been experiencing similar changes in their respective levels of market integration in response to

conflicts and ocean temperature changes. That is, they may have been experiencing similar stresses.

Table 8.8. Correlation Matrix for the CV of wheat prices, conflict levels and environment.

		Log Price CV		Conflict			AMV
	Lag	0	1	4	13	14	13
Log Price CV	0	1	0.88	0.26	0.23	0.21	-0.12
	1	0.88	1	0.24	0.16	0.15	-0.14
Conflict	4	0.26	0.24	1	0.55	0.53	-0.08
	13	0.23	0.16	0.55	1	0.87	-0.04
	14	0.21	0.15	0.53	0.87	1	-0.1
AMV	13	-0.12	-0.14	-0.08	-0.04	-0.1	1

8.3. Conclusions

In addition to the research in this thesis contributing new knowledge on the topics of market integration and commodity substitution for cod and herring, a review of research from previous scholars (i.e., Bateman, O'Rourke, Grafe, Unger, Federico, and Malinowski) reveals that the results presented in this thesis broadly agree on the “macro” scale, however, there are differences between regions and products. For example, there is evidence that cod markets may have become slightly less integrated during the 1500s, when the new supply of cod from Newfoundland was arriving. Also, a novel result in this chapter is that cod and herring prices behaved differently than wheat following conflict and climate changes, which may have aided commodity substitution, such as cod replacing herring.

Price volatility, as indicated by the Coefficient of Variation (CV), as well as price increases and decreases, suggest that the levels of market integration were different for cod and herring. These differences indicate that the conditions were conducive for commodity substitution to have occurred. The linear regression models indicate cod prices lowering during elevated levels of conflict while herring prices increase. This indicates that cod may

have become a substitute for herring in the aftermath of conflict, thus increasing its importance on the markets as a staple food. Wheat markets appear to have been less affected by conflict than the likes of cod and herring. This evidence supports the hypothesis that storage of wheat was better suited to ease demand pressures on the markets. Commodity substitution during “extreme” events, as indicated by the Superposed Epoch Analyses (SEA), suggests that price behaviour does change under the influence of extreme events such as elevated conflict and higher or lower drought levels and sea surface temperature variability.

Conflict, climate, and prices for marine fish products were statistically significantly linked as part of a complex system. In the cases of cod and herring, the price each year was largely influenced by the price in the previous year, explaining approximately 60% of the price variability. Climate and conflict account for almost 10% of prices variability in the case of both cod and herring. The situation was different for beef, in which over 90% of price variability could be explained by the previous year alone. Thus, even if beef was influenced by climate and conflict, the strength of its association to the previous year indicates it may have been a more integrated market than that of cod and herring, or that it was not as exposed to the influence of conflict and climate.³¹⁰

³¹⁰ It is possible that the beef market was more established than that of the marine fish markets. It is also possible that meat came from dispersed locations over the land, and it may not have incurred the same level of transport costs as marine fish produce. Further analysis is needed to better understand how the marine fish markets and the beef markets compared in this regard.

9. Conclusions

This thesis undertook an analysis of herring and cod commodities in early modern Europe (i.e., from 1500 to 1800 CE). The results are the first in-depth analysis of fish products and how they compare to wheat and beef. Both fish played an important role in diets during that time. The study was in large part devoted to understanding the economic impacts of Newfoundland cod arriving in European markets and to what extent conflict and climate interacted with this impact. Three core questions were asked to achieve this, summarised below together with the research results.

Changes in cod and herring market integration

The first main question aimed to understand levels of cod and herring market integration throughout the study period, and how they compared to beef and wheat. To this aid, four sub-questions were asked. This begins with the basic question about if the information available allows measurement of market integration? That is, do we have evidence that allows us to measure and study market integration? The next question related to the volatility of the prices for the Newfoundland cod, asking if the product came with volatile (i.e., less integrated) prices early in the study period and if these prices stabilised (i.e., become less volatile) throughout the study period. Third was if already established markets in Europe for cod and herring became relatively more or less integrated? And fourth was how did the levels of cod and herring market integration compare to that of beef and wheat? For the fourth question, coefficients of variation (CV) were calculated for prices for each ten-year period. Lower CV values indicate lower price volatility and higher levels of market integration, while higher CV values indicate the opposite.

Available evidence provided the means to measure levels of market integration, at least relative to other commodities, and how it evolved. The study of 50-year price averages over all locations provides a long-term view of the entire study period, including long-term price changes. These averages are a tool that indicates the existence of market integration. Based on these 50-year price averages, herring and cod showed ratios of 22 and 15 respectively, based on the largest to smallest 50-year price average over all locations. Thus, herring prices varied more than cod over all locations and over the long term. Beef was

more stable than both, with a ratio of 10, wheat was the most variable with a ratio of 27. The high value for herring indicated more volatile prices over the long term and a less integrated market over the entire study period and all regions, based on the available evidence. These indicators suggest that herring markets were more varied, volatile, and possibly less integrated than cod and beef over the study period. These price ratios, however, do not describe market integration levels in the shorter and more medium-term.

The CV is another tool used to study short and medium-term change, and a valuable one. These coefficients, rather than being an absolute measure of the levels of market integration, are used to understand relative levels of integration. That is, how market integration changed over time, and how it compared between locations and products. For most locations, by the early 1500s, the CV values for herring and beef showed evidence of similar levels of market integration as wheat, based on the CV values being similar for these commodities. Cod CV information was rare for that time. For the later years of the same century, more price information is more available - there were indications that cod may have been slightly less integrated than herring, beef, and wheat, but it quickly began to display similar CV values and long-term trends for the remainder of the study period as was seen for herring, wheat, and beef. All products were displaying signs of becoming more integrated until the mid-1600s, when the CV began to increase, in turn indicating the lowering levels of market integration. Later in the 17th century, the lowering CV values indicate that markets began to become more integrated, and by the 18th century, they had reached a similar level of integration as in the early 16th century. Wheat tended to display higher CV values than cod for much of the study period, particularly in the later part. This indicates that levels of integration for wheat were similar at the end of the study period as were displayed at the outset. Newfoundland cod prices became available in the late 16th century. They may have been slightly less integrated than wheat in that time, but they quickly began to follow similar trends over the long term.

The extent of the integration of the markets was also dependent on the “levels” within the markets. The wholesale prices were often more variable than the prices at the later levels in the markets. In some instances, a contributing factor to the price stability in the institutions came from contracts and supply agreements in place that lasted a term spanning multiple years.

Newfoundland cod as a commodity substitute

The second major question asked if the Newfoundland cod acted as an increasingly lower-priced commodity substitute to beef and already established cod and herring markets. This question was approached through three sub-questions to investigate the price movements that would support the occurrence of commodity substitution. That is, did the arrival of the Newfoundland cod co-occur with decreasing prices for cod products? Did cod products decrease in price relative to herring? Finally, did cod or herring (i.e., marine produce) prices decrease relative to the terrestrial sources that were beef and wheat?

To begin, the commodity prices shared long-term trends, and this is possible to summarise as three broad periods. The period from the mid-16th to early 17th century is often characterised as the “Price Revolution”, and most (if not all) prices followed a similar trajectory of gradual increases in that time. The next period was the General Crisis which occurred early in the 17th century and continued to the early 18th century. It was marked at its outset by higher levels of conflict. A major example was the Thirty Years’ War (1618 to 1648). In that time, commodity prices began to diverge, both between products and locations, which led to a shift in the price ratios between commodities. The third period began in the early 18th century when price divergences became more common and pronounced. Therefore, the relative value between commodities shifted over the course of the entire study period. In some instances, there was a trend of beef becoming increasingly more expensive relative to marine fish from the mid-17th century to the end of the 18th century.

There was a trend of beef prices increasing relative to cod and herring in northern Europe, for example in Gdańsk. Based on the example of Barcelona, however, that was not the case in southern Europe. Thus, supporting a hypothesis that there was a difference in the value of marine fish products in diets between northern and southern European regions. This became increasingly apparent from the late 17th century and throughout the 18th century when gaps between prices became larger.

Influence of conflicts and climate on markets

The third question concerns the influence of conflicts and climate on the levels of market integration and commodity substitution. Conflict influenced market integration and

commodity substitution. That is, conflict like war disrupted markets, with consequences felt on both the short and long term. The magnitude of conflict occurred to varying degrees, as did its influence. Of major importance was the General Crisis which occurred from the late 16th century to as far as the early 18th century in Europe. It was marked by elevated conflict levels. A very significant event during this crisis was the Thirty Years' War (1618 to 1648). In that time, it was evident that most price increases that had occurred during the 16th century and early 17th century ground to a halt. Events such as changes in trading companies may have caused changes in the markets. For example, in 1598 when the London merchants began to replace the Hanseatic League, this may have led to a change in the sale of cod products in the Southern England markets. However, this change occurred when conflict levels were elevated, thus it is another example of price changes occurring whilst conflict levels are elevated.

During times of elevated conflict, marine fish prices behaved occasionally differently to grain and beef prices. This was evident by increased price volatility and price differences between them. For example, when conflict levels were elevated, there were instances of cod and herring prices moving in opposing directions. Cod prices continued a long-term trend of price increase throughout the 17th century, unlike herring, which showed a slight decline during the latter half of the century. Thus, in the latter half of the 17th century, herring was becoming progressively lower-valued compared to cod. During the elevated levels of conflict in the early 18th century, marine fish products (i.e., cod and herring produce) behaved differently than terrestrial meats and grains in this time and the aftermath. They gained ground as lower-priced alternatives to beef and wheat, in particular during the first half of the 18th century.

Climate conditions behaved as an "exogenous" influence on the markets, occurring on both short and long-term time scales. Over the short term, the influence occurred through the likes of sudden droughts, while over the long term, it was expressed in decadal long shifts in the climate conditions. To understand the influence of climate, recently developed indices of historical climate conditions were compared to price and quantity information. The Atlantic Multidecadal Variability (AMV) indicated that the ocean temperature variability was correlated with price changes during periods such as the early 1600s. These correlations often occurred during times of elevated conflict such as the Thirty Years' War,

indicating a complex relationship existed between climate, conflicts, and price. On land, periods with increased Old World Drought Atlas (OWDA) values occur alongside price changes. Evidence suggests the OWDA behaved differently in northern and southern European locations, thus it may have been instrumental in changing preferences for marine fish between northern and southern Europe.

The influences of conflict and climate on prices were not “mutually exclusive”, i.e., there was a complex association between the three factors. The cross-correlations and autoregression techniques applied in Chapter 8 untangled the associations of the three factors, revealing the extent to which they related. The analysis went further, in an effort to understand how the relationship with conflict and climate differed between cod, herring, beef, and wheat. Results indicate that for cod and herring, about 10% of the year-on-year price variability was associated with conflict and climate factors. A large portion of price variance, approximately 60%, was related to the price from the previous years. Climate and conflict account for almost 10%. This was different from beef, where over 90% of price variability could be explained by the previous year alone.

Commodity substitution is likely to have occurred during “extreme” events. The Superposed Epoch Analyses (SEA) in Chapter 8 indicate that price behaviour did change when extreme events occurred, i.e., during events such as elevated conflict, and higher or lower drought levels and sea surface temperature variability. These changes in prices may have encouraged or facilitated commodity substitution. Thus, conditions for commodity substitution to occur happened during times of elevated conflict, specifically with cod prices lowering and herring prices increasing. Therefore, cod became well-positioned to act as a substitute for herring in the aftermath of conflict. Beef markets were well-integrated relative to cod and herring, thus it is unclear how they may have replaced each other, if at all, due to changing conflict and climate conditions. Also, wheat markets were less affected than cod and herring, suggesting the possibility that local production and the storage of wheat eased pressures on its markets.

Further Work

Building on the analysis conducted in the thesis, different techniques could be applied to develop and answer new research questions, ones that extend beyond or build upon the

gained results. This includes the application of further numerical models to the price information, specifically time-series methods such as autoregressions and Fourier analyses. Even more advanced methods, such as Vector Autoregressions (VAR)s and Vector Error Correction Models (VECM)s may yield results, after the price data has been studied further for its suitability for the models. As part of such an approach, a good set of research questions would need to include an analysis of how well the price information fits the requirements of the models. That is, does the price information satisfy the requirements of the models from a statistical hypothesis perspective.

Further research questions could be developed relating to the proposed “Great Divergence”, which occurred between the Western and Eastern worlds. This would be to understand the relationship of the marine fish produce and the divergence in growth in technology and wealth. Other research questions could involve a study of transport and trade networks in Europe. The evolution of such networks could further explain early parallels to the concept of “globalisation”. This would include a GIS model that studies geographical features such as the distances between locations, terrain, rivers, mountains, and territorial borders between locations. The study could be further explored by applying a network analysis. Finally, locations in eastern Europe could be further developed if more information on fish prices becomes available.

General Remarks

The thesis has contributed to our understanding of the formation of early modern food markets in Europe. Focusing on market integration, the main conclusion to draw is that when Newfoundland cod prices are available to study from the late 16th century, they indicate the Newfoundland cod market was only slightly less integrated than herring, beef, and wheat products, and quickly became integrated at similar levels. Newfoundland cod quickly established itself alongside traditional cod and herring markets and the likes of beef and wheat. All these markets became less integrated during the 17th century, however, they began to become increasingly integrated again towards the end of the century and during the 18th century. Thus, the “opening up” of the new supply of cod came with both long and short-term consequences for the already established European markets.

Products changed their position as relatively lower or higher priced substitutes for one another. Cod and herring prices followed two different trajectories. Cod may have been a higher-priced product, but its relative value was decreasing compared to herring. That would have caused cod to become an option for more consumers, allowing it to substitute traditional European cod sources, herring, beef, and wheat. Also beef and marine fish were very suitable substitutes for one another, they provided similar levels of nutrition per kilogram of produce, such as fats, calories, and protein. Grains, such as wheat, could also substitute to an extent, for example providing about half the amount of protein. Very significantly, the increased quantities of cod arriving from the Grand Banks were a supplement to already established food supplies and could (all other things being equal) have aided population growth in regions that were experiencing it. From some perspectives, this might be interpreted as contributing to overcoming any prevailing early modern “Malthusian Trap”. This is plausible but also quite debatable, with implications for analysis beyond what this thesis deals with, including population growth. Regardless though, the growth in fish supplies in many fisheries will have created a better level of food security.

In summary, the 300-year period from 1500 to 1800 began with new products arriving at European markets from the Americas. One of these products was cod, and it began arriving in increasingly large quantities. Throughout the study period, this product began to display indications of higher levels of market integration. From at least the late 16th century, levels of market integration for Newfoundland cod were in line with already established herring, beef, and wheat markets. For herring, beef, and wheat, they ultimately ended the study period with similar levels of market integration as were seen at the beginning. This journey was by no means smooth, with conflict and climate events coming with major price changes. The Thirty Years’ War (1618 to 1648) was especially prominent, influencing prices for all commodities and locations. In its aftermath, products began to follow different price trajectories. It is often the case that cod and herring were cheaper than beef, based on measures in kilograms of product, or per gram of protein. A decrease in the price of these fish relative to beef became more prominent in the 18th century, ultimately causing these marine fish products to become progressively lower priced sources of protein.

A. Appendix. Overview of Each Price Collection

What follows is a brief overview of each of the major sources that this thesis is developed from. This includes their respective methodologies and the character of the prices. Some sources do more than just provide historical price series, and also include analyses of the prices, including the influence of major conflicts. The description of these works is arranged by chronology. Thus, it begins with the works of Rogers and Beveridge from the 19th century, before proceeding to consider mid-20th century authors. The Allen-Unger database is then discussed, as it contains digitised versions of the price information for the sources discussed up to that point. Finally, more recent sources are discussed, such as that of Bauernfeind, Jansson and Allaire.

A.1. Rogers and Beveridge - Southern England

In the latter part of the nineteenth century, between 1866 and 1892, Thorold Rogers undertook extensive studies of prices and wages for Southern England from the 12th to the 19th centuries. Thus, these combined works have a very large temporal coverage. Rogers's works were pioneering. They were also a large collection of work, comprising a seven-volume collection spanning from 1259 to 1793, these volumes discussing a large variety of food commodities, including fish, meat, and grain.³¹¹ The information covers Southern England in particular, and remains highly influential for price historians. The Allen-Unger's collection contains a digitised compilation of this price information.

The methodology that Rogers employed was not as refined as that of works that followed later from William Beveridge³¹² and his contemporaries for other countries. Rogers' seven volume collection was developed before the larger price information drive of the 20th century. A particular concern with Rogers' work is that the prices were a collection from different locations, with less emphasis placed on compiling homogeneous series coming from the same location. This was something Beveridge was critical of. Thus, these price series are limited as an indicator of change over time, because of the lack of homogeneous source. As an example, for herring for 1259 and a small number of years that followed, the prices came from Winchester, Rochester, Braborne, Sandwich, Harewood, Stillington,

³¹¹ Rogers. *A History of Agriculture and Prices in England*, 7 vols. (Oxford, 1866-1892).

³¹² William Henry Beveridge. *Prices and Wages in England: From the 12th to the 19th Century* (1939).

Stockton, Stoke, to name but a few.³¹³ These prices are not presented as distinct price series for each location, they are instead combined as one series, with a single value per year. If more than one price is available for a year, the information is averaged.³¹⁴ Subsequently, during the period from 1401 to 1582, Cambridge became one of the more common locations.³¹⁵ As Cambridge is approximately 100 km from London, prices would certainly have borne some relationship to the London Prices, but to what extent is not certain. Produce transported from one location to the other should have increased in price as transport costs were incurred; thus, if any of the produce sold in Cambridge came from London, it would have been higher in price in Cambridge (all other things being equal, such as the quality of the product sold). Thus, Rogers' dependence on prices from different locations, such as Cambridge, raises concerns as to what the prices represent and how they can be used. For example, it is an oversimplification to state these prices represent London. Moreover, for Cambridge, prices tended to come from records kept by King's College. These prices do not therefore reflect annual movements on the market in some instances. For example, for a period from 1654 to 1674, herring prices are not available per year. Instead, a decadal average is given for each ten-year block. In the absence of this understanding, one might interpret this as a period of apparent market price stability, rather than an artefact arising from limitations in the underlying information.³¹⁶

Beveridge's work is subsequently called upon for the period from 1703 and extends some series beyond 1800 to around 1830. Beveridge's work came later than Rogers' and was supported by grants from the Rockefeller Foundation. The first grant was made in 1929 for five years, it was then renewed in 1934 for three more years, ending in 1937, with the first edition of Beveridge's efforts being published in 1939. Beveridge intended for his work to supersede that of Rogers', but he unfortunately died after completing the first volume. He was to some degree critical of the work of Rogers', in his introduction to this first volume, describing his work as a "new history", rather than a revision of Rogers' work. The Allen-Unger database also includes information from Beveridge's work, such as prices for salted cod, which are important for this thesis.³¹⁷ Prices for this product came from Lord Stewart's

³¹³ Ibid Vol I, 552-3.

³¹⁴ Ibid Vol I. 181-6; Vol IV, 211.

³¹⁵ Ibid Vol III, 310-34.

³¹⁶ Rogers Vol V: .422, 429.

³¹⁷ Beveridge. "Prices and Wages in England from the Twelfth to the Nineteenth Century." (1966).

Department, an office of the Royal Household. The prices are perhaps lower than other parts of the markets in Southern England, as a result of forced purchase (“purveyance”) of goods at low prices, which was a royal prerogative at the time.³¹⁸ These prices were static for periods of years, most likely due to contracts or agreements with merchants that were in place that were not renewed or changed on an annual basis.

The price series this thesis focuses on from Rogers and Beveridge are white herring, salted cod, stockfish, beef, and wheat (Figure A.1). The white herring was most likely a fresh or unsalted herring, with Chambers' Twentieth Century Dictionary of the English language defining a “white herring” as “a fresh or uncured herring”.³¹⁹

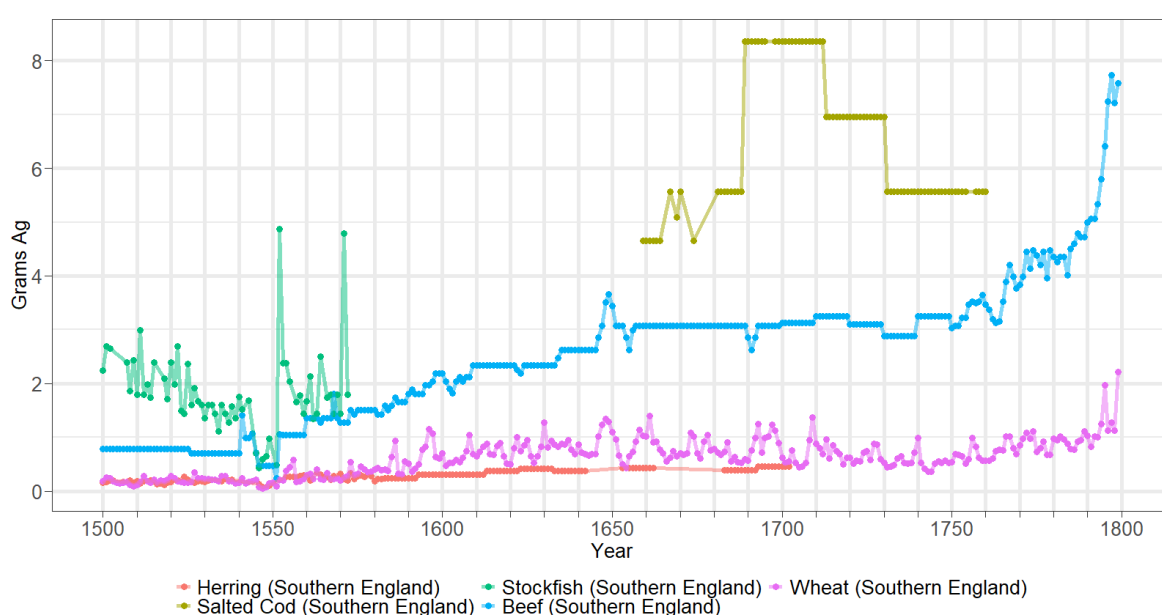


Figure A.1. Price series for Southern England based on the works of Rogers and Beveridge. The series represent prices for herring, salted cod, stockfish, beef, and wheat. (They have not yet been converted to a common unit of quantity, thus should not be directly compared.)

The white herring product comes from Rogers’ work with prices covering the period from 1403 up to 1702, though 1500 and later is the focus for this thesis. No information is available from 1703 onwards for herring from Rogers of Beveridge. There is a salted herring product with prices covering 1401 to 1582, this product comes from a variety of locations, it could also be included in an expanded analysis as an alternative, however, it covers a

³¹⁸ Ibid, 319. This also includes examples of transport costs.

³¹⁹ Thomas Davidson. *Chambers Twentieth Century Dictionary of the English Language* (London: W. & R. Chambers, 1903), 1126.

shorter period than the other herring series and thus has not been included. Cambridge is again the most common location, with prices possibly coming from Stourbridge fair at Barnwell near Cambridge.³²⁰

Prices for stockfish and salted cod are included in this thesis from Rogers and Beveridge's works. The stockfish prices are available from Rogers' work, covering a period from 1405 up to 1572. With the present focus from 1500 onwards, this is a short run of 73 years, also marred by missing values, but price trends are still apparent. The salted cod prices span from 1659 to 1760, coming from Beveridge's work. This is the most stable series used in this analysis for England so far, with the prices remaining constant for clusters of years. There were preferred suppliers in place for long periods of time, an important factor in the apparent price stability. When there was a change in supplier, this usually came with a change in price. The prices may have been influenced or set by royal prerogative, but it is possible they reflected the prevailing market prices at that time to some extent. Beveridge's work provides details of such contracts, for example, different contracts relating to Lord Steward's Department show what commodities were supplied and for what time periods the contracts lasted.³²¹ Change in supplier, or contract with the same supplier, do explain quite a few of the price changes that occur in the price series, if they have been previously stable for periods of time. Thus, these prices do not behave the same way as what is seen in other more variable markets, such as wholesale markets, where prices change more frequently.

Beyond fish, beef prices cover 1583 to 1702 and are another product from Cambridge, in this instance specifically King's College.³²² Roger's volumes are restricted to different time periods. This particular beef series is limited precisely to one such period, thus is in all likelihood there is an artificial beginning and end for the series. This is an example of where the methodology for collecting and reporting products varied between the periods of time that Rogers' work is divided into. Moving to wheat, the data comes from Rogers' work up to 1702.³²³ Prices are primarily from Oxford, Cambridge, Winchester, and Eton. From examining Rogers' list of sources, Cambridge appears to be the most common location

³²⁰ Rogers, Vol III, 310.

³²¹ Beveridge, 323-4.

³²² Rogers, Vols V and VI.

³²³ Rogers, Vols III and V.

again. Following this, from 1703 to 1800 and beyond, the prices come from Brian R. Mitchell and Phyllis Deane's 1971 price analysis, with the values representing prices paid for wheat by Winchester College.³²⁴ Further details can be found in appendix one.

It is lastly important to note that Prices from Rogers' and Beveridge's works were not always given in uniform measures; they have thus been converted to prices in grams of silver per kilogram of produce in the Allen-Unger database and these converted prices are used in this thesis.³²⁵

A.2. Hamilton - Spain - Madrid

Earl Hamilton was another prominent price historian, and his price history publications cover locations in Spain.³²⁶ Two volumes from Hamilton are relied on in this thesis, exactly covering the research period. The first volume is "American Treasure and the Price Revolution in Spain, 1501 to 1650", published in 1934 and the second is "War and Prices in Spain, 1651-1800", published in 1947.³²⁷ Prices in both volumes are focused on four regions: Andalusia, New Castile, Old Castile-Leon, and Valencia. These regions roughly correspond to southwestern, central, north-western, and eastern Spain respectively. To keep methodology consistent, Hamilton states that prices are only taken from long and extended lists that span several decades. To limit the influence and bias of seasonality on annual prices, the annual price each year for each commodity is based on a combination of prices taken from each of the four calendar quarters of a year. The prices varied within each quarter too, thus first four prices for each quarter from the sources are taken. This gives up to sixteen prices for a year and an average calculated from them.³²⁸ In a limited number of cases, there was not enough information to provide these 16 prices, Hamilton dedicated an appendix to discussing how prices were calculated in these years.³²⁹ Thus there is some interpolated information in the series, but it is limited to a small number of years. It is beneficial that a large number of prices are used, when possible (i.e., 16), and

³²⁴ B. Mitchell and P. Deane. *Abstract of British Historical Statistics* (Cambridge, 1971).

³²⁵ Robert Allen and Richard Unger. "The Allen-Unger Global Commodity Prices Database: Social and Economic History," *Research Data Journal for the Humanities and Social Sciences* 1 (2019), 1-10, 4.

³²⁶ They were also a prerequisite for future works from Gaspar Feliu, covering prices in Catalonia.

³²⁷ Earl Jefferson Hamilton. *American treasure and the price revolution in Spain, 1501-1650*. Vol. 1125 (Cambridge, MA: Harvard University Press, 1934); Earl Jefferson Hamilton. *War and prices in Spain: 1651-1800*. Vol. 81 (Cambridge, MA: Harvard University Press, 1947).

³²⁸ Hamilton, 1934, 147.

³²⁹ Hamilton, 1934, 309-10.

the averaging over the four quarters will limit or possibly completely remove the influence of seasonal trends. This approach should also decrease the level of price volatility that occurred within a year, as average based on larger samples of information tend to limit volatility. Thus, Hamilton's approach is useful to allow a discussion that is focused on interannual price movements. Though, if a scholar was interested in studying seasonal trends, this limit would of course be disappointing.

For both volumes of Hamilton's work, hospital records are described as the best sources for price information. This is because they are rich in food prices and abstinence from consuming meat at lent did not strictly extend to patients in hospitals.³³⁰ Hamilton notes how this is different from the works of Rogers and Beveridge, who more commonly based their price series on records from feudal estates.³³¹ At the time, many of these hospitals were known as charity hospitals because of their religious roots. Monasteries and convents are the second most important sources. Unfortunately, Hamilton indicates that record keeping was not completed to a high level earlier in his research period. He further states that the first location to start storing records was Valencia in 1413, almost a century before this started in Castile and that systematic keeping methods were not developed until the beginning in 1540, which is reasonable early in the period of study here.³³²

Hamilton discusses sources from New Castile as the most comprehensive in his study, specifically the prices from the Hospital de Tavera in Toledo.³³³ As for what the prices represent, for New Castile the most prominent hospital and archive is the Archivo del Hospital de la Venerable Orden Tercera in Madrid. In the case of Valencia, prices came from the Hospital dels Innocents, Valencia.³³⁴ Unfortunately, there is no information for cod and herring products, but it does include useful wheat price data for comparison to other locations.

The prices for Dried Fish, Mutton, Beef, Wheat, Barley, Cheese, Eggs and Wine are shown below in Figure A.2. An unfortunate limitation in this work is the lack of herring and there

³³⁰ Hamilton, (1934), 141-2.

³³¹ Ibid, 238.

³³² Ibid, 139.

³³³ Ibid, 139.

³³⁴ Ibid, 144.

is no certainty that the dried fish is cod. Regardless, examples from Hamilton's collection of price series have been included, they are valuable for comparisons of commodity prices in other locations to understand if similar products were following similar price trends. Further, the detailed information Hamilton included on his methodology is valuable for comparison to the methodologies applied in other locations.

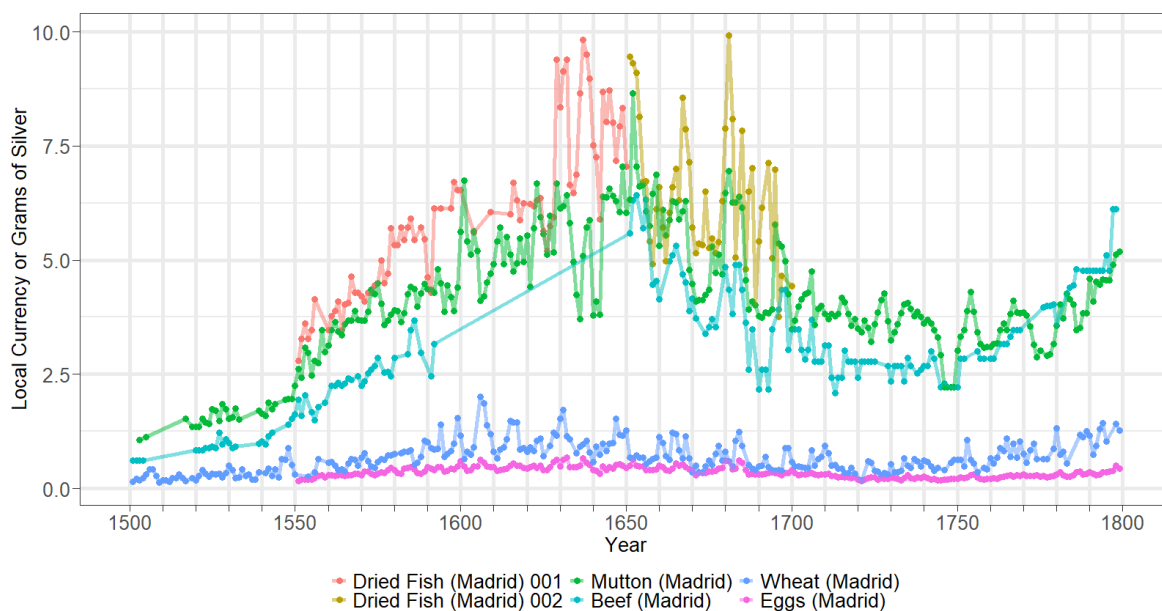


Figure A.2. Prices in Madrid based on Hamilton's work. They cover dried fish, mutton, beef, wheat, and eggs.

A.3. Posthumus - The Netherlands (Amsterdam, Utrecht, and Leyden)

Posthumus produced two volumes devoted to price information. The first covers the Amsterdam Exchange (see further below) while the second is dedicated to hospitals, religious institutions and a municipal orphanage.³³⁵ Price series selected from Posthumus are shown below in Figure A.3Error! Reference source not found., focusing on herring, stockfish, salted cod, meat, and wheat. The units are mixed, and the currency differs between the locations and over time.

Prices from the Amsterdam Exchange are wholesale prices, according to Posthumus. Thus, they are situated at an earlier point in the supply chain than the hospitals and other institutions in volume two of his work. These wholesale prices can be expected to be lower

³³⁵ Posthumus, vol. 1: Wholesale prices, xviii; Posthumus, vol. 2. Commodity prices recorded by the Utrecht chapters, 1348-1669, xix. The Posthumus sources are also available as another searchable database: <http://www.scc.rutgers.edu/memdb>.

and behave with different degrees of variability than the prices paid by the large institutes further along the supply chain and this will be studied later. The Exchange was the principal good-market exchange in Europe in the 17th century, but little is known today of precisely who the merchants were that bought and sold goods at the exchange, according to Posthumus.³³⁶ These wholesale prices were kept on an official register. There was motivation for the prices to be reliable and trustworthy for both those buying and selling at the time, as they wanted to maintain a good reputation. To this day, not much remains known about the Exchange, it may even have changed location over time. The sources come from a number of archives in Holland and The Netherlands, they also come from other locations that include Vienna and Gdańsk (but still represent the Exchange in Amsterdam).³³⁷ They are referred to as “price-currents” by Posthumus, which are sources that provide the prevailing prices at the Exchange at particular times, usually weekly. These sources end in 1811, after France annexed Holland in 1810, though Posthumus states price information continues in a French publication called “Affiches, annonces et avis divers d’Amsterdam: Advertentien, aan-kondigingen en verschillende berichten van Amsterdam”, as these prices are later than 1800, this is not required for this thesis.³³⁸ The prices most important to this thesis are herring (referred to as “herrings full”) and stockfish prices from the Exchange. As for the measurements, this wholesale herring product was recorded per last in guilders, while the stockfish were recorded in units of 100 pounds per guilders.

The second volume is based on prices that describe later stages in the supply chain than wholesale markets. Herring, stockfish, wheat, and meat have been included for this chapter and Posthumus derived them from records from St. Bartholomew’s Hospital in Utrecht. Thus, they do not directly represent Amsterdam. Utrecht is 35 km from Amsterdam, therefore it is possible these prices will differ to some degree that what may have been paid in Amsterdam. Salted cod prices are from St Catherine’s hospital in Leyden. The distance from Leyden to Amsterdam is similar to that of Utrecht, at just over 35 km. They also do not directly represent Amsterdam, therefore. Perhaps, at a similar from Amsterdam as Utrecht the prices may have been similarly influenced by distance, but this is not a certainty by any means.

³³⁶ Posthumus, (1964), LXVI.

³³⁷ Ibid, xxvi-ii.

³³⁸ Ibid, xxix.

The herring prices cover a period from before the 1500s up to 1678. These were bought for Lent, but many of the entries remain undated, thus seasonal variation is impossible to distinguish. These herring came in barrels, half barrels, and quarter barrels. It is possible that the herring barrels were not uniform in size, though Posthumus expects they were most likely quite similar. Further, he provides a list of the common measurements used at the time.³³⁹ This thesis applies the assumption in the Allen-Unger database that the barrel sizes do not vary largely over the study period, thus a uniform unit of measure is applied.

With regards to cod produce, stockfish prices also came from the Cathedral Chapter in Utrecht. The prices cover 1506 to 1795. The series is not complete and there are missing years. In all three locations, prices were given per 100 pounds of stockfish. Posthumus observes decreasing stockfish prices in the 17th century while it is being replaced by salted cod.³⁴⁰ This is an example of one cod product substituting another; other examples of commodity substitution will be discussed in a later chapter. The salted cod prices from St. Catherine's Hospital in Leyden are available from 1526 to 1794. These product prices were also recorded per 100 pounds.

Meat prices came from St. Bartholomew's Hospital. There was no difference in price between beef and mutton up until the middle of the 17th century observed by Posthumus.³⁴¹ It is not clear from Posthumus's publication if a series available for each of beef and mutton, or if the sources did not distinguish between them. Regardless, this series for meat represents both products in that time. Following the mid-17th century though, it is important to bear in mind this uncertainty about what the series represents when comparing it to beef or pork prices in other locations. The price series do have gaps and in the 1600s and 1700s they have been supplemented by prices documented for the orphanage associated with St. Bartholomew's and also located in Utrecht. The sources also do not provide certainty about the quality and uniformity of the meat product, thus this could be another source of price variability.³⁴² Thus it is possible that this will have had some influence on interannual price variability.

³³⁹ Posthumus, Vol. 2 (1964), 31-7.

³⁴⁰ *Ibid*, 335.

³⁴¹ *Ibid*, 318.

³⁴² *Ibid*, 319.

Wheat prices also came from St. Bartholomew's Hospital, and in this case Posthumus supplements them with information from two other locations, both also located in Utrecht: the Holy Cross Hospital and the Orphanage. Between the 15th and 18th centuries, the prices came from tenants of the hospital rather than from the market. This could have influenced the prices of the wheat, perhaps with a price lower than market rates, though Posthumus believes the market price would have been taken into account. A further source of price variability comes from a cheaper product known as "Red Wheat". It was sometimes purchased in the 18th century, and this might not be stated in the sources.³⁴³

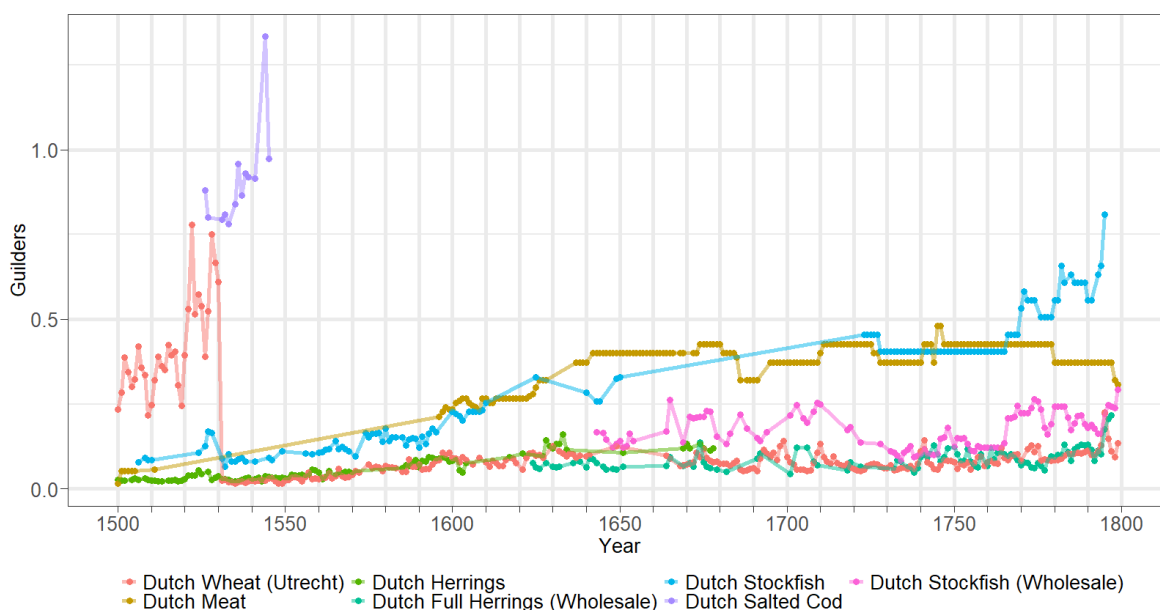


Figure A.3. Selection of Prices for the Netherlands from Posthumus.

The prices represent wheat, herring, stockfish, salted cod, meat, herring. The series represents either the wholesale market known as the Amsterdam Exchange, or Hospitals and religious institutions in Utrecht and Leiden. As the units of quantity differ between products, they cannot be directly compared at this point.

A.4. Elsas - Frankfurt and Munich

Elsas' price history study comprises two volumes, made up of three parts.³⁴⁴ The first volume, published in 1936, is a single publication that provides information for Munich, Augsburg and Würzburg. The second volume covers Frankfurt, Leipzig and Speyer and is

³⁴³ Posthumus, Vol. 2, 311.

³⁴⁴ M.J. Elsas. *Umriss einer Geschichte der Preise und Löhne in Deutschland* (Leiden, 1936). Vol 1; M.J. Elsas. *Umriss einer Geschichte der Preise und Löhne in Deutschland* (Leiden, 1940). Vol 2, Part 1; M.J. Elsas. *Umriss einer Geschichte der Preise und Löhne in Deutschland* (Leiden, 1949). Vol 2, Part 2.

divided into two parts that are separate publications. The first part, published in 1940, contains coins and currency, mass and weight and explanations of the prices, while the second, published in 1949, studies the sources in detail and analyses the development of these prices. It analyses the influence of topics such as effects of population decline on agriculture because of the Thirty Years' War.³⁴⁵ The nine-year gap between the publication is notable, this was due to a delay caused by World War II. Thus, while it was published in 1940, it did not become widely available until 1946.³⁴⁶

Elsas' works discuss the sources for each commodity in detail, and also analyse price trends. In the first volume he describes his methodology, giving five criteria for the selection of sources; continuous prices for a commodity recorded over centuries and if possible without interruption, as many types of commodity as possible should be recorded, as many sales of a particular product should be recorded as possible, prices should be as typical as possible for the type of goods and prices should be as close as possible to market prices.³⁴⁷ He does not appear to state explicitly that the same methodology is applied in the second two part volume, but this appears to be the case as both volumes follow a very similar format and style. Due to the large volumes of information available, Elsas applied a sampling methodology to collect the price information. It is difficult to find precisely from his texts if more than one price was used per year, and if perhaps some type of averaging was applied.

Elsas summarised the information in one currency unit, providing a simpler presentation. The unit was the "pfennig", the smallest unit of currency used at the time in both Frankfurt and Munich, thus giving a more precise view of the prices. Usually, the first price mentioned from a month was taken, rather than all, due to the large amounts of information, and averaged to obtain annual values.

A.4.1. Frankfurt

The prices for Frankfurt include barley, beef, ham, herring, mutton, rye, veal, and wheat (Figure A.4**Error! Reference source not found.** below).³⁴⁸ The unit of currency is the Pfennig. These price series are derived from hospital records and later from city tax records.

³⁴⁵ Elsas, (1949). Vol 2 Part 2, 2.

³⁴⁶ *Ibid*, v.

³⁴⁷ Elsas, (1936). Vol 1, 83.

³⁴⁸ Elsas, (1940). Vol 2, Part 1; Elsas, (1949). Vol 2, Part 2.

From the early 1500s, the majority of the prices came from the Heilig-Geist-Hospital (Holy Spirit Hospital).³⁴⁹

In the case of grains, wheat prices came from the books of the “Rechenmeisterbücher” (who was a type of accountant) only up to 1502. After that, prices came from Heilig-Geist-Hospital for 1502 to 1732 and Getreidetaxen (i.e., “Grain Tax”) records from 1733 to 1820. This was similar for rye, except the hospital price data continued to the later date of 1799, before the series switched to being based upon the grain taxes from 1800 to 1820.³⁵⁰ In the case of Barley, the prices are almost completely from Heilig-Geist-Hospital for the long period of 1476 to 1797, before moving the grain tax from 1800 to 1820. Thus, the grain taxes are a major source for the study period. This change from one type of price to another, especially for wheat, could cause a change in the behaviour of the prices within the price series, but this does not appear the case when looking at Figure A.4**Error! Reference source not found.** below.

As for meat, beef prices from 1509 to 1678 came from Heilig-Geist-Hospital; later they come from tax rates from 1679 to 1820. Veal prices are available, starting at a later date and come from Heilig-Geist-Hospital from 1598 to 1680. Prior to this they were based on tax documents from 1532 to 1558 and again later from 1684 to 1820. To achieve consistency between the three sources, which could exhibit variations in their respective average price levels and their variability, it is a task that requires considerable work, thus only prices from 1600 onwards are included in this chapter. (Including this one series in keeping with the approach in the Allen-Unger database.) Mutton prices are from Heilig-Geist-Hospital from 1509 to 1662 before moving to records based on taxes from 1663 to 1820. Ham prices come from Rechenmeisterbücher records up to 1502 (as with other products) before changing to those provided by the Heilig-Geist-Hospital records, 1503 to 1790. As for a rare detail on the origin of the products, there are instances in the early 1500s for the hospital where the ham is noted in the sources as being Westphalian.

³⁴⁹ Ibid, 55-6.

³⁵⁰ After a search of Elsas works, it is difficult to establish precisely what calculations he applied to the tax records. His works mention tax rates, usually for other products. But it does not appear to explicitly state what calculation he applied. Reassuringly, when prices change from one source to the other, they do not show a notable change.

Herring prices cover the period from 1475 to 1733 and came completely from Heilig-Geist-Hospital, with no component coming from the tax rate documents. The use of one single source makes this a more homogeneous series than the others, making it particularly useful to study price trends from 1500 onwards.

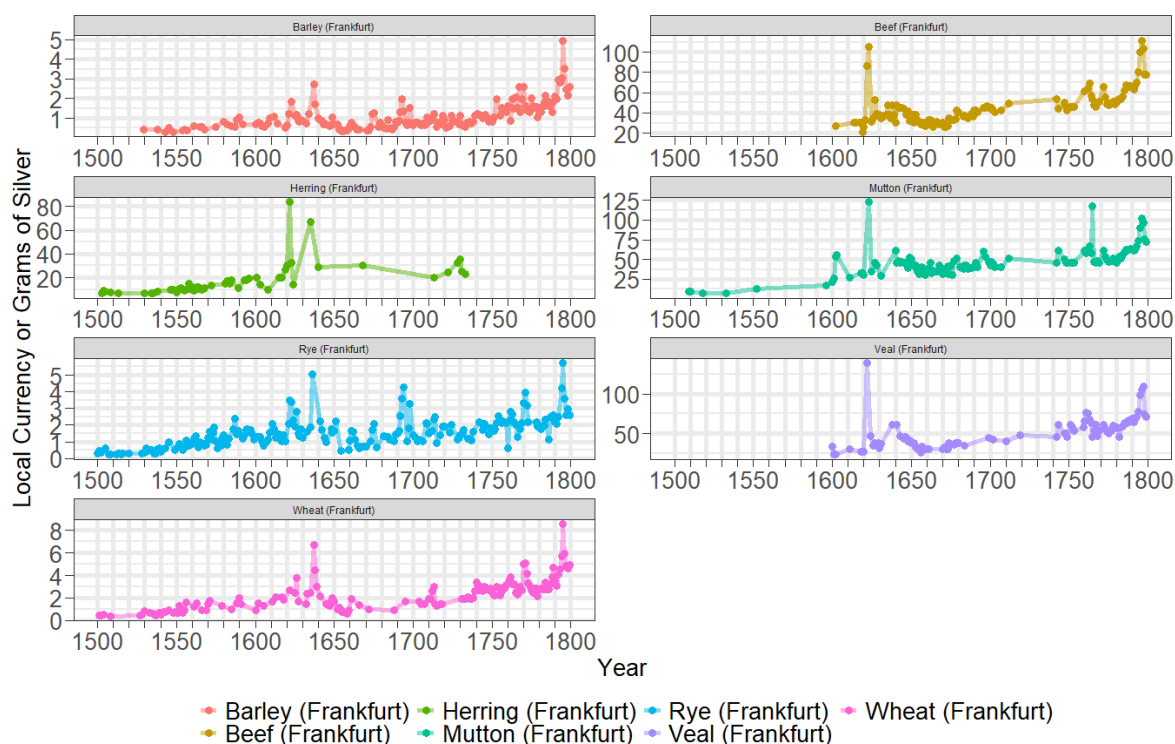


Figure A.4. Prices for Frankfurt, based on Elsas’s collections. for barley, beef, ham, herring, mutton, rye, veal, and wheat.

A.4.2. Munich

In the case of Munich, price series for beef, herring, rye, stockfish, and wheat (Figure A.5 below) were selected for this chapter.³⁵¹ The currency for Munich was based on pfennig again and the larger unit of a pfund.

The beef price series is referred to by Elsas as being derived from “mixed sources”, with data covering the period from 1492 to 1820. As the sources are mixed, the price series is not as homogeneous as ideally preferred and could include increased (and in a sense, artificial) price volatility because of this.

³⁵¹ Elsas, (1936).

As for grains, wheat prices were recorded at the Holy Ghost (Heilig-Geist) hospital in Munich. Rye prices cover the period from 1404 to 1773. They are developed from municipal chamber accounts (referred to as “Kammerrechnungen” by Elsas), which are official court documents.³⁵² These accounts relate to actual prices paid for food, rather than being recommended prices, for example.³⁵³ There are other price series for rye and wheat in Elsas’ collection, and for different locations.

Finally for fish, herring prices cover 1524 to 1627 and are from Munich Holy Ghost Hospital. Stockfish prices range over the period from 1530 to 1637 and are also from the same hospital.

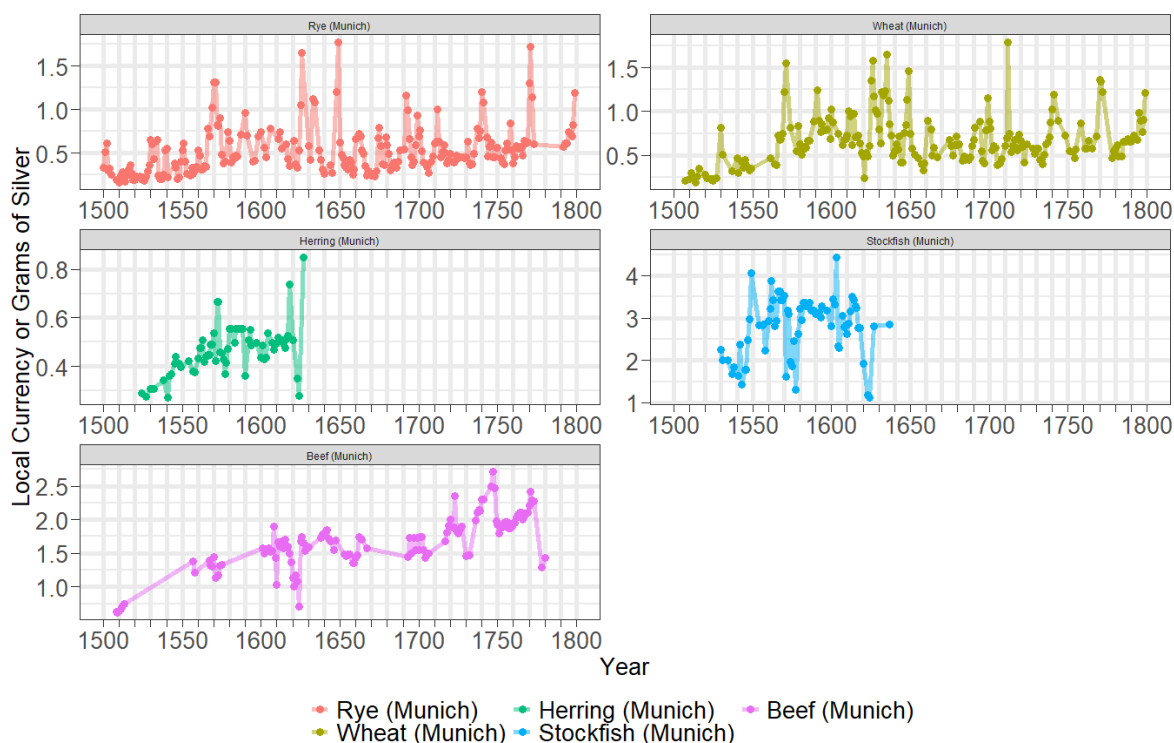


Figure A.5. Prices for Munich, based on Elsas’s collections. Covering rye, wheat, herring, stockfish, and beef.

A.5. Pelc and Furtak - Gdańsk

The prices from Gdańsk are based on two volumes of work.³⁵⁴ One was developed by Julian Pelc, published in 1937, and covers the 16th and 17th centuries. The other directly follows

³⁵² Ibid, 4.

³⁵³ Elsas, (1936), 211.

³⁵⁴ Julian Pelc. *Ceny W Gdańsku W Xvi I Xvii Wieku* (skł. gł. Kasa im. Mianowskiego-Institut Popierania Polskiej Twórczości Naukowej, 1937); Tadeusz Furtak. *Ceny W Gdańsku W Latach 1701-1815* (Skł. gł.: Kasa im. J. Mianowskiego, 1935).

this period, covering the 18th century and the first 16 years of the 19th century. It is a study by Tadeusz Furtak's, published two years earlier in 1935.

The price series included from this work are beef, cow, veal, pork, mutton, and herring. Wheat was not included in Pelc or Furtak's collections, because there was little mention of it in the sources, making it difficult to establish a good price series.³⁵⁵ The rye prices have been included in this analysis as an alternative to wheat, though acknowledging that they may display different price dynamics.

The sources drawn on by these authors, as was the case for most locations so far, are municipal and hospital records. From the 1650s, much came from the City Hospital, St. Barbara's Church and Hospital and St. Spirit and Saint hospital. (See Pelc's work for the entire list.)³⁵⁶

In both Pelc and Furtak's works, prices are summarised with the minimum, maximum and average for each year, as well as the number of cases/values (or in other terms, the "sample size") per year.³⁵⁷ Pelc's methodological discussion states the material was collected in as raw a form as possible; this was to give researchers information that was less biased by assumptions.³⁵⁸ Furtak appears to have taken a very similar approach. This is most likely as their works were part of a large collection of works for Poland that was carried out under the direction of Francis Bujak of the University of Lwów.³⁵⁹ Both Pelc and Furtak apply a methodology that attempts to limit the seasonality of prices by including prices for each quarter in a year if possible.³⁶⁰

The price series are developed from a similar collection of sources in both works. Thus, the authors appear to have focused on series with long temporal coverage. They supplement these sources with some others in some instances, similar to the approach in Elsas' collections. The minimum and maximum values provide the range of prices for each year. Perhaps it is the case that these minimum and maximum were related to particular

³⁵⁵ Pelc, (1937), 34*.

³⁵⁶ Ibid, 10*-13*.

³⁵⁷ Ibid, 31*.

³⁵⁸ Ibid, 31*.

³⁵⁹ Arthur H. Cole and Ruth Crandall. "The international scientific committee on price history," *Journal of Economic History* (1964): 381-388, 387.

³⁶⁰ Pelc, 31*; Furtak, 6.

seasons, but this is impossible to tell from Pelc and Furtak's works as they have not included this information. This is an indication of how accurate the price might have been, i.e., a larger difference in the minimum and maximum would suggest less confidence in how accurate the average is. A large range also, however, indicates the possibility of higher price variability, which could be an indication of a volatile market. From a statistical perspective, the inclusion of the number of prices per year is also useful, as larger samples of information tend to provide a more accurate average.

The selection of prices is shown below (Figure A.6 **Error! Reference source not found.**). There are many meat price series available in the two volumes, as reflected in this chart. The beef prices are provided as two separate series, as they are two different beef products. They are referred to as "Wol" and "Mieso Wolowe", which translate to "Ox" and "Beef" respectively; Wol covers the period, 1607 to 1700, from the first price volume (i.e., Pelc's work), while the Mieso Wolowe is more extensive and ranges from 1648 to 1815, coming from both Furtak and Pelc's works.³⁶¹ Veal prices are another long series, covering 1546 to 1785. Mutton prices are available in two series; the first is from Furtak and covers 1573 to 1700, while the second comes from Pelc and covers 1701 to 1813. It is not clear if these two mutton series are for the same product, thus they are not combined as one and are kept as two separate series, (as is also the case in the work of Allen-Unger). In this instance, there is uncertainty about the unit of quantity. It is very likely that they are the same in both volumes, but without confirmation of this, there is no need to make such an assumption. As for pork, it is included as one series, ranging over both works for a period from 1567 to 1813. Finally, a product referred to as "cow" is included and covers 1700 to 1791. It is not clear how it differs from other beef produce.

Moving to the marine produce, herring is also one series and covers 1504 and 1702. Pelc states the herring product was not very homogeneous, coming from locations such as Dutch, English, Scottish and Bornholm. This is not surprising perhaps, because of the substantial herring trade that was occurring in Europe during the study period.³⁶² Because of this mix of locations, it is possible that the price trends and variability is in part due to this lack of homogeneity in the product. For example, commodities not studied in this

³⁶¹ More information is available in Appendix 1.

³⁶² Poulsen, *Dutch herring*.

thesis, such as fat, milk and butter are considered by Pelc more uniform products, due to measures being more standardised.³⁶³

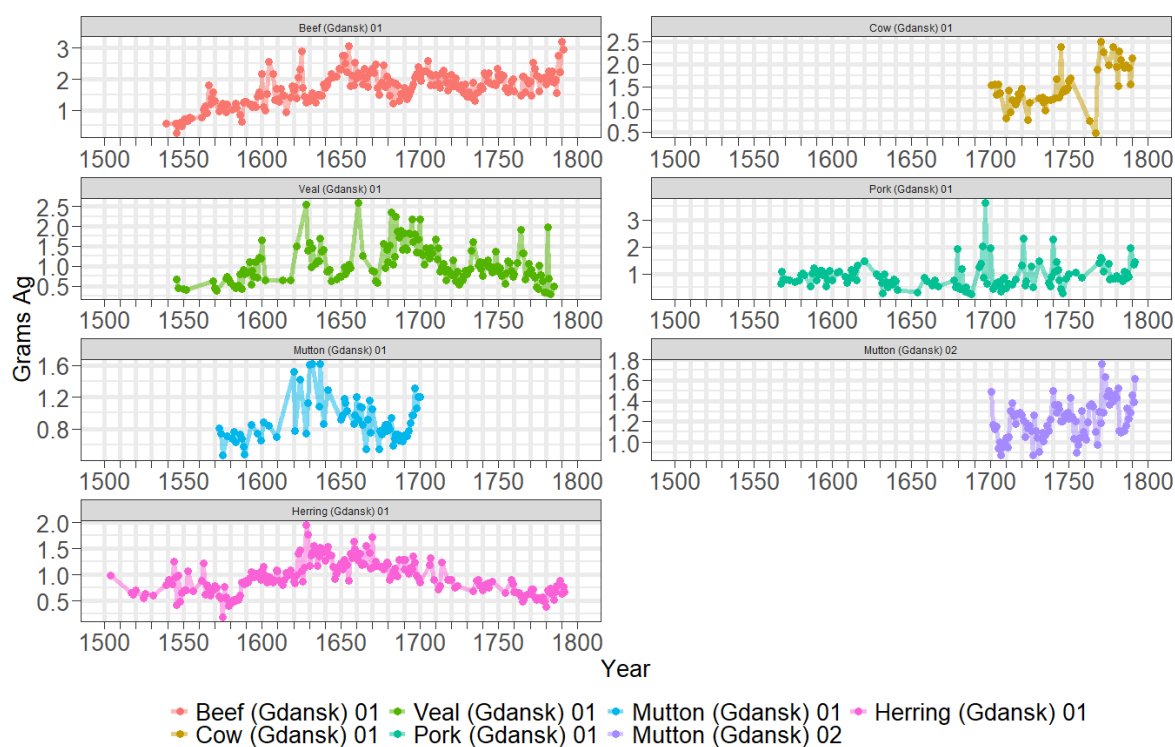


Figure A.6. Prices in Gdańsk, from the work of Pelc and Furtak, Covering beef, cow, veal, pork, mutton, and herring.

A.6. Hauser and Baulant - Paris

For Paris, prices from two sources are included here (Figure A.7 **Error! Reference source not found.**). The first is Henri Hauser's work on various French prices, published in 1936, and the second is Micheline Baulant's work on wheat prices from 1968.³⁶⁴ The present chapter draws wheat, bread, egg, and butter prices from these sources. Hauser's work covers a number of locations, not just Paris, drawing his information from "mercuriales", which translates as market list prices, municipal records and other miscellaneous accounts. The full list is available in Baulant's work.³⁶⁵ Baulant's work is used in this thesis for Paris, but also includes information for other locations in France such as Orleans Lyon and Bordeaux, though all to a lesser extent. As for the period covered per commodity, bread

³⁶³ Pelc, 35*.

³⁶⁴ Henry Hauser. "Recherches et Documents sur l'histoire des Prix en France depuis 1500 à 1800," *Parigi, Les Presses Modernes*. 135-138, (1936): 147-151; Micheline Baulant, "Les prix des grains à Paris de 1431-1788," *Annales: E. S. E.*, 23 (1968), 520-40.

³⁶⁵ Hauser, (1936), 44-5.

prices are available from 1738 to 1791, eggs from 1505 to 1685, butter 1503 to 1791, and wheat from 1431 to 1788.

Unfortunately, fish are not included in this collection. The value of the prices compiled by these two authors thus lies within the opportunity to compare the commodity prices to new research from results from archival research performed on the NorFish project on French fish and other prices for Paris, which is examined later in this chapter. This will show similar prices for eggs within both Hauser’s collection and the NorFish collection are quite similar. This indicates that the prices paid in the markets both sets of sources represent could be similar. (The Norfish Data will be discussed in more detail later, but it represents contract prices for wealthy nobles in Paris.)

The wheat (blé) prices, which are wholesale, come from Baulant. They are mainly derived from a record of the highest prices of wheat from the “Halles de Paris”, which was itself a wholesale market. The prices are an average for the four seasons from 1520 onwards; prior to that (1500 to 1519), they were for St Martin’s Day, which is during winter. Thus, it is necessary to be aware of a potential change in behaviour of this price series pre-1520.

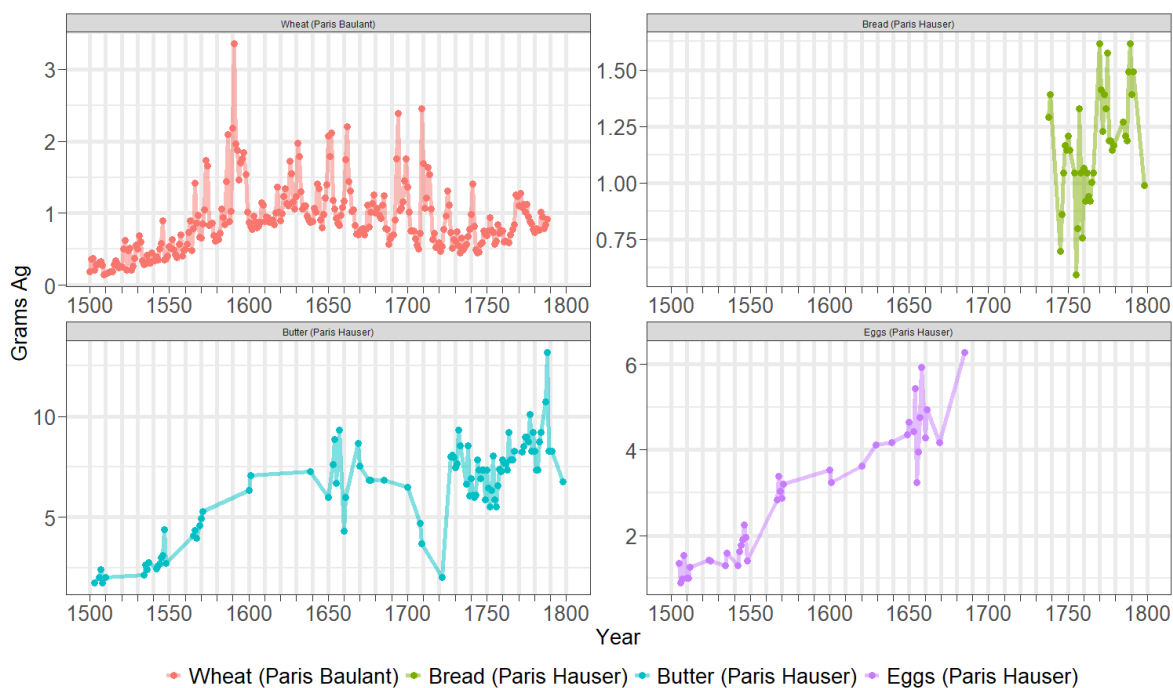


Figure A.7. Prices in Paris from the works for Baulant and Hauser. These prices cover wheat, bread, butter, and eggs.

A.7. Pribram - Vienna

What is included in this chapter for Austria is specifically for Vienna. This comes from a large volume of work developed by Alfred Francis Pribram.³⁶⁶ This publication is another example that is based on sources that represent the prices paid within hospitals and religious institutions, as well as market list prices (Marktprotokolle).³⁶⁷ The most prominent three sources are from Vienna Public Hospital (Wien Bürgerspital), market protocols (Marktprotokolle) and from Klosterneuburg Abbey (Stift Klosterneuburg). This thesis focuses on information from the hospital and the abbey. These locations are within or near Vienna. Of benefit too is that these prices are based on actual transactions, rather than list prices. As discussed in the introduction in this chapter, the transaction prices come with the benefit of being a more accurate reflection of market activity than the list prices, as they are based on actual transactions, rather than recommendations.

Pribram's prices for herring, stockfish and another product referred to as "cheap stockfish" are displayed below in Figure A.8 **Error! Reference source not found.** The information is patchy in some cases, and the stockfish prices are not based on a common unit throughout the series, which leads to a distortion of the graph. This will be adjusted later in this chapter when dealing with conversions of units to a common unit for all commodities.

There are two price series for herring. The first series covers a period from 1528 to 1734 and is based on prices from Wien Bürgerspital. The second covers a range from 1442 to 1765 and derives from prices paid in Stift Klosterneuburg. Stockfish prices are from Wien Bürgerspital and range over 1688 to 1750. The "cheap stockfish" product covers a period from 1694 to 1772 and these were paid in the Stift Klosterneuburg. Thus, there is a set of price series for herring and stockfish for each of Wien Bürgerspital and Stift Klosterneuburg, allowing a comparison of the prices in both locations.

³⁶⁶ Alfred Francis Pribram, *Materialen zur Geschichte der Preise und Löhne in Oesterreich*, Vol. 1 (Vienna, 1938).

³⁶⁷ Pribram, xxv.

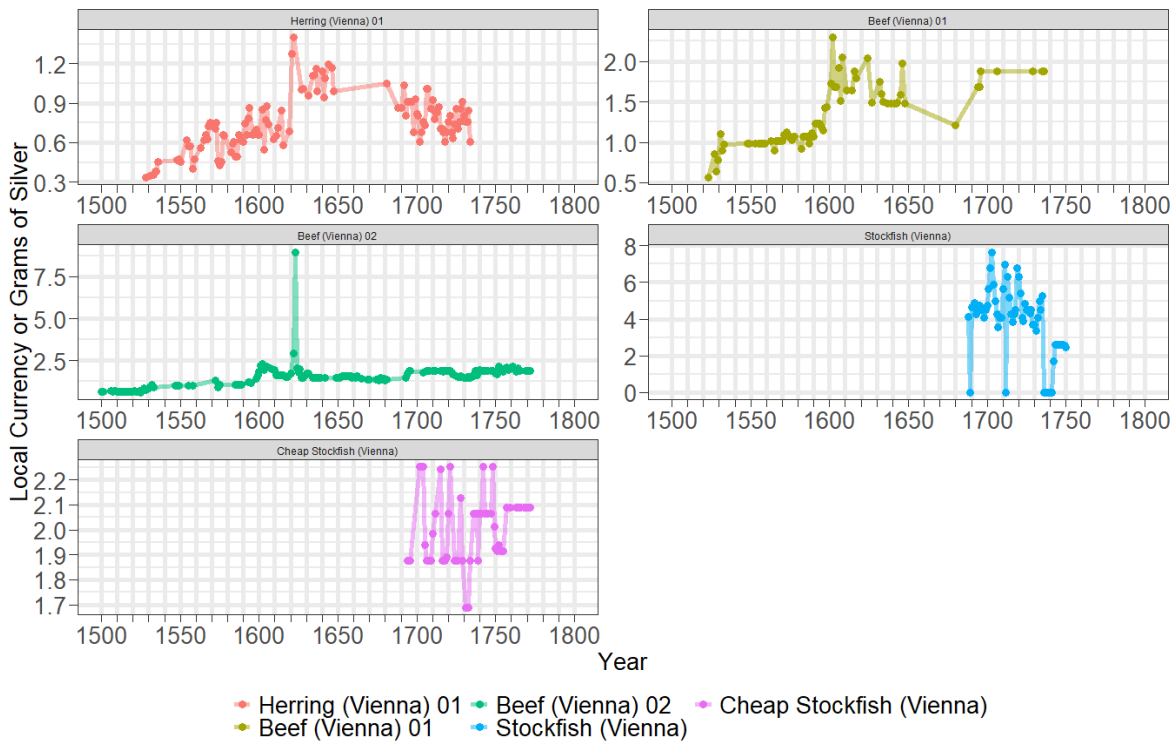


Figure A.8. Prices in Vienna for herring, beef, and stockfish from Alfred Francis Pribram. Two price series are included for stockfish.

A.8. Van der Wee - Antwerp

Herman Van der Wee's three volume collection on prices in Antwerp and market development, published in 1963, provides a critical source of herring price data (Figure A.9).³⁶⁸ These prices cover the period from 1386 to 1600, and are based on purchases from markets in Antwerp and Malines. Malines is approximately 20 km from Antwerp. The prices are those from bulk purchases for large institutions.³⁶⁹ Thus it is likely they represent a market position similar to the large institutions discussed already for the other locations.

³⁶⁸ Herman van der Wee. *The Growth of the Antwerp Market and the European Economy: Fourteenth-Sixteenth Centuries. Interpretation* (Nijhoff, 1963).

³⁶⁹ van Der Wee, 277.

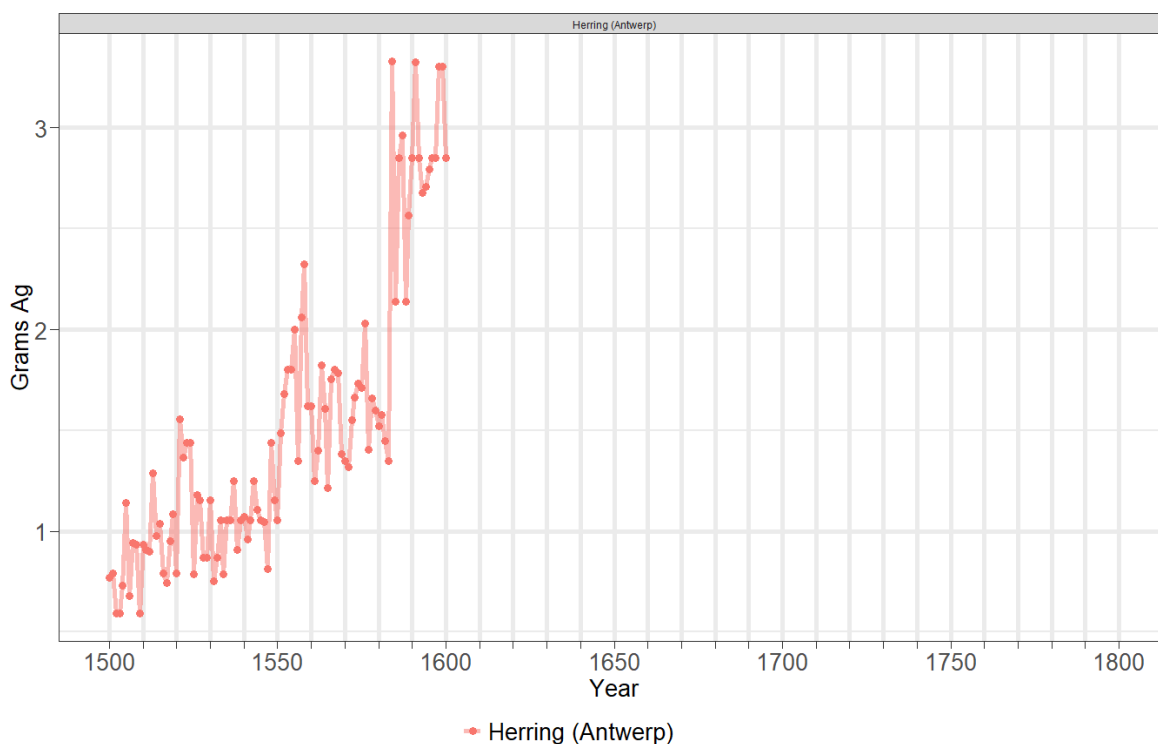


Figure A.9. Prices in Antwerp for herring.

A.9. Allen-Unger Database

The already mentioned Allen-Unger database is a collection of price series for many types of food, drink, raw materials, and manufactured goods, in addition to wages, gathered from the work of multiple scholars, including the above authors.³⁷⁰ The collection, as available online, does provide information for the sources they collated information from, but the detail is not always sufficient. As such the earlier sections have provided additional and important information by studying these works in detail, including their respective methodologies. It is a time consuming but important exercise to study each of the sources, as it provides a deeper understanding of what the price information represents, which in turn is beneficial for the analysis of the information. What the various prices in the database represent is now clearer. More specifically, the prices generally represent hospitals, religious institutions, and wealthy nobles, and in some cases, wholesale markets. They do not tell us what the poor ate.

³⁷⁰ Richard Allen and Robert Unger. "The Allen-Unger Global Commodity Prices Database," *Research Data Journal for the Humanities and Social Sciences* 4, 1 (2019): 81-90, doi: <https://doi.org/10.1163/24523666-00401006>.

A.10. Feliu - Barcelona

Feliu's collection of price information represents the region of Catalonia.³⁷¹ For the most, the price information represents Barcelona and the surrounding region and locality.³⁷² Commodity prices include bacalao (which is a type of cod product), herring, grain, and mutton (referred to as "sheep meat"). The price series begin early in the 16th century and continue until the early 19th century. The prices are from municipal and religious records. These prices are available for almost every year, thus there are not many missing years. Feliu has converted the prices from local silver-based coins to a common standard of silver. The unit of quantity differs over the products.

Feliu discussed the motivation to develop the price collection for the Catalonia region, referring back to work from Hamilton in 1934 (covered above). Feliu states that Hamilton expected that due to a lack of source for the likes of Barcelona, that sources for Valencia were sufficient to represent the entire region of the "Crown of Aragon", a region that during much of the study period included both Barcelona and Valencia. As more information became available from archives for regions such as Barcelona, Feliu's work became possible. Feliu indeed shows wheat prices for Valencia and Barcelona do tend to be similar, but vary enough at particular times, he believed, to make it of sufficient interest to study them both.

Beginning with the municipal sources, they are derived from the Municipal de Historia de Barcelona (IMHB). They are the first main source of price information and fall into three categories.³⁷³ First, price-setting proclamations, which are set prices that were set centrally to guide institutions that were dependent on or controlled by municipal authorities. For the price-setting records, Feliu notes the now familiar argument in this chapter of the weaknesses of these sources. That is, they mask short-term change, which on the other hand, makes them more useful for medium and long-term perspectives. The second type of prices are the price and salary annotations kept to understand prices in the markets. They were usually related to cereals and grains. These appear to be notes on list prices that

³⁷¹ Gaspar Feliu. *Precios y Salarios en la Cataluña Moderna. Vol. I: Alimentos* (Banco de España, 1991). <https://EconPapers.repec.org/RePEc:bde:esheco:21>.

³⁷² Gaspar Feliu. *Precios Y Salarios en la Cataluña Moderna. 2 Vols.* (1991). (The price information is discussed in the first volume. The list of sources can be found in the second volume.)

³⁷³ Feliu, Vol 1, 11.

would relate to prices at markets, perhaps made by the municipal authorities to decide on their own price recommendations. The third category are accounting records of municipal institutes.

The second major source of information are the documents of ecclesiastical origin. They are divided into two main groups: cathedrals, and convents and monasteries. The information for the cathedrals is of limited use, due a lack of clear dating, and Feliu did not use it beyond 1617 CE. For the convents the documentation is preserved in the Crown Archive de Aragón, located in Barcelona. A series referred to as monastic (or “monacales”) represents the majority of the documentation, covering seven institutes (specifically five convents and two monasteries).

Feliu’s methodology takes the first monthly mention of a price for each product, and then calculates the average for all twelve months to provide an annual price, though it might be the case that this method was only applied to grain.³⁷⁴ If the data is sufficiently homogeneous (i.e., this doesn't mean that the prices are the same, but that the methodology, units and so on are the same), they were included by Feliu. Preferably information is collected from series that cover longer periods of time. Feliu states that entire product series were rejected if the results were based on too small a sample or if problems occurred with inconsistent units of measurement.

Three commodities covered by Feliu are included in this thesis and shown below (Figure A.10), namely, sheep meat, bacalao and herring. The Bacalao prices cover a relatively long period from 1574 to 1798, with no years missing. Feliu states that he had the option of studying other price series in more detail, such as salted tuna, conger, and herring, but focused on bacalao due to its importance as food and because two types of prices are available: actual purchase prices and set prices, (set prices would have been recommended prices, rather than what was paid). Feliu thus provides two series as based on these; the first comprises purchase prices for convents (Compras de los convento) and the second municipal taxes (Tasa municipal). He additionally provides a third series, which is a combination of the first two, referred to as a “propuesta de unificación”. This thesis studies

³⁷⁴ Feliu, Vol 1, 24.

the first because it is the most complete, and is more representative of actual purchase prices, rather than set or list prices.

The herring series covers a large period from 1502 to 1808. Feliu expresses reservations about these prices as he observes very different prices occurring over time. He suspected that this was possibly due to the available prices “silently” reflecting different units of quantity in different periods. For this reason, when these prices are studied later, it is important to consider how this lack of uniformity could influence the price trends, perhaps as a higher level of price volatility.

In the case of or mutton, there are three annual price series, covering the 16th to 18th centuries to varying degrees. The three series are based on municipal tax records in Barcelona, municipal butcher prices in Cervera and finally, market prices in Arenys de Mar. The first series is studied in this thesis as it is the most complete series, covering the period from 1501 to 1761 and with very few missing year, also it specifically represents Barcelona.

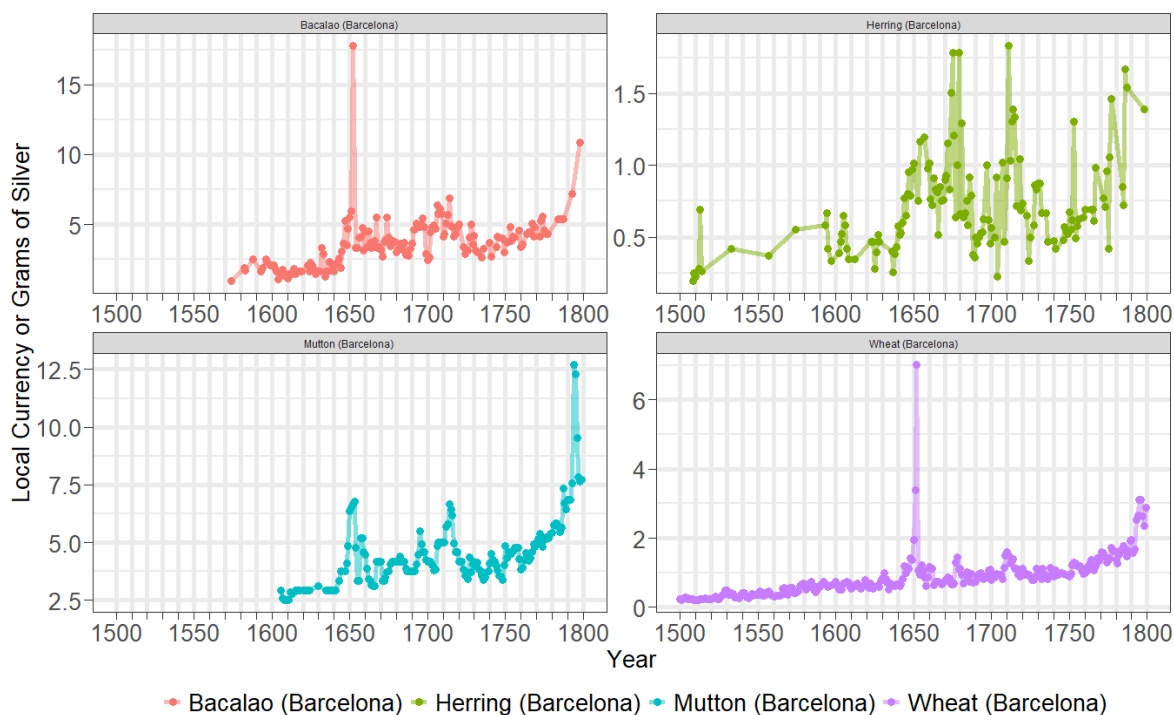


Figure A.10. Prices in Barcelona from Gaspar Feliu’s collection. Covering bacalao, herring mutton and wheat.

A.11. Bauernfeind - Nuremberg

Walter Bauernfeind's price series are based on prices paid in Nuremberg and the surrounding region. Herring and rye prices are shown below (Figure A.11).³⁷⁵ The prices are derived from sources from two locations; a Cistercian monastery in Heilsbronn (approximately 20km from the centre of Nuremberg) and the bills of the Nuremberg Holy Spirit Hospital.

Rye prices relate to Nuremberg and the surrounding region. In assessing these data, Bauernfeind states that the prices in locations such as Heilsbronn were almost identical to rye prices in Nuremberg, and therefore believes the prices information for the surrounding regions is representative of prices paid in Nuremberg.³⁷⁶ The series covers a period from 1339 to 1670. Only three annual values are missing, they are not relevant to this thesis though as they relate to the 14th century.

Herring prices come from Heilsbronn Abbey.³⁷⁷ Specifically within the research period, the prices cover years from 1500 to 1640. Bauernfeind notes that these prices are harder to work with than the grain to generate a price series, because there is less information available. Bauernfeind has applied interpolations to some price series to remedy this. For example, in the case of the herring price series, over the 332 year period from 1339 to 1670, there are 180 years available with actual prices (54%), with the final value in 1640. Thus, over half of this series is interpolated.³⁷⁸ Bauernfeind himself expresses reservations about applying these interpolations. Their inclusion does indicate that this price series could include trends that are to some degree an artefact of the interpolation process.

³⁷⁵ Walter Bauernfeind. *Materielle Grundstrukturen Im Spätmittelalter Und Der Frühen Neuzeit: Preisentwicklung Und Agrarkonjunktur Am Nürnberger Getreidemarkt Von 1339 Bis 1670* (Neustadt/Aisch, BRD: Schmidt, 1993). Table A23, 465-70.

³⁷⁶ Ibid, 64-6. (Also, page 69 includes information on what locations were used and for what periods they covered).

³⁷⁷ Ibid, 78.

³⁷⁸ Ibid. 78. (Interpolations are also applied to butter and salt in his collection, but to a lesser extent. i.e., they are 89% and 83% complete, rather than the 54% of the herring series.)

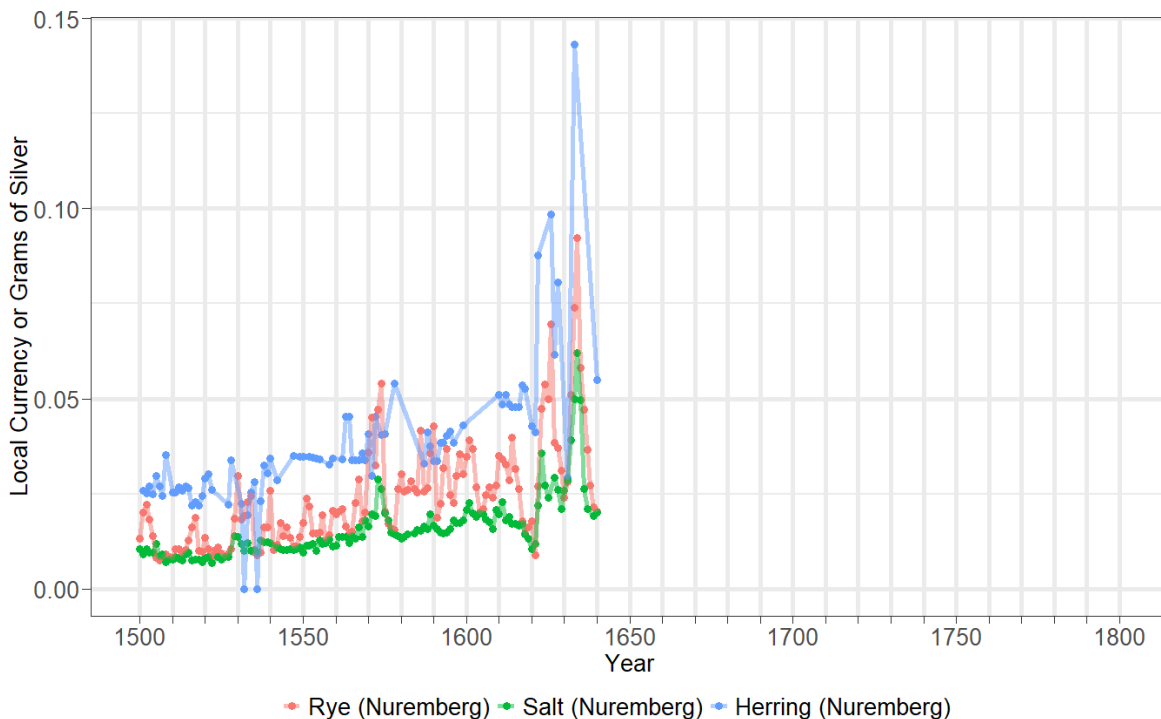


Figure A.11. Prices in Nuremberg. (Rye and herring).

A.12. Jansson, Palm and Soderberg - Stockholm

The 1991 work from Arne Jansson, Lennart Palm, and Johan Söderberg, entitled *Dagligt Bröd I Onda Tider: Priser Och Löner I Stockholm Och Västsverige 1500-1770*, includes two essays that are relevant to this chapter because they provide a Scandinavian price perspective; they discuss prices in Stockholm and West Sweden, respectively.³⁷⁹ The first was written by Jansson and Söderberg, covering 1600 to 1719 CE, while the second was developed by Palm and studied 1551 to 1770 CE. Jansson and Söderberg’s analysis is the source drawn upon in this thesis. It focuses on prices paid in Stockholm. The second essay, which is focused on West Sweden rather than Stockholm, is a rich source of price information. The information has not been included in this thesis. It requires further analysis to understand each of the series and what they represent. Thus, it is left open for further study to develop an analysis of how the price compares between Stockholm and West Sweden.

Herring, pork, and oxen prices are provided by Jansson and Söderberg for Stockholm and are shown below (Figure A.12Error! Reference source not found.). The prices range over

³⁷⁹ Arne Jansson, Lennart Palm, and Johan Söderberg. *Dagligt Bröd I Onda Tider: Priser Och Löner I Stockholm Och Västsverige 1500-1770* (Inst. för Lokalhistorisk Forskning, 1991).

the years 1600 to 1719. These price series have been developed from municipal accounts, mainly building societies, which Jansson *et al.* indicates the prices are market prices for purchase mainly for Stockholm Castle, and to a lesser extent “City Billboards”, which the translation of is unclear. To a limited degree, prices from hospitals are also included to supplement the series. The prices are expected to be similar to wholesale market prices as they were for purchase of large quantities.³⁸⁰ Herring prices are in fact available in two series, each representing different herring products, one being the lower quality Baltic herring known as “stromming” and the other the higher quality “sill”. Sill generally came from the North Sea, similar to other herring products discussed in this thesis and, therefore is more comparable to the other herring produce discussed thus far. Thus, the stromming is not included in this thesis. These sill (and the exclude stromming) prices cover a short period from 1600 to 1719, however. The Oxen prices cover the same period. Pork covers a slightly later period from 1705 to 1749.³⁸¹

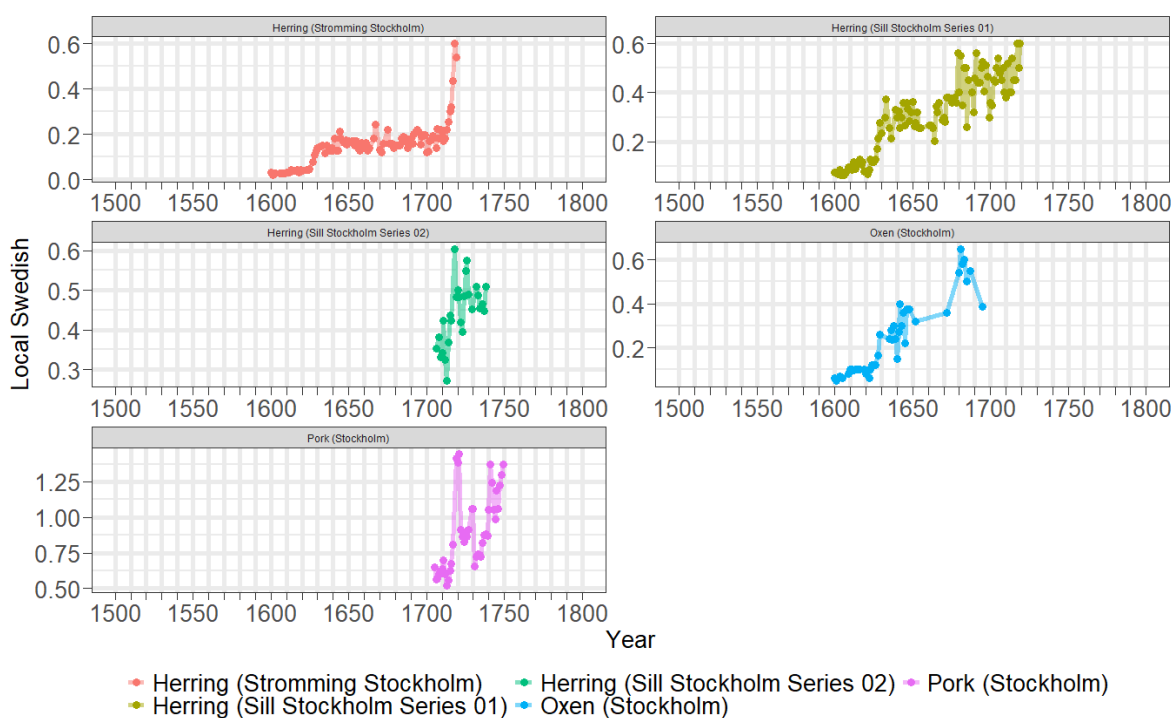


Figure A.12. Price paid in Stockholm, based on research by Arne Jansson and Johan Söderberg. This includes herring (sill and stromming products), pork, and oxen.

³⁸⁰ Jansson, (1991), 2.

³⁸¹ Jansson, (1991), 66-9.

A.13. Allaire - Paris

The NorFish project has developed new catch volume and price series for Paris and Bordeaux. This is based on research undertaken by the NorFish project.³⁸² For this thesis, price series developed for the period from 1530 to 1750 CE are of particular interest. I took the opportunity to work directly with Allaire in Bordeaux in 2018, visiting archives to experience his work first-hand.³⁸³ Allaire's price information is presently available in a number of internal project reports, two of which this chapter discusses. The first is focused on prices in Paris and the sources comprise supply contracts located in the *Minutier Central des Notaires de Paris*. The second report discusses prices in Bordeaux and the sources are from records kept by notaries, who kept detailed records of vessels journeying to Newfoundland. As Allaire describes, the notaries were professionals in charge of formalizing and validating civil or commercial acts and contracts. These records are used by many specialists because they contain valuable testimonies about the human activities of the medieval and modern periods.³⁸⁴ However, these archives cannot be used to search for documents without a minimum of information.

The notaries were incentivised to maintain accurate information as they were hired to act as recordkeepers for individuals on both sides of a transaction. This is evidence in support of the records being both accurate and reliable. The sources are located in the *Archives Départementales de Gironde* in Bordeaux. Both Paris and Bordeaux were important economic locations, with Paris as the capital of France. Also, maritime activity was important to Bordeaux, with Allaire stating around 5% to 10% of the work produced by notaries could relate to maritime and commercial transactions.³⁸⁵ The two reports provide a view of the Paris market and to a lesser extent Bordeaux. The Paris report includes a larger amount of price information, this is because a larger amount of relevant material was available to work with in the case of Paris. The value of the two reports is not just that new price information is available to study, but that they also allow a comparison of

³⁸² Bernard Allaire. "Internal Norfish Report One: Fish and Commodity Prices in Food Supply Contracts in Paris (1538-1756)"; "Internal Norfish Report Two: Landing, Price and Packaging in Bordeaux Fish Trade 1530s - 1580s."

³⁸³ A visit to the Archives Départementales de Gironde in Bordeaux was undertaken (April 2018). This involved researching with Dr. Bernard Allaire and directly studying the archival sources his NorFish based research is developed from.

³⁸⁴ Allaire, Report 1, 8.

³⁸⁵ *Ibid*, 3.

commonalities and differences in price behaviour between the Paris and Bordeaux markets. The period of overlap in the new price data for both cities is between the 1530's and the 1750's.

The first report covers Paris for the period from 1538 to 1756. The documents created by the notaries were contracts between wholesalers or purveyors (known as "pourvoyeurs" in French) and wealthy elites or their representatives such as families of the court, managers of the houses of the royal families and high ranking military officers, as well as government institutions. The prices can thus be expected to be higher than those paid by merchants at an earlier wholesale position in the supply chain. Moreover, because the prices are based on contracts, they can be expected to be more stable through time. The contract provided the prices for various products, but to some degree they were flexible, allowing the provider to adapt to what they could find on the markets.³⁸⁶ (Thus these prices might vary from those paid by an individual who visited a market, with no contract, to simply purchase produce.) It was in the interests of all parties involved in these transactions to maintain accurate records to keep reputations intact, thus the records can be expected to be quite reliable. The contracts were chosen by Allaire based on their level of completeness and quality. To develop high quality and robust price series from the archival material, inadequate, incorrect, absent, or imperfect documents were identified and removed. Ultimately, 74 contracts met the research criteria and were included in the report. For this thesis, examples of the contracts have been transcribed, tracing information from the sources to the final tables created by Allaire.

³⁸⁶ Allaire, Report 1, 7.

Figure A.13. presents further examples of the archival documents Dr. Allaire studied for this first NorFish report.

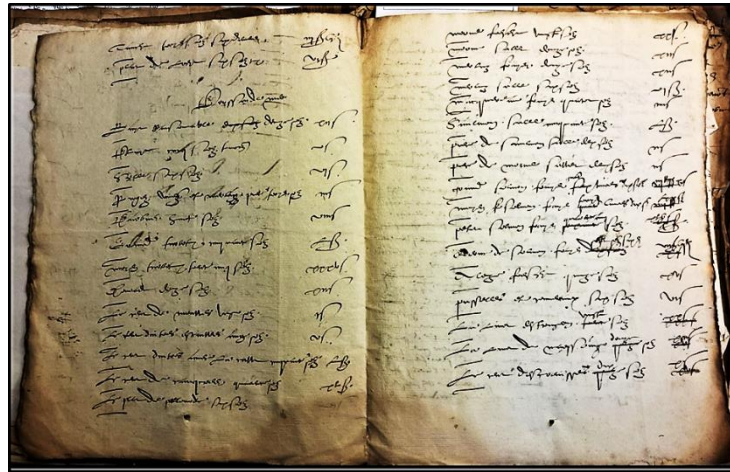


Figure A.13. Example of the archival documents from Paris. (Document III-208, 30-05-1549 Allaire, "Internal Norfish Report One: Fish and Commodity Prices in Food Supply Contracts in Paris (1538-1756).")³⁸⁷

It is possible there is a degree of seasonal variation within the prices, as the contracts are dated from different months throughout the year. Thus, this could influence the year on year price variation. As there are missing years in these price series, they are likely to prove more useful in informing us of medium to long term price changes.

Figure A.14. (below) is a selection of price series from the report. This selection includes cod, herring, pork, beef, chicken, wheat, eggs, meat, butter, cheese, and wine.

³⁸⁷ Allaire, Report 1.

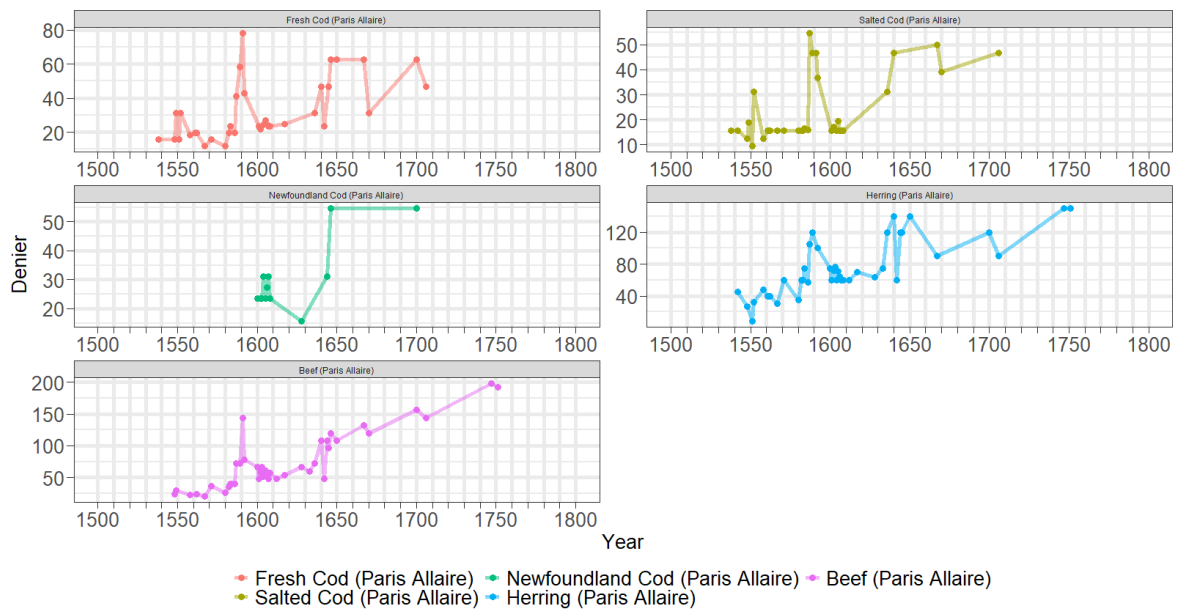


Figure A.14. Prices for cod, herring, and beef. They are from contracts drawn up for government officials and wealthy families of the court in Paris.

A.13.1. From Transcription to Quantification

What follows is an outline of the development of the price series in the first internal Norfish report. Additional original work for this thesis has involved the extraction of this price information and its formatting within a structure that facilitates further quantitative analyses.

The process begins with the transcription and translation of information from the supply contracts, which is arranged into a tabular format that allows the information to be stored in a standardised and uniform setup for the internal report. A sample of this information is illustrated in this tabular form in Figure A.15 (below). An initial simple demonstration of the power of this format comes from the summary statistics that can be readily generated from it. Thus, we have some 2,492 individual price data (points) for 71 years and 121 species/commodities. The first two columns provide the name of the commodity, with the French translation first followed by English. After this, there are repeating groupings of four columns, representing the currency units of Ecu (E), Livre (L), Solz (S) and Denier (D). Each of the four column groupings represents one of the 71 documents, for example document XIX-174, 17-03-1548ns, displays a price of 10 Solz for “Fresh Cod” in 1548.

fournitures et références	commodities and references	ADPA, B-2083 (1538)				VIII-69: 17-02 1542ns				XIX-174, 17- 03-1548ns				XLIX-38, 26- 04-1548				III-208, 30-05- 1549				CXXII-1374, 28-10-1551			
		E	L	S	D	E	L	S	D	E	L	S	D	E	L	S	D	E	L	S	D	E	L	S	D
prix en écu, livre, sou et denier	price in écu, livre, sou and denier																								
morue	cod																								
morue entière	entire cod																								
morue fraîche	fresh cod			10								10					20								10
grande morue fraîche (de 20 pouces et +)	big fresh cod (20 inches & more)																								
morue fraîche (16-18 pouces)	fresh cod (16-18 inches)																								
morue fraîche (plus petite)	smaller fresh cod																								
pièce de morue	piece of cod								5																
morue sèche (stockfish ? Séche non salée)	dry cod (maybe Stockfish : dry non-salted)			6																					
morue salée	salted cod			10					10				6				10								12
morue salée (faisant 4 pièces)	salted cod (making 4 pieces)																								
morue salée (faisant 3 pièces)	salted cod (making 3 pieces)																								
pièce de morue salée	piece of salted cod																								
morue salée de Terre-Neuve	salted Newfoundland cod																								2
morue de Terre-Neuve entière et salée	entire and salted Newfoundland cod																								
morue de Terre-Neuve (entière)	entire Newfoundland cod																								
morue de Terre-Neuve (faisant 6 pièces)	Newfoundland cod (making 6 pieces)																								
morue de Terre-Neuve (faisant 5 pièces)	Newfoundland cod (making 5 pieces)																								
morue de Terre-Neuve (faisant 4 pièces)	Newfoundland cod (making 4 pieces)																								
pièce de morue de Terre-Neuve	piece of Newfoundland cod																								
morue nouvelle (faisant 6 pièces)	new cod (making 6 pieces)																								
morue parée (sec)	prepared (dry) cod																								
grande morue parée (pour 2 ou 3 plats)	big processed cod (for 2 or 3 plates)																								
pièce de morue blanche	piece of white cod																								
morue de Flandres	Flanders cod																								
morue de Flandres salée	salted Flanders cod																								
morue de Flandres (pièce)	piece of Flanders cod																								
morue d'Islande entière et salée	entire & salted Iceland cod																								
pièce de morue d'Islande	piece of Iceland cod																								
moluant (molle nante 1642)	moluant (unidentified but with cod)																								
cabillaud (cabelliau)	cabelliau			3																					
calibault (colibau)	calibaud (cabelliau?)																								
tripes de morue (100)	cod tripe (100 of)								50								50								

Figure A.15. Table from NorFish Internal Report One. Summarizing price information for 32 Cod commodities over 71 years spanning from 1538 to 1751. (Tables of the same format are also provided, summarising Gadidae, Sea Species, Shellfish, Freshwater and Other Commodities.)

Figure A.16 **Error! Reference source not found.** (below) focuses on one of the documents, in which a price of 20 solz for fresh cod was reported for 1549.³⁸⁸

fournitures et références	commodities and references	III-208, 30-05- 1549			
		E	L	S	D
prix en écu, livre, sou et denier	price in écu, livre, sou and denier				
morue	cod				
morue entière	entire cod				
morue fraîche	fresh cod			20	
grande morue fraîche (de 20 pouces et +)	big fresh cod (20 inches & more)				
morue fraîche (16-18 pouces)	fresh cod (16-18 inches)				
morue fraîche (plus petite)	smaller fresh cod				
pièce de morue	piece of cod				

Figure A.16. An extract from previous table. Showing a price of 20 Solz for Fresh Cod in 1549.

The above table covers cod produce. Sheets in a similar format are also available for gadidae, sea species, shellfish, freshwater fish, and other commodities such as eggs. The next step within the report was to consolidate these into one sheet (below Figure A.17). One common currency column is included with all prices converted to denier.

³⁸⁸ Document III-208, 30-05-1549 from Allaire, Report 1.

	Prix en deniers, (Les écus sont estimés sur la base de 3 livres ou 60 sous ou 720 deniers)	Price in deniers (The écu are counted on the basis of 3 livres or 60 sous or 720 deniers)	III-208, 30-05-1549
	Notes	Notes	
COD	morue	cod	
	morue entière	entire cod	
	morue fraîche	fresh cod	240
	grande morue fraîche (de 20 pouces et +)	big fresh cod (20 inches & more)	
	morue fraîche (16-18 pouces)	fresh cod (16-18 inches)	
	morue fraîche (plus petite)	smaller fresh cod	
	pièce de morue	piece of cod	

Figure A.17. An extract from the final consolidated table. Again, showing the price for Fresh Cod in 1549, but with the currency converted to 240 Deniers (i.e., 20 Solz = 240 Deniers).

A.13.2. Transcription, Currency and Conversions

The base price unit (i.e., the unit of account) employed in the reports are “Deniers Tournois”, the common currency of much of France from the thirteenth century, originating from the region of Touraine.³⁸⁹ This currency consisted of a sequence of non-decimal denominations in coin format: the Ecu, Livre, Solz³⁹⁰ and Denier. These can be equated in the manner shown below, ordered from larger to smaller denominations.

$$1 \text{ Ecu} = 3 \text{ Livre}, 1 \text{ Livre} = 20 \text{ Solz}, 1 \text{ Solz} = 12 \text{ Denier}.$$

Returning to the supply contracts and with the example from 1549, Figure A.18 is excerpted from the food supply contract from Paris for a Parisian noble in Figure A.13. A straightforward list of items supplied in a left-hand column with the corresponding price on the right. The excerpt indicates “Fresh Cod” (morue fraiche) for the price of 20 Solz. After transcription, all such information is then converted to the common unit of Denier within the report, in this case giving a price of 240 Denier, as per the conversion laid out below.

³⁸⁹ D. Metcalf. “The Currency of “Deniers Tournois” in Frankish Greece,” *The Annual of the British School at Athens* 55 (1960): 38-59, 38.

³⁹⁰ Solz is sometimes written as “Sols”. Sol later became known as Sou. Solz is the standard in this chapter.

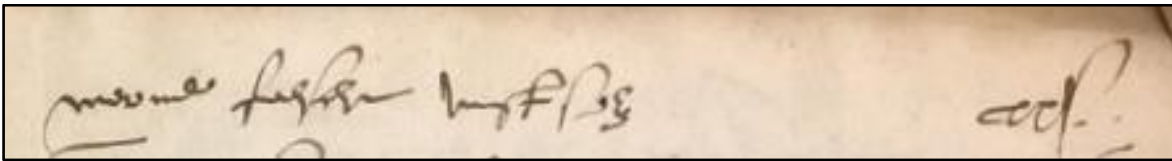


Figure A.18. From the text just above. On the left we have fresh cod (morue fraiche) and the amount of produce. Finally on the right the price is shown at 20 solz in roman numerals as “xxs”.

$$1 \text{ Fresh Cod} = 20 \text{ Solz}$$

$$1 \text{ Sol} = 12 \text{ Deniers}$$

$$1 \text{ Fresh Cod} = 240 \text{ Deniers.}$$

The question could be asked, why didn't the person writing the document simply write 1 livre? For example, the following is not what we see in the contracts

$$1 \text{ Fresh Cod} = 1 \text{ Livre}$$

$$1 \text{ Livre} = 20 \text{ Solz.}$$

This is because larger currency units were not commonly available or exchanged; 20 solz was convenient to split into a half or fourth/quarter, unlike the 1 livre tournois unit.³⁹¹

A second example can be observed from 1551 for a fresh cod purchased for Parisian nobles at a cost of 10 solz. On conversion, this becomes 120 Deniers.³⁹²

$$1 \text{ Fresh Cod} = 10 \text{ Solz}$$

$$1 \text{ Sol} = 12 \text{ Deniers}$$

$$1 \text{ Fresh Cod} = 120 \text{ Deniers.}$$

A.13.3. Comparison to Hauser's Price Series

There is little overlap of the commodities studied by Hauser when compared to that from Allaire's work, though a series for “eggs” does overlap to a useful extent. The prices are quite similar for both series, reinforcing the reliability of both sources, at least of the egg

³⁹¹ Dr. Allaire, personal communication, 15th March 2018. “The 20 sols (or sous) amount can easily be split into half or fourth, when you cut the fish on the market. This is not the case with 1 livre tournois. Small currencies are more flexible”.

³⁹² Document CXXII-1374, 28-10-1551 from Allaire, Report 1.

price series. It is impossible to state the answer definitively, but as both reports are representative of prices for large institutions or wealthy individuals, it is not surprising that the prices are similar. The prices are not always similar in the two sources though. A price series for bread in the Hauser's collection is substantially lower than bread in the NorFish collection, at about 15th the price. Hauser does note that the quantity of bread can vary, thus the above comparison might not be accurate due to inconsistent units of measurement of the bread. An adjustment to the quantity unit of bread could bring these more in line between the two locations. Further, the price per kg was similar to that of wheat, so perhaps there is some confusion on whether the commodity was wheat rather than bread.

B. Appendix - Currency and Quantity Conversions

B.1. Southern England and London

In the case of Southern England, the silver conversions came from Feavearyear's *Pound Sterling: A history of English money*.³⁹³ Feavearyear's publication covers a period from 1219 to 1816, thus encompassing the entire study period here. A digitised version of these is included in the Allen-Unger database. This copy was reformatted and included in the library of csv files developed and collected for this thesis. The quantity units of bushels and pound weights applied in this thesis correspond with the Allen-Unger database. The bushel was used to measure quantities of grains such as wheat, and was equivalent to 35.238l, which is based on the "Winchester" bushel.³⁹⁴ This bushel is not explicitly mentioned in the sources, but it was commonly used during the study period, having been standardised in 1496.³⁹⁵ Beef and salted cod were measured in pounds in Rogers and Beveridges' collections of prices. This is equated to 0.4535kg in the Allen-Unger database. This weight was established in 1853. A "Hanseatic Merchant's pound was also a standard from the 16th century onwards, weighing 0.46656kg.³⁹⁶ This is only slightly different from the value established in 1853. For this reason, this thesis remained with the conversion of 0.4535kg applied in the Allen-Unger database. Herring quantities were measured in barrels, each containing around 1,125 pieces. Prices for stockfish, which as noted in the introduction is a dried cod product, were per 120 pieces, which was usually described as a "wrap". Interestingly, and somewhat confusingly, the table of prices in Rogers' collection refers to this as "Stockfish, per 100", but this means the "long hundred" of 120.³⁹⁷ To convert these to a kilogram equivalent, an estimate is needed for the weight of a "piece" of herring and for the stockfish also. The value of 0.12kg is applied, following the discussion by Bauernfeind.³⁹⁸ In some later examples in this chapter, a value of 0.75kg is used, due to

³⁹³ Albert Edgar Feavearyear. *Pound Sterling: A History of English Money* (1931), 346, 348-9.

³⁹⁴ Ronald Edward Zupko. *A Dictionary of Weights and Measures for the British Isles: the Middle Ages to the Twentieth Century*. Vol. 168. American Philosophical Society, (1985), 55.

³⁹⁵ Ronald Edward Zupko. *British Weights & Measures: A History From Antiquity to the Seventeenth Century*. (Madison: University of Wisconsin Press, 1977), 77.

³⁹⁶ Jan Gyllenbok. *Encyclopaedia of Historical Metrology, Weights, and Measures* (Cham: Birkhäuser, 2018), 3:2372.

³⁹⁷ Rogers, Vol iv, 540 for the price table and 534-5 discusses the hundred and the wrap.

³⁹⁸ Walter Bauernfeind, *Materielle Grundstrukturen Im Spätmittelalter Und Der Frühen Neuzeit: Preisentwicklung Und Agrarkonjunktur Am Nürnberger Getreidemarkt Von 1339 Bis 1670* (Neustadt/Aisch, BRD: Schmidt, 1993), 321 for the 120g herring piece estimate.

uncertainty about whether a “piece” of herring is perhaps a fillet, or the entire fish. For stockfish, a value of 1.3166kg is applied. This is based on the conversion in Hayes Naval Diet study.³⁹⁹

As is the case for each location, some conversions are for volume (e.g., litres), rather than weight (i.e., kilograms). By definition, a kilogram of water is the same as a litre of water, but this is not necessarily the case for other commodities, because their densities differ. Certain sources provide prices in either volume or weight for the likes of grains such as wheat, barely, and rye. To conform to a standard, conversions have been applied in this chapter from “litres” of produce to a kilogram equivalent, based on densities of commodities. Thus, the following densities are applied for grains; wheat at 0.79kg/l, rye at 0.67kg/l and barley at 0.60kg/l.⁴⁰⁰

B.2. Spain - Hamilton

Hamilton’s price collections include the necessary details to calculate silver exchange rates from the maravedis, a unit of account in Spain, to its equivalence in grams of silver. The maravedis was a long running currency with origins as far back as the Moorish dynasty during the 11th and 12 centuries.⁴⁰¹ For the period from 1651 to 1800, Hamilton supplied silver conversions for grams of silver per maravedis in New Castile.⁴⁰² Prior to this, the conversions were more complicated. From 1501 to 1602 the maravedi contained 0.094 gram of pure silver.⁴⁰³ Thus the value of 0.094 is applied for conversions for the New Castile Maravedis at that time. Following this, there were premiums on silver in New Castile, (meaning silver was more expensive in that location), beginning from 1603 and tabulated up to 1650 by Hamilton.⁴⁰⁴ For this period, a percentage is applied each year to the value of 0.094 to adjust to this silver premium for the New Castile maravedis.

³⁹⁹ Patrick Hayes, https://figshare.com/articles/European_Naval_Diets_Database_xlsx/6446345.

⁴⁰⁰ Hayes, “Naval Diets”, Further information in grains.

Rye: https://figshare.com/articles/European_Naval_Diets_Database_xlsx/6446345 within “Conversions” tab.

Wheat: <https://www.aqua-calc.com/page/density-table/substance/grain-blank-wheat>;

Barley: <https://www.aqua-calc.com/convert/volume-to-weight/substance/grain-blank-barley>.

⁴⁰¹ Albert R. Frey. “A Dictionary of Numismatic Names: Their Official and Popular Designations,” *American Journal of Numismatics (1897-1924)* 50 (1916): v-311. p.143

⁴⁰² Hamilton, 1947, 34 Table 2 for 1651-1700, 53 Table 3 for 1701-1750, 77 table 4 for 1751-1800.

⁴⁰³ Hamilton, 1934, 318.

⁴⁰⁴ Hamilton, 1934, 95-6, (See Table 7, 96.)

The Allen-Unger database includes a calculation for the conversion from the maravedis to grams of silver for the period 1686 to 1709. This approach is, however, complicated and does not appear to be necessary due to Hamilton's inclusion of the series of values from 1651 to 1800 in his publication.⁴⁰⁵ Regardless, this serves to validate the silver conversions from another perspective, as the values from Allen-Unger's calculation are similar to those provided by Hamilton. To explain the conversion, intermediary steps are needed to translate from the maravedis to the grams of silver. This begins with the maravedis, converting to the number of reals, to a mark of silver, to the number of grams of silver in the mark and finally a percentage is applied to adjust for a recalculation in the silver purity of the mark. Thus, unwinding the calculation, (i.e., working backwards to match it), it corresponds to the following conversion:

$$\text{No of Grams of Silver} = (0.9306 * 230.046/84)/34 * \text{No of Maravedis}$$

First, there were 34 maravedis in a real.⁴⁰⁶ From a mark of silver, 84 reals were struck. A Castillion mark weighed 230.046 grams.⁴⁰⁷ Finally, this is multiplied by 0.9306.⁴⁰⁸ This last value is the percentage (i.e., 93.06%) of silver in silver reals of 11 dineros and 4 grains compared to 12 dineros, with 24 grains in a dinero. This represents the purity of the mark, with 12 dinero being the maximum purity.⁴⁰⁹

Moving to the quantities of produce, the dried fish are first studied. There are two dried fish series, the first was measured in libras of 0.46kg⁴¹⁰ (a "libra" linguistically translates as a pound, thus this is the origin of the abbreviation of "lb") and the second series is measured in arroba, equating to 25 pounds, in turn weighing 11.5kg (i.e., 0.46*25=11.5). Beef and mutton were also sold by the libra of 0.46kg. Finally, whole wheat was sold by the Fanega, measuring 55.5l.⁴¹¹ To convert wheat from litres to kilograms, the conversion of 0.79 discussed in the last section is applied again.

⁴⁰⁵ Hamilton, 1947, 34 Table 2 for 1651-1700, 53 Table 3 for 1701-1750, 77 table 4 for 1751-1800.

⁴⁰⁶ Hamilton, 1947, 38 footnote 7.

⁴⁰⁷ Ibid, 38.

⁴⁰⁸ Ibid, 22 or 38.

⁴⁰⁹ Patrick Kelly. *The Universal Cambist and Commercial Instructor: Being a Full and Accurate Treatise on the Exchanges, Monies, Weights and Measures of All Trading Nations and Their Colonies; with an Account of Their Banks, Public Funds, and Paper Currencies*. Vol. 1. (Lackington, 1821), 319.

⁴¹⁰ Hamilton, 1934, 185. See footnote for pound in grams.

⁴¹¹ Hamilton, 1934, 168 states that after 1435 the official value of the Fanega for the kingdom of Castile was around 55.5 litres.

B.3. Netherlands - Amsterdam and Surrounding Regions.

The currency commonly used in Amsterdam and the surrounding region was based on the guilder. The guilder was a larger denomination and was worth 20 stuivers.⁴¹²

$$20 \text{ stuivers} = 1 \text{ guilder.}$$

Posthumus provides the conversion for grams of silver in a guilder from 1575 to the end of the study period.⁴¹³ For the years from 1501 to 1575, the conversions are based on work by David S. Jacks, which covers the Utrecht stuiver for the period from 1501 to 1530. The period from 1531 to 1575 is also available in this file, though it has not been possible to establish the origin of these values.⁴¹⁴ The values are, however, quite in line with those before and after this period. This suggests that they are reasonably accurate, thus they have been included for the conversions in this thesis. In a limited number of cases, specifically Leyden, the grotten, a Flemish currency, was used. Two grotten were worth a stuiver.⁴¹⁵

The herring from St. Bartholomew's Hospital were acquired in barrels, half barrels, and quarters (kintgens).⁴¹⁶ Posthumus does note that it was difficult to be precise about the quantities due to variation in barrel sizes of the time. The sources for the Hospital provide no information on this. For simplicity, the "vat" is the unit of quantity that is applied for herring by Posthumus.⁴¹⁷ Posthumus does express reservations about studying the herring series over time, he states the sources are not as uniform as he would have preferred, by which he appears to be referring to uncertainty to do with the measurement of the vat.⁴¹⁸ Given this, it is difficult to be certain about the necessary weight conversion for herring. It is therefore possible that this uncertainty will influence the CV values. The price per gram of silver that is applied in the Allen-Unger database is a price for a piece of herring. The

⁴¹² Posthumus, Vol 1, liv Table V.

⁴¹³ Ibid, cix Table V.

⁴¹⁴ The Allen-Unger database refers to a file called "Silver content of currencies 1258-1979 annual". After searching online, the information is no longer available. I received a copy of this file directly from Prof Jacks in a personal communication dated 13th Feb 2020. (Also noted in Allen-Unger database is that it is from "V. Magalhaes Godinho) (Prix et Monnaies au Portugal 1750-1850) (Paris: Librairie Armand Colin-1955)", but I have not been able to get access to this).

⁴¹⁵ Posthumus, Vol 2, 20. Table V.

⁴¹⁶ Ibid, 332. See notes on herring in St. Bartholomew's Hospital, Notes in Table 112.

⁴¹⁷ Ibid, 332.

⁴¹⁸ Posthumus, Vol 2, 36.

database includes an assumption that the vat (sometimes called a tonne, which is not the same as a metric tonne) contains 833 herring, and proceeds to calculate the value of one herring, rather than per kilogram of produce.

Thus, for this chapter, a number of calculations were performed to estimate this price per kilogram. The first step is to observe that Posthumus notes a beer-barrel as having a volume of 155.2l.⁴¹⁹ If the herring vat was in the same unit, and with a volume to weight conversion of 1:1 is applied for herring,⁴²⁰ This suggests a weight of 155.2kg, or 150kg with rounding. Alternatively, assuming the barrel contained 833 pieces of herring and a herring is assumed to weigh 0.75kg (based on a recalculation from information provided by Elsas, provided in the next section), this would suggest a barrel weighing 625kg, and this seems too heavy for a unit such as a vat or barrel. Thus a “piece of herring” might have referred to a smaller portion of fish, such as a “fillet”. Working with Bauernfeind’s lower weight for a piece of herring at 0.12kg leads to an estimate that seems too low.⁴²¹ Specifically $833 * 0.12\text{kg} = 99.96\text{kg}$, or approximately 100kg. Thus, the value of 150kg has been chosen as it is the median of the three values. It is also the type of weight that is reasonable when considering how the barrel equated to the last, as the next section shows.

Moving to the herrings sold on the wholesale market at the Amsterdam Exchange, the prices are per last. The last consisted of 12 tons, and this ton, also known as a vat, was most probably a barrel.⁴²² Assuming this is the same size and weight barrel as herrings at St Bartholomew’s Hospital, that is 190kg, this suggests a last weighed $12 * 190 = 2,280\text{kg}$. From another perspective, this last was said to contain 14 zeestuiks (sea-barrels) or 21 verpakte (packed) tuns, equivalent to 1,694 and 1,452 litres, respectively.⁴²³ If a litre of herring is again assumed to weigh 1kg, this suggests the weight of the vat is between 1694kg and 1452kg. These values appear low, the value of approximately 2,000kg for a last has been

⁴¹⁹ Ibid, 34.

⁴²⁰ Poulsen, *Dutch Herring*, 47.

⁴²¹ Walter Bauernfeind, *Materielle Grundstrukturen Im SpätMittelalter Und Der Frühen Neuzeit: Preisentwicklung Und Agrarkonjunktur Am Nürnberger Getreidemarkt Von 1339 Bis 1670* (Neustadt/Aisch, BRD: Schmidt, 1993), 321.

⁴²² Posthumus Vol I, li, Posthumus Vol II, 36.

⁴²³ Posthumus Vol II, 333, refers to the work of “Staring” for this measure. This appears to refer to: “W. C. H. Staring, *De Binnen- en Buitenlandsche Maten, Gewichten en Munten*; editions of 1871, 1885 and 1902”, which can be found mentioned in a footnote on page 31 of Posthumus’ work. I have not been able to find a copy of this reference, but it would be useful to better understand the origin of the quoted figures.

used in the work of Bo Poulsen.⁴²⁴ Perhaps it is the case the conversion from litres to kilograms should be higher than 1:1. On this basis, the value of 2,000kg has been used as an estimate for the vat. Based on this quantity for the last, recalculated prices are around three times that given by the Allen-Unger database.

On closer inspection of the Allen-Unger database, it assumes the last holds 12,000 herring. Returning to the estimate of the weight of a piece of herring. If a herring is assumed to weigh 1.5lb, or 0.75kg, this suggests a last with 12,000 herring weighs around 9,000kg, which is substantially higher than the estimate this thesis applies. If instead a piece weighed 0.12kg this suggests a last weighed closer to $12,000 * 0.12\text{kg} = 1,440\text{ kg}$. This is substantially lower than the estimate in the Allen-Unger database and more in keeping with Dutch herring estimates based on the work of Poulsen, where a last weighed almost 2,000kg.⁴²⁵ Thus the lower estimate for a piece of herring, based on 0.12kg rather than 0.75 is a more reasonable estimate, on the basis of Poulsen's studies.

There are two stockfish series, one from hospital records and the second is referred to as wholesale (discussed under Posthumus in Section 2.1.3). The wholesale stockfish prices are in "100 pounds in Guilders".⁴²⁶ This is based upon references in the sources to stockfish in units of "100 pounds". Posthumus notes there are references to a "heavy pound" in the sources; this is assumed to be an Amsterdam (heavy) pound, which weighed 0.494kg.⁴²⁷ The wholesale values do not appear to be converted correctly to silver in the Allen-Unger spreadsheet, as they are referring to a different series in the Excel formula in their spreadsheet (to a salted cod column). This has been amended for this thesis.

For wheat quantities, the Allen-Unger database applies a volume of 3148.74l per last. This is based on an estimate of 27 muds in a last and a mud with a volume of 116.62l, leading to $3,148.74\text{l} = 116.62\text{l} * 27$. Posthumus notes though in his work that a figure of 27 is a mistake in work from Sillem, and instead Posthumus uses 25.⁴²⁸ He also notes the last was 3,003.56l. Based on the assumption this consisted of 25 mud, this leads to a value of

⁴²⁴ Poulsen, *Dutch Herring*, 141.

⁴²⁵ *Ibid*, 45.

⁴²⁶ Posthumus, Vol. 1.

⁴²⁷ Posthumus, Vol. 2, 31.

⁴²⁸ Posthumus, Vol. 2, 34. Posthumus is referring to the following work: Sillem, Jérôme Alexandre. *Tabellen van Marktprijzen van Granen te Utrecht in de Jaren 1393 tot 1644, uit de rekeningen en weeklijsten der Domprossdij*. No. 4. J. Müller, 1901.

approximately 120l for the mud.⁴²⁹ The estimate of $120 \times 25l = 3,000l$ is therefore applied in this thesis.

For meat, the Allen-Unger database applies 46.9kg as the unit of measure, based on 100 Amsterdam light pounds, each weighing 0.469kg.⁴³⁰ Posthumus artificially re-scaled the prices by 100 to allow their variation to be seen more readily when charted against commodities that display much larger prices per pound.⁴³¹ This type of conversion is not necessary in this thesis, as all price series have been converted to the standards of a kilogram of produce, removing the need for scaling.

The Salted cod price series are for produce sold to St Catherine's Hospital in Leyden and covers years from 1526 to 1794. The prices are per ton, which is again assumed to have been a barrel that weighed 190kg, following a similar argument to that presented for herring. There are two herring price series and the second one is a continuation of the first. The first series is given in prices units of gliders and the latter in grotten. The two are kept as separate series, as it is not clear to what extent the units are comparable. The series are based on different units of measurement, in addition to coming from different locations. This distinction is also made in the Allen-Unger database, with the series represented as two distinct series. The quantities are the same in both series, however, and the 190kg unit of quantity is again assumed.

B.4. Germany - Frankfurt

In Frankfurt, the pfennig was the unit of currency during the study period.⁴³² Elsas' work provides the information required to convert prices to grams of silver per kilogram of produce. The Allen-Unger database includes a conversion of 240 pfennig to a gulden as a part of this calculation, which can be found in Elsas' work.⁴³³

$$1 \text{ gulden} = 240 \text{ pfennig}$$

⁴²⁹ Ibid, 34.

⁴³⁰ Ibid, 31.

⁴³¹ Ibid, 319.

⁴³² M.J. Elsas. *Umriss einer Geschichte der Preise und Löhne in Deutschland* (Leiden, 1940). Vol 2, Part 1, 9.

⁴³³ Ibid, 5.

First, there is a conversion from gulden to grams of silver, this is then followed by dividing by 240 provides the conversion from pfennig to grams of silver.

Regarding the quantities of produce, the Allen-Unger database conversions do not appear to be fully correct, thus calculations are reworked below.⁴³⁴ For example herring, appears to be overpriced by around a multiple of ten. Thus, the prices were recalculated, bringing them more into line with the prices in the surrounding regions.⁴³⁵ It became apparent when reconstructing certain calculations, that not all citations of sources in the database were clear and accurate. For example, for herring in Frankfurt, the unit of “1 Tonne” was the unit of quantity for some products.⁴³⁶ This is assumed to be 1 metric tonne, and on a closer inspection of the source material from Elsas, this could not be the case. Firstly, Elsas notes that for herring, $1 \text{ Last} = 12 \text{ Tonnes}$.⁴³⁷

$$1 \text{ Last} = 12 \text{ Tonnes}$$

A conversion for either the last or the tonne to modern units is not mentioned explicitly in the source for Frankfurt examined by Elsas'. But based on the sources discussed thus far, in many cases the last weighs around 2,000kg approx.⁴³⁸

$$1 \text{ Last} = 2,000\text{kg}$$

As was mentioned earlier, in the case in the Netherlands, the tonne was most likely a type of barrel. With a last of 12 barrels, this would imply the Tonne of herring to be around 166kg. For another comparison, Elsas provides examples from the sources, such as 1 piece of herring costing 4.5 pfennig and a pound of herring costing 3 pfennig.⁴³⁹ This would imply a herring weighted in the region of 1.5 pounds, or approximately 0.75kg

$$1 \text{ herring} = 0.75\text{kg}$$

⁴³⁴ Information for Frankfurt was available in a different format from the Allen-Unger database than most other locations included in this chapter. It was downloaded from a dataset online available at <http://www.gcpdb.info/>). This database was queried by applying a limit on locations to Frankfurt and selecting “all” for other query options.

⁴³⁵ This issue arose as I could not understand why the Allen-Unger values were so much higher than the surrounding locations.

⁴³⁶ Elsas, Vol 2, Part 1. (1940) 297-8, 566-8.

⁴³⁷ Ibid, 24.

⁴³⁸ Poulsen, *Dutch Herring*, 45.

⁴³⁹ Elsas Vol 2. Part 1, 142.

If there were 1,000 herring for a tonne, this gives a weight of around 750kg. This is too high as the last would then have been 8,400kg. Thus, for Frankfurt an estimate of 170kg is applied in this chapter for a tonne or barrel, based on a rounding of the figure of 166kg for a barrel, mentioned in the previous paragraph.

$$1 \text{ Frankfurt Tonne} = 170\text{kg}.$$

In further support of the 170kg weight, Elsas' noted another measure, the "Ohm", stating the following:⁴⁴⁰

$$1 \text{ Ohm} = 143,415 \text{ Liter (Chelius)}$$

Elsas later states that for vinegar some sources note that 1 Ohm holds 1 Tonne.⁴⁴¹

$$1 \text{ Ohm} = 1 \text{ Tonne}$$

If this tonne, or barrel, is the same volume as that for the herring in Frankfurt, then the weight of 1 tonne of herring equates to $1.22 * 143.415\text{litre} = 174\text{kg}$, assuming the 1.22 conversion density for herring volume to weight that was also applied earlier. This is very similar to the already mentioned estimate that a tonne of herring weighed about 170kg. With 12 barrels in a last, this supports the contention that a last weighed around 2,000kg. It is also close to the value of 190kg that was used for the barrel in Amsterdam, and it is possible the barrels in Frankfurt may have had the same or a similar measurement. Without further information, the estimate of 170kg is used in this case.

B.5. Germany - Munich

For Munich, the work of Elsas is again called upon. In this instance, the first volume of his work is the basis.⁴⁴² The herring tonne here was perhaps similar to that of Frankfurt. Also, the Gdańsk Tonne is described as being either of the following alternatives.⁴⁴³

$$\text{Die Tonne Heringe} = 1,200 \text{ Stuck Or A Tonne of Herring} = 1,200 \text{ Pieces}$$

Or

⁴⁴⁰ Ibid, 19.

⁴⁴¹ Ibid, 20.

⁴⁴² M.J. Elsas. *Umriss einer Geschichte der Preise und Löhne in Deutschland* (Leiden, 1936).

⁴⁴³ Ibid. 1, 147.

Die Tonne Heringe = 1,040 Stuck Or A Tonne of Herring = 1040 Pieces

If a herring weighed around 0.12kg, this would imply the Tonne was around 144kg or 124.8kg. These are lower than the estimates used for a tonne in Frankfurt of around 170kg. It is possible this value for a barrel is somewhat high for Munich, but both Frankfurt and Munich may have used similar barrels, thus a common estimate for both has been applied for this chapter. Information from Gdańsk (shown later), supports the use of this common value.

In the case of the currency, conversions are based first on grams of gold, in this case per pfennig (equivalent to a denar). These are next converted to an equivalent in grams of silver, based on values included in the work of Pribram, who is discussed later in this section for prices in Vienna.⁴⁴⁴

B.6. Germany - Nuremberg

Bauernfeind's work was previously discussed in (Section 2.1.3).⁴⁴⁵ In his work, all price tables were converted to grams of gold per unit of quantity. The prices are available for the period from around 1500 to around 1650. To further convert these prices to grams of silver, an exchange rate from gold prices to silver 12: 1 has been applied, reflecting the rate that broadly prevailed during the research period.⁴⁴⁶

Three commodities are included here. The quantities, rye (roggen), salt (salz), butter (butter) and herring (heringe) are measured in Summer Roggen (Su), Metzen (Me), Centner (Cen) and ton units, respectively. The following conversion applies,⁴⁴⁷

1 Summer Roggen = 16 Metzen.

Also

1 Summer Roggen = 16 Metzen = 318 Liter = 218 or 220 kg

⁴⁴⁴ Elsas, Vol. 1, 117 for the conversions from Pfennig/Denars to grams of gold; 89 notes that the Pfennig is same as a Denar, just named differently.

⁴⁴⁵ Bauernfeind, (1993).

⁴⁴⁶ Pribram, (1938), 84. This ratio prevailed for the earlier half of the study period. This is also the period the price information is available for. Thus, this ratio has been chosen. A more refined conversion could be applied, such as that undertaken for Munich, above, but was not applied because this does not cause a large change in the price trends.

⁴⁴⁷ Bauernfeind, (1993), 511.

This indicates a density for conversion from litres to roggen of $220/318 = 0.69$. This is very similar to the conversion rate of 0.67 noted earlier for Southern England.

For salt, Bauernfeind states the following conversion from metzen to litres,⁴⁴⁸

$$1 \text{ bayerischer Metzen} = 37.0596 \text{ Liter.}$$

As for the density conversion, $1 \text{ l salt} = 2.16 \text{ kg salt}$ is suggested.⁴⁴⁹ This leads to a value of 80.04kg. Or with slight rounding, the Bayerischer Metzen thus approximates to 80kg.

$$1 \text{ bayerischer Metzen} = 80 \text{ Kg.}$$

Similarly, studying butter for completeness:⁴⁵⁰

$$\text{Centner} = 100 \text{ Numberger Pfund and } 1 \text{ Numberger Pfund} = 509 \text{ g.}$$

Therefore, a butter centner weighed around 50.9kg.

$$1 \text{ Butter Centner} = 50.9 \text{ kg.}$$

For herring, Bauernfeind suggests a “ton” contains 1,000 pieces of herring of 0.12kg,⁴⁵¹ which will give a weight of around 120kg per “ton”. As discussed earlier, first for Southern England, this value of 0.12kg is much lower than the 0.75kg estimate that was seen in some instances. A degree of confusion in the literature concerning what a piece of herring represented must be the reason for this. Perhaps references to a full herring and to a portion of the herring such as a fillet are being confused. Thus, Baunerfiend’s estimate of 0.12kg of a piece of herring appears more reasonable. These “ton” barrels would have therefore weighed approximately 120kg, based on 1,000 herring units at 0.12kg. This though is lower than the earlier discussed estimates for both Germany and Amsterdam of around 170/190kg for tonnes.

⁴⁴⁸ Bauernfeind, (1993), 511.

⁴⁴⁹ <https://www.aqua-calc.com/page/density-table/substance/salt>.

⁴⁵⁰ Bauernfeind, (1993), 514.

⁴⁵¹ Bauernfeind, (1993), 321.

B.7. Poland - Gdańsk

Relevant conversions come from the works of Pelc and Furtak.⁴⁵² Prices in the original currency have not been included by Pelc and Furtak, they have already been converted to grams of silver. The units of quantity do need to be converted to a kilogram of produce, however. A tonne of herring is indicated as being 1040 pieces, a value familiar from Frankfurt and Munich.⁴⁵³ Pelc notes that herring was nearly always sold by the barrel, locally known as the “Bezeka”.⁴⁵⁴ The Allen-Unger database assumes 1 Bezeka is 1 tonne and contains 1,000 fish.⁴⁵⁵ As 1 Last = 12 tonnes of herring,⁴⁵⁶ the value of 0.12kg for the weight of a piece of herring is applied, thus estimating a barrel weight of 120kg. Further, if a last consists of 12 barrels, this implies a last weighs around 1,440kg. This weight is somewhat low compared to the value of 2,000kg was applied for Amsterdam. The value of 120kg per barrel is applied though, as the measurements tend to be per barrel.

B.8. Hauser and Baulant - Paris

Unfortunately, Hauser and Baulant’s price collections do not contain fish prices for Paris. The prices that they do provide are, however, used as an alternative to (and an independent check of) Allaire’s internal NorFish reports. Prices for bread, butter and eggs are found in the work of Hauser, while the wheat prices come from Baulant. Hauser’s work presents prices in both the local currency of livre tournois (or “livre en sois tournois”), and a silver equivalent. The silver equivalent has been directly used in this thesis, rather than completing new conversions. In part, this is due to the absence of a silver conversion table accompanying Hauser and Baulant’s work. Their units of measurement, though, are not standardised. In the case of the wheat in Baulant, the unit is the setier, which was equivalent to 156litres.⁴⁵⁷

$$1 \text{ setier wheat} = 156l \text{ wheat.}$$

⁴⁵² Pelc, (1937); Furtak, (1935).

⁴⁵³ Furtak, 43.

⁴⁵⁴ Pelc, 42*.

⁴⁵⁵ “The IISH List of Datafiles of Historical Prices and Wages - Europe”, The International Institute of Social History. Accessed August 8, 2020. <http://www.iisg.nl/hpw/data.php#europe>. Gdańsk Spreadsheet. Note (f) in the “Conversions, Sources & Comments” tab.

⁴⁵⁶ Furtak, 38.

⁴⁵⁷ Bertholon M.M. Monge Cassini. *Méthodique, Encyclopédie: Dictionnaire de Physique*. Paris: Imprimeur-Libraire, rue des Poitevins, no. 6 (1822), 578.

For bread and butter, the units were French livre, and were equivalent to 0.489g during the study period.⁴⁵⁸ This value is also used in the Allen-Unger database. Egg prices are by the piece and a weight of 50g per piece has been applied.⁴⁵⁹

B.9. Austria - Vienna

Both conversions to grams of silver and gold from the local currency of “kreuzer” can be found in Pribram’s 1938 work.⁴⁶⁰ Pribram provides the grams of silver per pfennig, stating that it is equivalent to 1/240 of a pfund. He also states that 1 Kreuzer = 4 Pfennig. Thus, the silver equivalent for the kreuzer is found by multiplying the pfennig silver equivalent by four. This conversion is applied in this thesis to prices from 1354 to 1524. From 1525 to 1891, the prices in Pribram's collection were already in kreuzer and did not require a conversion from pfennig to kreuzer.⁴⁶¹ For this thesis, a step is included to convert the kreuzer values to a gram of silver equivalence.

The herring is measured in a Tonne; this is a price series representing Wien Bürgerspital. The Allen-Unger database converts this based on a “zentar”. The herring Tonne is equivalent to 2.5 zentar.⁴⁶²

$$1 \text{ herring Tonne} = 2.5 \text{ Zentar}$$

The Zentar is 100 pounds, with a pound in this instance weighing 0.56kg.⁴⁶³ Thus the herring Tonne is 250 pounds, and weighs 140kg.

$$250 * 0.56kg = 140kg.$$

In the Allen-Unger database, this figure is divided by 1,000 to find the price of a (piece of) herring, thus the assumption is that there are 1,000 herring in a zentar. This also suggests that one piece of herring weighs 0.14kg, close to the 0.12kg weight for a piece of herring

⁴⁵⁸ Henri Hauser. Recherches et Documents sur l'histoire des prix en France depuis 1500 à 1800. *Parigi, Les Presses modernes* (1936), 31.

⁴⁵⁹ “Chicken eggs 5 Sizes Conversion Plus Nutrients Values” <http://convert-to.com/720/chicken-eggs-5-sizes-conversion-plus-nutrients-values.html>. Accessed November 29, 2020. Also, the 50g value is applied in the Allen-Unger database.

⁴⁶⁰ Pribram, (1938), 71-84.

⁴⁶¹ Allen-Unger also includes conversion from 1892 to 1913, however a reference is not included. This is not analysed in this thesis, so it is not a concern.

⁴⁶² Pribram, (1938), 127-8

⁴⁶³ Pribram, (1938), 126.

that has been observed in a number of sections throughout this chapter, hence implying that these conversions are reasonably aligned to one another.

There is another price series for herring that is included in Pribram's work, and the Allen-Unger database. It relates to a different location, Stift Klosterneuburg, which was located 10km outside Vienna. This price series consists of two components (one chronologically following the other) that are based on different quantity measurements. It was excluded from this analysis further research should be taken to either separate it into two series or justify why it is reasonable to combine them as one.

B.10. Belgium - Antwerp

Van Der Wees' 1963 price collection contains a large selection of products. Herring is the single commodity from this work included in this thesis.⁴⁶⁴ Though a more extensive study of this work could include further commodities to expand analysis of the location.

Two sets of conversions have been studied for this chapter, covering the groat and the guilder currencies. Grams of silver per Brabant groat, provided by Van der Wee, covers the period from 1366 to 1644.⁴⁶⁵ The analysis in Van Der Wees' work is limited to the 14th to 16th centuries. As for the units of quantity, a barrel of herring is stated as containing 833 herring.⁴⁶⁶ Allen-Unger calculates a silver price per herring by dividing this amount by 1,000. Calculations for this thesis have applied the value of 833, following similar steps as in previous sections. Further, a weight per herring of 0.12kg has been applied, thus the unit of quantity weighs 100kg.

B.11. Spain - Barcelona

This is completely based on Feliu's already introduced price collections. Prices are included for bacalao, herring and mutton. For the unit of measurement, bacalao was sold by the arroba.⁴⁶⁷ The arroba is a Spanish and Portuguese unit of weight; in Spain it was equivalent to 26 libras or pounds.

⁴⁶⁴ Herman Van der Wee. *The Growth of the Antwerp Market and the European Economy: Fourteenth-Sixteenth Centuries. Interpretation* (Nijhoff, 1963).

⁴⁶⁵ *Ibid*, Vol 1, 126-9.

⁴⁶⁶ *Ibid*, 277.

⁴⁶⁷ Gaspar Feliu. "Precios Y Salarios En La Cataluña Moderna" (1991).

$$1 \text{ Arroba} = 26 \text{ Libras}$$

This pound was of 12 ounces, which Feliu states was approximately 400g.⁴⁶⁸ Thus an arroba weight approximately 10.4kg based on 26×0.4 . Herring prices are calculated by the dozen.

$$1 \text{ Arroba} = 10.4 \text{ kg}$$

Applying the conversion of a herring weighing 0.12kg leads to a weight of 1.44kg per dozen, which is applied to calculate the price per kilogram. The higher value of 0.75kg per herring (as previously discussed) was tested, but the resulting prices appear to be unrealistically high. Meat was sold by a value that equates to 3 libras, thus the unit is 1.2kg.

Herring, bacalao and “meat” were all sold in a local currency unit of sueldos. Feliu provides the grams of silver equivalence for the sueldo over time. From this the prices to the grams of silver equivalence are computed for this thesis.⁴⁶⁹

B.12. Sweden - Stockholm and West Sweden

The Swedish price information is based on work from Jansson and Palm.⁴⁷⁰ This source required more conversions, including digitising price information, that many of the already mentioned sources in this chapter. In addition, the prices for Sweden come with the extra difficulty that coinage and currency are complicated at this time. A number of steps were required to convert prices to grams of silver. Firstly, the prices are measured in “Daler Kopparmynt” (Dkm), which was a copper-based coin, rather than silver. The first conversion step was to convert these values from a conversion from the Dkm to the “Daler Silvermynt” (Dsm), which was silver based. Finally, another set of conversions was applied to convert these coins to the grams of silver they contained. For these conversions of the coins, “Exchange rates, prices, and wages, 1277-2008” was studied.⁴⁷¹ The conversions from the Dkm to the Dsm are as follows (Table 8.1 **Error! Reference source not found.**):⁴⁷²

⁴⁶⁸ Ibid,18.

⁴⁶⁹ Gaspar Feliu. “Precios Y Salarios En La Cataluña Moderna” (1991), 19-21.

⁴⁷⁰ Arne Jansson and Johan Soderberg. “Priser och löner i Stockholm 1600-1719,” in *Dagligt Bröd I Onda Tider: Priser Och Löner I Stockholm Och Västsverige 1500-1770*, ed. Arne Jansson, Lennart Palm, and Johan Söderberg (Inst. för Lokalhistorisk Forskning, 1991).

⁴⁷¹ R. Edvinsson, T. Jacobson. and D. Waldenström. Exchange rates, prices, and wages, 1277-2008. (Ekerlids förlag), 2010, 50. Describes the Daler klippingmynt and Daler silvermynt.

⁴⁷² Edvinsson, 45-7 (Table 2.3) for Dkm to Dsm conversions.

Table B.1. Swedish currency conversions. Between daler kopparmynt (Dkm) and daler silvermynt (Dsm).

Time Period	Conversion
1633 to 1643	2 Dkm = 1 Dsm
1644 to 1665	2.5 Dkm = 1 Dsm
1666 to 1776	3 Dkm = 1 Dsm

The conversion rates for the Dkm to Dsm are the “official rates” and were specified by authorities. In some instances, information on “market rates” is also available, but to a limited extent. Thus, the official rates were chosen to provide a more consistent and detailed set of conversions.⁴⁷³ In support of the usage of the official rates, when information was available for both market and official rates, they were similar. With a conversion from the copper coin to a silver coin in place, the next step is to estimate the number of grams of silver in the Dsm per period. This was based on the values in Table B.2 **Error! Reference source not found.**⁴⁷⁴

Table B.2. Conversions for Sweden. From daler silvermynt (Dsm) to grams of silver.

Time Period	Conversion (grams silver per Dsm)
1534-36	28.0593
1537-41	27.6245
1542-1638	25.5957
1639-75	25.2739
1676-1830	25.6973
1831-73	25.5045

Combining these two sets of conversion leads to a gram of silver equivalent for the Dkm, which has been applied for this thesis for each year.

⁴⁷³ Edvinsson, 32.

⁴⁷⁴ Edvinsson, 50. (Discussed in the text describing the “Daler”).

B.13. France - Paris

The internal Norfish reports that cover prices in Paris and Bordeaux from Allaire are initially reported in local units of quantity and price. The prices have been converted to Denier. For this thesis, they have been converted to a silver equivalence based on annual conversions from Philip T. Hoffman.⁴⁷⁵ The quantities are complicated, and assumptions have been made regarding the most suitable units to apply, following discussion with Allaire. Thus, based on an estimate of 20kg for a full cod and then applying a ratio of full to gutted that is set at 1:2.6, the fresh cod is estimated as weighing 7.69kg. A chicken is estimated to be 1.2kg.⁴⁷⁶ 100 herring pieces weigh 12kg, based again on 0.12kg weight for a piece of herring that was applied earlier. 0.05kg for an egg, thus 5kg for 100 eggs. 12 ounces of bread is estimated at 0.34kg based on modern units.

⁴⁷⁵ Global Price and Income History Group url: <https://gpih.ucdavis.edu/index.html>. Specific file can be found at url: https://gpih.ucdavis.edu/files/Paris_1380-1870.xls. Accessed 14 August 2020.

In this spreadsheet, currency values are available in the "Currency" tab. The conversion values are referred to as "Value of livre (1450-1796) and of franc (1797-1870)".

⁴⁷⁶ Based on person communication from Allaire from 23rd June 2019, for the cod and chicken conversions.

C. Appendix. Price Series Sources in further detail

This Appendix provides further information on how to find the price information from the source literature. It is particularly useful for Chapter 2 and Chapter 3, as it allows a quicker search for precisely where to locate the price information in each collection of literature. It is not entirely exhaustive, but the aim is to help a reader understand and locate the price series information.

C.1. Rogers and Beveridge for London

This information comes mostly from Rogers and from Beveridge.⁴⁷⁷ Rogers' main work is "A history of agriculture and prices in England", and comprises seven volumes, each representing a different time period, beginning at 1259 and ending in 1793. To cover the research period for this thesis, volumes III to VII are studied in particular. (I & II cover 1259 to 1400, III & IV cover 1401 to 1582, V & VI cover 1582 to 1702, and VII cover 1703 to 1793). The volumes correspond precisely to their respective periods, though slightly different methodologies have been applied in each. Thus, series are limited to these respective periods in many cases. This leaves it open that the research methodologies may not have been precisely the same for each period. For each period, there exists a volume that includes a chapter dedicated to discussing the fish commodities.⁴⁷⁸ As the volume progresses, unfortunately fish price series become less complete, and less common entirely.

Beef: Beef prices are from 1583 to 1702. This can be found in Rogers's work Vol V, this is also the precise period that Vol V covers. Prices are under prices for Stock and Meat, with the price table from p.347-53 and they are for King's College. (Vol VI covers the same period and includes more information on the sources).

Herring: The prices for the most are from Rogers, but unfortunately do not cover the study period⁴⁷⁹. The first part of the price series can be found in Vol I, Table 1, p.635-640 covering 1259 to 1400, but this is before the study period of the thesis. Herring are described, (i.e.,

⁴⁷⁷ William Henry Beveridge. *Prices and Wages in England from the Twelfth to the Nineteenth Century* (London: Frank Cass, 1966).

⁴⁷⁸ For example, Rogers, Chapter XXIV Vol 1 page 606, there is a chapter called "On the Price of Fish".

⁴⁷⁹ Rogers. *A History of Agriculture and Prices in England*, 7 vols. (Oxford, 1866-1892).

discussed, not the table) from p.608-10 of Vol I. The prices are coming from different locations; Winchester, Rochester, Braborne, Sandwich, Harewood, Stillington, Stockton, Stokes and so forth. Vol II then goes a step back and gives more information on the sources for each year, fish can be found from p.552-557. There is no more information on “Herring”.

There are also prices for “White Herring”, beginning in 1403 and ending in 1702. For its inclusion in the Allen-Unger database, it has been correctly pointed out that this “White Herring” cannot be assumed to be the same as the earlier herring product, thus it has been categorised as another product. The prices come from Rogers vol III and IV for 1401 to 1582 and vol V and VI for 1583 to 1702. The following provides more detail.

Vol III covers the period from 1401 to 1582 and also has a chapter called “Prices of fish” (p.310-344). The white herring prices cover the period from 1403 to 1582. Vol IV also covers the same with a “Price of Fish” chapter from p.526-45, this contains a more complete table (Table 1 from p.540-4) for all the fish prices together, including herring, cod, stockfish, salted fish. This data is also the source for Allen-Unger. Vol V covers 1583 to 1702 and has another Price of Fish Chapter (Chapter XV Price of Fish p.417-429), with fish prices shown from p.427-9. The herring prices are less prominent in this volume and can be found on p.429. Vol VI covers the same period and has a more detailed chapter on the sources called “Prices of Fish” from p.392-408, this is a step back to the sources again.

Vol VII comprises two parts and covers 1703 to 1793. Part 1 focused on the sources and the fish prices are found in the chapter “Prices of Fish” from p.343-4, there is not much information available in this volume on fish. The second part 2 is the tabulated information and this corresponds also to what used in the Allen-Unger commodity database. It does not contain herring, this series ended in 1702, with the previous volume.

Stockfish: Prices can be found in Rogers Vol IV, Table 1 on p.540-4. The volume covers 1401 to 1582, with the stockfish prices covering 1405 to 1572.

Salted Cod: Salted cod covers 1659 to 1760 and can be found in Beveridge’s work, p.420. A description of the different cod products (salt, crimped and fresh) can be found on p.369.

Wheat: This is based on Rogers' work from 1259 to 1702 from the work of Mitchell, B.R. and P. Deane from 1703 to 1914.⁴⁸⁰ Rogers Vol 1. Table 1 p.226-34 covering 1259 to 1400.

Vol III Table 1 p.282-90 covering 1401 to 1582. Vol IV chapter 8 Price of Grain p.219-93 from 1401 to 1582.

Vol V Table 1 p.268-274 covering 1583 to 1702. Chapter VII Prices of Grain p.170-288.

Mitchell and Deane. Price Table 9. p.486-7 covering 1703 to 1817 and prices are from Winchester College. (To expand this analysis beyond the study period, prices from 1818 to 1914 can be found on p.488-9 and represent what is referred to as an average price for wheat for the United Kingdom.

Bread: Prices are from 1545 to 1914, with no missing years and can be found on p.497-8 of Mitchell and Deane's collection. They are described as an average price of bread in London.

C.2. Hamilton - Spain

The prices come from two volumes of work from Hamilton. The first covers 1500 to 1650 and the second covers 1651 to 1800.

American treasure and the price revolution in Spain, 1501 to 1650:⁴⁸¹ The prices can be found in three appendices, one for each 50-year period. They are on p.319-334, p.335-357 and p.358-389. For Andalusia, New Castile and Old Castile-Leon, the prices are in the currency of Maravedis. For Valencia, the currency is Dinars.

Dried Fish are for "New Castile and the currency is measured in maravedis. They cover a period from 1551 to 1650, with prices from 1551-1600 on p.340-7 and p.370-5 for 1601-1650. I suspect this is not cod, as there is a small amount of what is specifically called "dried codfish" in the prices Hamilton collected. As it is ambiguous and I have no reason to believe the dried fish is cod, I will have to either exclude it or do something else with it.

War and prices in Spain: 1651-1800:⁴⁸²

⁴⁸⁰ Mitchell, B.R. and P. Deane (1971). *Abstract of British Historical Statistics* (Cambridge, 1971).

⁴⁸¹ Earl Hamilton. *American treasure and the price revolution in Spain, 1501-1650*. Vol. 1125 (1934).

⁴⁸² Earl Hamilton. *War and prices in Spain: 1651-1800*. Vol. 81 (Cambridge, Harvard University, 1947).

Prices can be found in appendix 1, which covers New Castille, from p.229-57. Prices for New Castille are shown only, broken into three periods, from p.234-41, p.242-9, p,250-7. The currency is again in maravedis.

There is an item number associated with each and they are as follows: Beef, Item 5. Dried Fish, Item 34. Mutton, Item 53. Wheat, Item 91.

The Price Series Combined:

For both volumes of Hamilton's work, all the following commodities were prices from New Castille specifically. Unfortunately, there is no herring information and very little that can be said for definite about cod. It is possible that "dried fish" refers to cod, but this is not certain. It has been included below regardless.

The first dried fish series covers a period from 1551 to 1650. The other dried fish series covers 1651 to 1700. Thus, the difference being on series is from each volume. They were measured in pounds (.46kg) for the first series and 25 pounds for the 2nd series (11.5kg).

Beef prices range from 1501 to 1798 and are per pound. Allen-Unger have combined them as one series.

Wheat prices are from 1501 to 1799 and is also combined as one series.

Eggs prices range from 1551 to 1800, so come both volumes.

C.3. Posthumus - Amsterdam

Posthumus, vol 1 (Leiden, 1964)⁴⁸³: (Wholesale prices from The Amsterdam Exchange).

Herring Full: p.85-8. Table 44, covering from 1624 to 1866.

Matie: p.88-90. Table 45, covering 1624-1810. "Matie" is another type of herring that can be referred to as "Soused herring", which is a type of pickled herring. It has not been included in the thesis.

Stockfish: p.90-3. Table 46. From 1643 to 1864.

⁴⁸³ Posthumus. Inquiry into the history of prices in Holland, vol.1 (Leiden, 1964): Wholesale prices.

Posthumus, N.W., vol.2 (Leiden, 1964)⁴⁸⁴: (Retail Prices from hospitals, municipal records, and religious institutions).

Herring and Stockfish: pp. 272-83. (Tables 112 and 113). Series notes on p.332-4 and p.334-6. These are for St. Bartholomew's Hospital.

Salted Cod: pp. 498-501. Table 214. From St Catherine's Hospital in Leyden. Allen-Unger have divided this series into two parts, one is in Guilder, and the latter information in Grotten. Notes on this can be found on p.545-6.

Meat: These are undistinguished meat types in some cases: pp.243-55. Table 101. Explanation notes on p.318-9.

Wheat: pp. 243-55. Table 91. Explanation notes on p.311-3. Prices from 1867 onwards are for Groningen, before they are for Utrecht and from St Bartholomew's Hospital. For Groningen, the prices up to 1530 are not in Dutch guilders but in Utrecht stuivers. (up to 1821, more is available later, but not used Allen-Unger). I am only interested in up to 1800, so prices are from Utrecht for my study period.

In some cases (herring, stockfish, and wheat) the stuivers was used, and the Allen-Unger collection has converted them to Guilder by applying the following conversion.

$$20 \text{ Stuivers} = 1 \text{ Guilder.}$$

C.4. Elsas - Frankfurt and Munich

C.4.1. Frankfurt

Elsas, M.J 1940 and 1949 work on prices, vol 2 part 1 & 2.⁴⁸⁵

All the following price information is found in Part 1.

Overview of each series: Wheat (weizen) p.93-5, rye (roggen) p.95-9, barley (gerste) p.100-3, beef (rindfleisch) p.128-130, veal (kalbfleisch) p.130-1, mutton p.131-2 (hammelfleisch), ham (schinken) p.133-4, herring (hering) p.142-3.

⁴⁸⁴ Posthumus. *Inquiry into the history of prices in Holland*, vol.2 (Leiden, 1964):

⁴⁸⁵ M.J. Elsas. *Umriss einer Geschichte der Preise und Löhne in Deutschland* (Leiden, 1940). Vol 2, Part 1; MJ Elsas. *Umriss einer Geschichte der Preise und Löhne in Deutschland* (Leiden, 1949). Vol 2, Part 2.

Tables of data: Wheat (weizen) p.461-9, rye (roggen) p.461-9, barley (gerste) p.464-9, beef (rindfleisch) p.477-480, veal (kalbfleisch) p.477-480, mutton p.475-480 (hammelfleisch), ham (schinken) p.475-80, herring (hering) p.475-479.

The Locations:

Wheat: Three locations, the first is not really important to my study period, 1373-1501 Frankfurt a.M. Rechenmeisterbücher. 1502-1732 Holy Spirit Hospital. 1733-1820 grain taxes.

Rye: 1347-1501 Frankfurt a.M.-Rechenmeisterbücher. 1502-1799 Holy Spirit Hospital. 1800-1820 grain taxes.

Barley: a) Raw barley 1476-1797 Frankfurt a.M.-Holy Spirit Hospital. 1800-1820 grain taxes.

Barley: b) Hulled barley, 1543-1800 Frankfurt a.M.-Holy Spirit Hospital.

Beef: Meat a) 1509-1678 Frankfurt a.M.-Heilig-Geist-Hospital. 1679-1820 taxes.

Veal: Meat b) 1598-1680 Frankfurt a.M.-Heilig-Geist-Hospital. 1532-1558 and 1684-1820 taxes.

Mutton: Meat c) 1509-1662 Frankfurt a.M.-Heilig-Geist-Hospital. 1663-1820 taxes.

Herring: 1475-1733 Frankfurt a.M.-Heilig-Geist-Hospital.

C.4.2. Munich

Elsas, M.J 1940 and 1949 work on prices, vol 1.⁴⁸⁶

There are multiple series that Allen-Unger have collected, but I focus on what is below, from the work of Elsas.

Rye (Roggen) prices are explained from p.211-3. The table can be found from p.539 to 545 for chamber accounts (Kammerrechnungen) in Munich with prices ranging from 1404 to 1773.

⁴⁸⁶ M.J. Elsas. *Umriss einer Geschichte der Preise und Löhne in Deutschland*. Vol 1 (Leiden, 1940).

Wheat (weizen) prices range from 1507 to 1805 and can be found p.560-5. Further descriptive information can be found from p.269-70. They are also from the Holy Ghost Hospital in Munich. Allen-Unger suggests a 2nd source for more information, but I have not had the opportunity to explore it, so it has not been included in the analysis).⁴⁸⁷

Beef (Rindfleisch) prices range from 1492 to 1820. Information can be found on p.352 and the prices are tabulated from p.590-2 and for various (Verschiedene) sources.

Herring prices range from 1524 to 1627 and can be found on p.566-8 for the Holy Ghost Hospital in Munich. They are explained in more detail from p.297-8.

Stockfish prices range from 1530 to 1637 and can be found from p.566. They are further explained from p.300-1 and also come from the Holy Ghost Hospital in Munich.

Other wheat: These are unused in the thesis. There are three series in Allen-Unger's collection of price information. One has been studied in this thesis. Another corresponds to "Schrannenzettel" in Munich and ranges over 1689 to 1820.

C.5. Pelc and Furtak - Gdańsk

Pelc's Sources: For Pelc, source discussion starts on p9* (the "*" is for the first set of pages in the book, before the tables of information. Below is a list of the main sources, there is a more exhaustive list in the publication. Most are from the State Archives in Gdansk and a smaller amount from the City Library.

From the State Archives in Gdansk: I. City hospital Food office bills, ranging from 1563 to 1700. II. Bills, church and hospital of St Barbara from 1613 to 1699. III. Hospital bills Spirit and St Elizabeth from 1537 to 1689. IV. Hospital bills Jalkmba - Rechmmgen des St. Jctkob-Hospitals from 1527 to 1700.VII. Receipts of the municipal fiscal office V. Accounts of the Hospital of All Saints 1493 to 1603. VI. Treasury books from 1530 to 1700.

The sources for Cený's work are similar, with some of the larger hospitals being the same sources for both, and a list can be found listed in the volume.

⁴⁸⁷ Alfred Jacobs and Hans Richter. *Die Grosshandelspreise in Deutschland von 1792 bis 1934* (Hanseatische Verlagsanstalt Hamburg, 1935).

The page numbers in Pelc for the prices refer to specific page numbers for the section on the tables of price information (add table name here). An index of the series locations can be found beginning at p.175. As for the names of the documents used for the prices, they fall under a section towards the end called "Materialy Zrodlowe" starting on p.145 of the table section.

Pelc and Furtak Source pages:

Beef (Wol): Series 01: 1607 to 1700 (Pelc p.59-60 Table 21, Furtak p.139-140 Table 27).

Beef (Mieso wolowe): Series 02: 1648-1700 and 1701 to 1815 (Pelc p.67 Table 28, Furtak p.146-7 Table 35).

Veal (name): 1546 to 1700 and 1701 to 1785 (Ciele) (Pelc p.60-61 Table 22, Furtak p.142-3 Table 31).

Mutton (name): series 01: 1573 to 1700 (Baran) (Pelc p.61-2 Table 23, not in Furtak).

Mutton (name): series 02: 1701 to 1813 (Skop) (Not in Pelc. Furtak p.141 Table 29).

Pork (name): 1567-1700 and 1702 to 1813 (Wiepi/Wieprz) (Pelc p.62-63 Table 24, Furtak p.143-4 Table 32).

Herring (name): 1504-1700 and 1706 to 1792 (Sledz) (Pelc p.64-5 Table 26, Furtak p.152 Table 42).

Cow: 1700 to 1791 (Not from Pelc, Furtak p.140 Table 28).

C.6. Hauser and Baulant - Paris

The sources are in the following footnote:⁴⁸⁸

Hauser (1936). (Table below is on pp. 135-138, 147-151). This is for the Paris region.

The prices have already been converted to grams of silver equivalence.

⁴⁸⁸ Henri Hauser. *Recherches et Documents sur l'histoire des prix en France depuis 1500 à 1800* (Parigi, Les Presses modernes, 1936), 135-138, 147-151; Ernest Labrousse. "Le prix du froment en France" (Paris, 1970); Ernest Labrousse. *Esquisse de mouvement des prix* (Paris, 1933); M. Baulant. "Les prix des grains à Paris de 1431-1788," (Annales: E. S. E., 23,1968): 520-540.

Bread (Pain): Prices are shown on p.135, covering 1738 to 1791.

Butter (Beurre): prices are on p.136-8 covering from 1503 to 1791.

Eggs (Oeufs): can be found on p.140-1. They cover a period from 1505 to 1685.

Wheat: Baulant (1968). Baulant is the source for the third Wheat price series that Allen-Unger uses. It covers a period from 1431 to 1788 with prices in the first annex, from p.537-40. The prices are for what is called best quality wheat and for the Halles de Paris.

As for the two series from Labrousse's work, I have not got access to thesis publications at the time of submitting the thesis, so I have not included them. Based on Allen-Unger, they cover a period of 1726 to 1913 as some sort of National Average. The other series only starts from 1806, so this is beyond the study period of the thesis.

C.7. Pribram - Vienna

Pribram, A.F., *Materialen zur Geschichte der Preise und Löhne in Oesterreich*, Vol. 1 (Vienna, 1938).

Each price series has a table number. The prices come from a number of locations, some of the major locations being the Vienna Public Hospital (Wien Bürgerspital), which are market protocols (Marktprotokolle). Another example is from Klosterneuburg Abbey (Stift Klosterneuburg).

Wheat: First is Table 397. (p.269-274 for Wien Bürgerspital). Covers 1439 to 1779. The explanatory table is on p.133.

Two herring (heringe) series: first is Table 433. Notes found on p.158. (p.290-2 for Wien Bürgerspital), ranging over 1528 to 1734; 2nd is a combination of Tables 659 and 660. Table 659, for Stift Klosterneuburg, ranging over 1442 to 1661. Table 660 (p.471-6) and ranges from 1664 to 1765 but will have a lot of missing years. Notes found on p.221.

Beef (Rindfleisch): has two tables. First is Table 434. (p.292-4 for Wien Bürgerspital) ranging from 1531 to 1736, 2nd is Table 652 (p.471-6 for Stift Klosterneuburg), ranging from 1461 to 1772. Notes on the commodities can be found on p.154.

Stockfish (stockfisch): Table 444 (p.298-300 for Wien Bürgerspital). Notes on p.158. Range over 1688 to 1750.

Cod (Kabeljau): Table 653 (p.471-6 for Stift Klosterneuburg) is not used for some reason. Years cover 1489 to 1771.

Cheap Stockfish: Table 681 (p.483-3 for Stift Klosterneuburg). Covers 1694 to 1772. It also contains another version (possibly the “non cheap” versions, in another table in the table. Notes on p.221.

Grains: are on p.269-74.

C.8. Bauernfeind - Nuremberg

Source is from Walter Bauernfeind’s work from 1993, on prices in Nuremberg.⁴⁸⁹ The prices can be found from p.465-70, making up Table A.23. This covers rye, salt, and herring. (It also includes butter, but that is not included in this analysis).

C.9. Jansson, Palm and Soderberg - Stockholm and West Sweden

The main source is an essay in a publication from Arne Jansson, Lennart Palm, and Johan Söderberg, divided into two essays.⁴⁹⁰ The first is used in this thesis as it has the most uniform price-series.

In this thesis, herring, oxen (i.e., beef) and pork have been included.

Table A7 begins on p.62 and ranges from 1600 to 1719. Oxen can be found in part a from p.62-5. Herring, both stromming and sill can be found in part b from p.66-9.

Table A8 begins on p.82 and ranges from 1705 to 1749. Herring and pork have been taken from this table for this analysis. Both herring and pork can be found in part b for this table from p.84-5. The herring ranges from 1706 to 1738 while the pork is the full range from 1705 to 1749.

⁴⁸⁹ Walter Bauernfeind. *Materielle Grundstrukturen Im Spätmittelalter Und Der Frühen Neuzeit: Preisentwicklung Und Agrarkonjunktur Am Nürnberger Getreidemarkt Von 1339 Bis 1670* (Neustadt/Aisch, BRD: Schmidt, 1993), 465-70: Table A23.

⁴⁹⁰ Arne Jansson, Lennart Palm, and Johan Söderberg. *Dagligt Bröd I Onda Tider: Priser Och Löner I Stockholm Och Västsverige 1500-1770* (Inst. för Lokalhistorisk Forskning, 1991).

An additional source for Swedish is available for the short period from 1539 to 1588.⁴⁹¹ A closer inspection could provide more insight into the Swedish markets, as this period is part of the period that directly followed the introduction of the Newfoundland cod in the early 1500s.

The second source in Arne Jansson, Lennart Palm, and Johan Söderberg's publication comprises a collection of different sources that would require analysis to distinguish them or "harmonise" them into one source. The publication includes useful information on herring (1552 to 1770) and meat (1530 to 1736), but time has not allowed an exercise to untangle the sources and study in great detail for this thesis. If that were finished, it would give some perspective on a slightly earlier part of the study period, but also it is for a different location and is not directly comparable. This is thus also a lower priority for the study.

C.10. Van der Wee - Antwerp

There are three herring price series in the work that Allen-Unger collected, one is from Van Der Wee and this is what is studied in this thesis.⁴⁹² It covers 1386 to 1600 and can be found in Appendix 22 of volume one from p.277-86, specifically in Appendix 22/1 from p.279-82. It is noted as herring in barrels in Antwerp and Malines with prices per barrel with the money of account changing. First being of Flanders and Brabant from 1386 to 1435, then for Brabant from 1436 to 1600.

The Allen-Unger database contains price information for later periods, for Brabant, but I have not been able to find a copy of the source, so it has not been included in my analysis.

C.11. Feliu - Spain

From Feliu's work, the commodities can be found on the following pages:

Cod: Table VII.4 p.134-5, with more information on the following table, also a description on p.120.

⁴⁹¹ Arne Jansson, Lennart Palm, and Johan Söderberg, *Dagligt Bröd I Onda Tider: Priser Och Löner I Stockholm Och Västsverige 1500-1770* (Inst. för Lokalhistorisk Forskning, 1991).

⁴⁹² Herman van der Wee. *The Growth of the Antwerp Market and the European Economy: Fourteenth-Sixteenth Centuries. Interpretation* (Nijhoff, 1963).

Herring: Table VII.15 p.155-6. There are two sources: “1. Precios de Compra” and “II. Precios de Tasa”. These are described on p.119 as not as reliable as some other commodities.

Sheep Meat: described in section IV p.71-81. There are three tables IV.1 p.75-77 (local units?), table IV.2 p.78-9 (five-year averages). Table IV.3 p.80-1 (prices in silver per kilogram).

Wheat: Table III.1 p.37-40.

D. Appendix. R Scripts

A substantial amount of R code was written to support the analysis in this thesis. This was primarily the quantitative analysis, but also GIS analysis and flow diagrams. The more important code has been included in this appendix to explain how some of the studies were constructed. The analysis was more “technical” for Chapter 6 and 7, that is the conflict and environmental factors analyses.

D.1. Collating the Input Files

Script Name: 00101. Collate Input files.R

```
# Uploading 00000 List of Files...
```

```
df_Files <- read.csv(paste(Folder_CSvs,"00000 List of Files.csv",sep=""),header = TRUE )
```

```
#df_Files
```

```
# loop for upload
```

```
df_list = list()
```

```
i=1
```

```
j=1
```

```
for (val in df_Files[, "File.Name"]) {
```

```
  if (df_Files[i, "Include.File"] == 1 ){
```

```
    df_list[[j]] <-
```

```
    read.csv(paste(Folder_CSvs,df_Files[i, "File.Name"],sep=""),header = TRUE )
```

```
    j=j+1
```

```
  }
```

```
  i=i+1
```

```
}
```

```
df.AMO.Mann <- read.csv(paste(Folder_Environ_Proxies,"R Input - AMO (Mann)  
2009.csv",sep=""))
```

```
df.AMV.Wang <- read.csv(paste(Folder_Environ_Proxies,"R Input - AMV (Wang) 2017  
(also inc AMO30).csv",sep=""))
```

```
#remove "xx" from numbers
```

```

df.AMO.Mann[,"AMO.region.temperature..Mann.et.al....Riina"] <-
gsub("xx","",as.character(df.AMO.Mann[,"AMO.region.temperature..Mann.et.al....Riina"])
)
#From Factor to Numerical
df.AMO.Mann[,"AMO.region.temperature..Mann.et.al....Riina"] <-
suppressWarnings(as.numeric(gsub("","",as.character(df.AMO.Mann[,"AMO.region.temper
ature..Mann.et.al....Riina"]))))
colnames(df.AMO.Mann) <- c("Year","AMO")
#df.OWDA.FRA.SPA <- read.csv(paste0(Folder_Dropbox,"Als
Folder/Database/OWDA/Rough Rectangle maps/OWDA France and Spain Ave.csv") )
#colnames(df.OWDA.FRA.SPA) <- c("Year","OWDA.Sp.Fr")
# range of years
yrmin <- 1500
yrmax <- 1800
#bigLen = yrmax - yrmin + 1
# for multiple years, provide one figure (the average).. This is for Allaire Report 1.
library(dplyr)
# Allaire REport one Table:
df_list[[2]] = summarize_all(group_by( df_list[[2]][,-
c(2:3)],Year),funs(mean(.,na.rm=TRUE)))
#Allaire Report one Header file:
df_list[[1]] = df_list[[1]][-c(1:2),] # removed 2 col for other info (i.e., not price series)
rownames(df_list[[1]]) <- seq(from = 1, to = nrow(df_list[[1]]) )
# Create the main dataframe for prices
all_years <- data.frame(c(yrmin:yrmax));names(all_years)="Year"
Big_DF <- all_years
# All att Tables to one file
for (val in which(df_Files$Type == "Table" & df_Files$Price.or.Quantity == "Price" &
df_Files$Include.File == 1 )) {
  Big_DF <- merge( Big_DF, df_list[[val]] ,by="Year",all.x = TRUE, all.y = TRUE)
}
#output Big_DF to csv

```

```

write.csv(Big_DF, file = paste(Folder_CSVs,"Big_DF.csv",sep=""))
# Now start creating the main Header File
file.col.names <-
c("Series.ID","Report.Header.01","Series.Grouping.1","Country","City","Unit",
"Unit.Amount","Weight.KG","Name","Product.Category.01","Product.Category.02",
"Currency","FX.to.apply","Source","Price.Level")
main.df.col.names <- c(file.col.names,"File.Name")
Big_DF_H <- data.frame(as.list(main.df.col.names),stringsAsFactors=FALSE)
colnames(Big_DF_H) <- main.df.col.names
for (val in which(df_Files$Type == "Header" & df_Files$Include.File == 1)) {
  Big_DF_H = rbind( Big_DF_H,
  cbind(df_list[[val]][,file.col.names],
  "File.Name" = df_Files[val,"File.Name"])
  )
}
#transform(Big_DF_H, "Weight.KG" = 'numeric')
suppressWarnings(Big_DF_H[, "Weight.KG"] <- as.numeric(Big_DF_H[, "Weight.KG"]))
suppressWarnings(Big_DF_H[, "Unit.Amount"] <- as.numeric(Big_DF_H[, "Unit.Amount"]))
# Not sure why I do the following:
rownames(Big_DF_H) <- seq(from = 1, to = nrow(Big_DF_H) )
Big_DF_H = Big_DF_H[ order(as.numeric(row.names(Big_DF_H))), ]
write.csv(Big_DF_H, file = paste(Folder_CSVs,"Big_DF_H.csv",sep=""))
# Create Dataframes for each summary (not sure what I do this)
df_summary_list = list()
Sub.Fields <- Big_DF_H[which(Big_DF_H$Series.Grouping.1 == 1),"Series.ID"]
Sub.Fields.name <- Big_DF_H[which(Big_DF_H$Series.Grouping.1 == 1),"Name"]
df_summary_list[[1]] <- Big_DF[,c("Year",Sub.Fields)]
# Fixed error in csv relating to 4 livres entry in table...
# 1 Ecu=3 Livre, 1 Livre=20 Solz, 1 Solz=12 Denier. Hence 4 livres = 960 deniers
# Error was in: A1FW007    Freshwater fish    saumon frais (livre)    fresh salmon
(pound) 1617 VIII-593, 22-03-1617
# Upload Event Chronology

```

```

df_Events <- read.csv(paste(Folder_CSVs,"Timeline of Events.csv",sep=""),header = TRUE )
# Upload conflict Chronology
df_Conflict <- read.csv(paste(Folder_CSVs,"Conflict Catalog 18 vars.csv",sep=""),header =
TRUE )
# Sample Warfare Chronology
df_ConflictSample <- read.csv(paste(Folder_CSVs,"Sample Warfare
Chronology.csv",sep=""),header = TRUE )
# Build a DF for fish Quantities: This will be a rougher and simpler process for now
# For simplicity, this will simply involve loading one csv file
# It might be revisited later to refine and improve it.
DF_Quantities <- df_list[[which(df_Files$Price.or.Quantity == "Quantity" &
df_Files$Include.File == 1 )]]
DF_Quantities_H <- read.csv(paste(Folder_CSVs,"Quantities All Data - Not processed in R
Headers.csv",sep=""),header = TRUE )
df_FX.Rates <- read.csv(paste(Folder_CSVs,"Currency Conversions to Ag
Silver.csv",sep=""),header = TRUE )
# Remove outliers (might check later)
Big_DF[which(Big_DF$Year == 1623),c("ViennaHerring001")] = NA
#Big_DF[which(Big_DF$Year == 1652),c("FeSpanCod001")] = NA # Value is very large.
probably due to Siege of Barcelona
Big_DF[which(Big_DF$Year == 1594),c("SwedenHerring001")] = NA
Big_DF[which(Big_DF$Year == 1632),c("SwedenHerring001")] = NA
#Big_DF[which(Big_DF$Year == 1798),c("FeSpanCod001")] = NA
Big_DF[which(Big_DF$Year == 1591),c("A1SS004")] = NA # Herring Paris
#Big_DF[which(Big_DF$Year == 1622),c("FrankfurtHerring001")] = NA # Herring Frankfurt
#Big_DF[which(Big_DF$Year == 1635),c("FrankfurtHerring001")] = NA # Herring Frankfurt
# error in Allaire's first report: fresh beef (pound) in 1592
Big_DF[which(Big_DF$Year == 1562),c("A1Ot007")] = 12
# Uploading coordinate Files...
coordPrice_file <- read.csv(paste(Folder_CSVs,"coordFile.csv",sep=""), header = TRUE )
coordPrice <- coordPrice_file[which(coordPrice_file$include==1),]
require(reshape2)

```

```

# Upload Regions and Companies
#regions.companies <- read.csv(paste(Folder_CSVs,"Regions Companies.csv",sep=""),
header = TRUE )
#regions.companies[,2:length(regions.companies)] <-
lapply(regions.companies[,2:length(regions.companies)], function(x) as.character(x))
#regions.companies.melt <-
melt(regions.companies,id.vars="Year",variable.name=c("Location"),value.name =
"company")
regions.companies.summary <- read.csv(paste(Folder_CSVs,"Regions Companies
Summary.csv",sep=""), header = T, na.strings=c("") )
# Upload Regions and Empires
#regions.empires <- read.csv(paste(Folder_CSVs,"Regions Empires.csv",sep=""), header =
TRUE )
#regions.empires[,2:length(regions.empires)] <-
lapply(regions.empires[,2:length(regions.empires)], function(x) as.character(x))
#regions.empires.melt <-
melt(regions.empires,id.vars="Year",variable.name=c("Location"),value.name = "empire")
regions.empires.summary <- read.csv(paste(Folder_CSVs,"Regions Empires
SUMmary.csv",sep=""), header = TRUE, na.strings=c("") )
Nrth.Hem.Temp.Recon.Decadal <- read.delim(paste(Folder_CSVs,"Environmental
Proxies/Temperature Variability/Extract for R.txt",sep=""), header = T, na.strings=c("") )

```

D.2. Creation of Central Price Data Frame and Conversions

D.2.1. First Script: 02001. DF Create price.df.core

```

#Series to include in the analysis (by ID)
header.fields.core <- Big_DF_H[which(Big_DF_H$Series.Grouping.1 %in% c(1,2)),]
#header.fields.core <- Big_DF_H[which(Big_DF_H$Series.Grouping.1 == 1 &
Big_DF_H$Product.Category.01 %in% c("Grain", "Wheat", "Barley")),]
#header.fields.core <- Big_DF_H[which(Big_DF_H$Series.Grouping.1 == 1 &
Big_DF_H$Country == "Poland" ),]
#header.fields.core <- Big_DF_H[which(Big_DF_H$Series.Grouping.1 == 1 &
Big_DF_H$Country == "England" ),]

```

```

#header.fields.core <- Big_DF_H[which(Big_DF_H$Series.Grouping.1 == 1 &
Big_DF_H$Country == "France" ),]
#header.fields.core <- Big_DF_H[which(Big_DF_H$Series.ID %in%
c("SwedenHerring001","FeSpanCod001")),]
#header.fields.core <- Big_DF_H[which(Big_DF_H$Series.Grouping.1 == 1 &
Big_DF_H$Country == "The Netherlands" ),]
#header.fields.core <- Big_DF_H[which(Big_DF_H$Series.Grouping.1 == 1 &
# Big_DF_H$Product.Category.01 %in% c("Pilchards","Herring")),]
#header.fields.core <- Big_DF_H[which(Big_DF_H$Series.Grouping.1 == 1 &
!(Big_DF_H$Product.Category.01 %in% c("Pilchards","Cod","Herring"))),]
series.id.limit <- header.fields.core[,"Series.ID"]
name.limit <- header.fields.core[,"Name"]
# DF limited to these series
price.df.core <- Big_DF[,c("Year",series.id.limit)]
price.df.core.excl.year <- Big_DF[,c(series.id.limit)]
# change col name from series.it to Name
colnames(price.df.core) <- c("Year",name.limit)
colnames(price.df.core.excl.year) <- name.limit

```

D.2.2. Second Script: 02002. Common Price and Quantity Unit

This creates df xy.to.plot.ag.grams.common.unit

```

#price.df.core.ag.grams <- price.df.core
#rm(price.df.core.ag.grams)
# Standard unit calc: (possibly best to do most of this in excel)
# price.silver: price * (gram silver per currency unit currency)
# amount.KG: amount * (unit.amount in KG ) * no of units
# price.silver.per.kg = price.silver / amount.KG
# Weight Unit conversion done based on calc per series
# Currency conversion based on yearly values
# test on weight.kg to mult the df
weight.kg.per.series <- header.fields.core[,"Weight.KG"]
#t(t(price.df.core.excl.year)*weight.kg.per.series)

```

```

# quick check of the currencies
#header.fields.core[,c("Name", "Currency")]
# dataframe based on .csv of FX rates
#df_FX.Rates
#colnames(df_FX.Rates)
# test French (something better might be moved to earlier df)
#df.core.price.and.fx <- merge(price.df.core,df_FX.Rates,by="Year",all.x=T)
#colnames(df.core.price.and.fx)
#price.df.core.ag.grams[,c("A1SS004", "A1SS004", "A1Ot006", "A1Ot007", "A1Ot008")]
#fx rate for each series (done on csv)
df_FX.Rates.full.range = setNames(data.frame(Big_DF$Year), "Year")
df_FX.Rates.full.range = merge(df_FX.Rates.full.range,df_FX.Rates,by="Year",all.x=T)
#df_FX.Rates.full.range[,header.fields.core[, "FX.to.apply"]]
price.df.core.ag.grams.fx <-
df_FX.Rates.full.range[,c("Year", header.fields.core[, "FX.to.apply"])]
price.df.core.ag.grams <- price.df.core * price.df.core.ag.grams.fx
price.df.core.ag.grams$Year <- price.df.core$Year
range.min <- 1400
range.max <- 1800
year.range <- range.min:range.max
price.df.core.ag.grams <- price.df.core.ag.grams[price.df.core.ag.grams$Year %in%
year.range,]
price.df.core.ag.grams.excl.Year <-
price.df.core.ag.grams[,!(colnames(price.df.core.ag.grams) == "Year")]
# Next convert to common unit
price.df.core.ag.grams.common.unit <- price.df.core.ag.grams
weight.kg.per.series <- header.fields.core[, "Weight.KG"]
price.df.core.ag.grams.common.unit[,!(colnames(price.df.core.ag.grams) == "Year")] <-
t(t(price.df.core.ag.grams.excl.Year)/weight.kg.per.series)
# also a version in local currency, but standard kg quantity
price.df.core.common.quantity.excl.Year <- price.df.core[,!(colnames(price.df.core) ==
"Year")]

```

```

# Next convert to common unit
price.df.core.common.quantity <- price.df.core
weight.kg.per.series <- header.fields.core[,"Weight.KG"]
price.df.core.common.quantity[,!(colnames(price.df.core.ag.grams) == "Year")] <-
  t(t(price.df.core.common.quantity.excl.Year)/weight.kg.per.series)
# Graph here for now. Might move this to another file when the above is better
developed.
library(ggplot2)
library(reshape2)
xy.to.plot.ag.grams.common.unit <- price.df.core.ag.grams.common.unit
#xy.to.plot <- as.data.frame(price.df.core.ag.grams)
#xy.to.plot <- as.data.frame(price.df.core)
# define a log trans for percentages... Not necessary and maybe using 'log2' or 'log10' is
# simpler and enough. I cannot make this work yet anyway.
# require(scales)
#tn <- trans_new("log1.01",function(x) log(x,1.01),function(y) y^1.01,
# domain=c(0, Inf)#,breaks=
# )
# extract the slopes. I think these equate to average inflation increase
# technically it is not the average though... so be clearer on what that is.
# I do not know if any of the following is used
require(scales)
slopes <- data.frame(apply(xy.to.plot.ag.grams.common.unit,MARGIN=2,FUN=function(y)
  {if(all(is.na(y))){NA}else lm(y~xy.to.plot.ag.grams.common.unit$Year)$coefficients[2]}
)
colnames(slopes) <- "slope"
slopes$slope <- percent(slopes$slope,accuracy = 0.1)

```

D.2.3. Third Script: 02003. Creates Main Dataframe

Create melt df (both xy.to.plot.melt and xy.to.plot.melt.big.chart.price)

xy.to.plot.melt is created here. Most likely this should be renamed.

maybe to prices.common.unit


```

# xy.to.plot.melt should be adjusted to become a temp variable only important to this
script
require(reshape2)
xy.to.plot.melt <- melt(xy.to.plot.ag.grams.common.unit, id.vars="Year")
#xy.to.plot.melt$Decade <- floor(xy.to.plot.melt/10)*10
#log prices
xy.to.plot.melt$value.log1.01 <-
  log(xy.to.plot.melt$value,1.01)
xy.to.plot.melt <-
  merge(xy.to.plot.melt,Big_DF_H[,c("Name","Product.Category.01","Product.Category.02"
  ,"Source","Country","City","Series.Grouping.1","Price.Level")],by.x="variable",by.y="Name",all.x=T)
#feed to a larger df of different data for graph
xy.to.plot.melt.big.chart.price <- xy.to.plot.melt
xy.to.plot.melt.big.chart.price$Data.Type <- "Price"
# test: add col to melted data for region
Temp <-
  merge(xy.to.plot.melt.big.chart.price,Big_DF_H[,c("Name","Country")],by.x="variable",by.y="Name",all.x=T,all.y=F)
#Temp <- Temp[,c(colnames(xy.to.plot.melt.big.chart.price),"Country")]
#colnames(Temp) <- c(colnames(xy.to.plot.melt.big.chart.price),"Location")
#xy.to.plot.melt.big.chart.price <- Temp
xy.to.plot.melt.big.chart.price$Location <- Temp$Country
xy.to.plot.melt.big.chart.price <-
  xy.to.plot.melt.big.chart.price[which(xy.to.plot.melt.big.chart.price$Series.Grouping.1
  %in% c(1,2)),]

```

D.2.4. Forth Script: 02004. Extra measures

Creates a dataframe for xy.to.plot.melt.grouping

```

### work with df created in common price and quantity unit.
#xy.to.plot.melt <- xy.to.plot.melt[xy.to.plot.melt$Year %in% 1500:1800,]
xy.to.plot.melt$Decade <- floor(xy.to.plot.melt$Year/10)*10

```

```

xy.to.plot.melt$Year50 <- floor(xy.to.plot.melt$Year/50)*50
#xy.to.plot.melt$grouping <- xy.to.plot.melt$Decade
xy.to.plot.melt$grouping <- xy.to.plot.melt$Year50
xy.to.plot.melt.grouping <-
aggregate(xy.to.plot.melt$value,
  by=list(xy.to.plot.melt$variable,xy.to.plot.melt$grouping),
  #xy.to.plot.melt$Product.Category.01,xy.to.plot.melt$Product.Category.02,
  #xy.to.plot.melt$Country,
  #xy.to.plot.melt$City,xy.to.plot.melt$Series.Grouping.1),
  #FUN=mean,na.rm=TRUE,simplify=T)
FUN=function(x){mean(x,na.rm=T)},simplify=T,drop=T)
colnames(xy.to.plot.melt.grouping) <- c("variable","grouping",
  #"Product.Category.01","Product.Category.02",
  #"Country",
  #"City","Series.Grouping.1",
  "value.grouping")
xy.to.plot.melt.with.grouping <-
merge(xy.to.plot.melt,xy.to.plot.melt.grouping,
  by=c("variable","grouping"),
  #"Product.Category.01","Product.Category.02",
  #"Country",
  #"City","Series.Grouping.1"),
  all.x=T)

```

D.3. The Core Dataframe with all information Types

D.3.1. First Script: 03101. Dataframe for Quantities

```
xy.to.plot.melt.big.chart.quantities
```

D.3.2. Second Script: 05100. Dataframe for Conflict

```
Creates xy.to.plot.melt.big.chart.conflict
```

```
library(ggplot2)
```

```

library(reshape2)
library(scales)
range.min <- 1500
range.max <- 1800
year.range <- range.min:range.max
df_Conflict_date_na.rm <- df_Conflict[which(!is.na(df_Conflict$EndYear)),]
# temp range
conflict.year.range = 1400:2000
# list of regions to study
countries <- c(unique(Big_DF_H$Country))
#countries <- c("England","France")
xy.to.plot <- as.data.frame(conflict.year.range)
colnames(xy.to.plot) <- "Year"
# Map Reduce
for (country in countries){
  if(country %in% colnames(df_Conflict_date_na.rm)){
    df_Conflict_date_na.rm.temp <-
    df_Conflict_date_na.rm[which(df_Conflict_date_na.rm[,country] ==1 ),]
    xy.to.plot.temp <- as.data.frame(table(Reduce(c, Map(
      seq, df_Conflict_date_na.rm.temp$StartYear,df_Conflict_date_na.rm.temp$EndYear))))
    colnames(xy.to.plot.temp) <- c("Year",country)
    xy.to.plot.temp$Year <- as.numeric(levels(xy.to.plot.temp$Year))[xy.to.plot.temp$Year]
    xy.to.plot <- merge(xy.to.plot, xy.to.plot.temp,by="Year",all.x=T,all.y=F)
  }
}
# Use similar to above to find total per year, but with no country limit
df.temp <- df_Conflict_date_na.rm[,colnames(df_Conflict_date_na.rm) %in% countries]
df.temp$sum <- apply(df.temp,1,FUN=function(x){sum(x,na.rm=T)})
df.temp <- df_Conflict_date_na.rm[which(df.temp$sum > 0 ),]
df.Conflict.Total.Europe <- as.data.frame(table(Reduce(c, Map(
  seq, df.temp$StartYear,df.temp$EndYear))))
colnames(df.Conflict.Total.Europe) <- c("Year","TotalConflict")

```

```

df.Conflict.Total.Europe$Year <-
as.numeric(levels(df.Conflict.Total.Europe$Year))[df.Conflict.Total.Europe$Year]
xy.to.plot <- merge(xy.to.plot, df.Conflict.Total.Europe,by="Year",all.x=T,all.y=F)
# end of that part
xy.to.plot <- xy.to.plot[which(xy.to.plot$Year %in% year.range),]
xy.to.plot.melt.2 <- melt(xy.to.plot, id.vars="Year")
xy.to.plot.melt.2[is.na(xy.to.plot.melt.2)] <- 0
#feed to a larger df of different data for graph
xy.to.plot.melt.big.chart.conflict <- xy.to.plot.melt.2
xy.to.plot.melt.big.chart.conflict$Data.Type <- "Conflict"
xy.to.plot.melt.big.chart.conflict$Product.Category.01 <- "Any.Conflict"
xy.to.plot.melt.big.chart.conflict$Product.Category.02 <- "Any.Conflict"
xy.to.plot.melt.big.chart.conflict$Price.Level <- "NA"
xy.to.plot.melt.big.chart.conflict$Series.Grouping.1 <- "NA"
xy.to.plot.melt.big.chart.conflict$Country <- xy.to.plot.melt.big.chart.conflict$variable
xy.to.plot.melt.big.chart.conflict$Location <- xy.to.plot.melt.big.chart.conflict$Country
xy.to.plot.melt.big.chart.conflict[xy.to.plot.melt.big.chart.conflict$Country ==
"TotalConflict", "Product.Category.01"] <- "Any"

```

D.3.3. Third Script: 05110. DF all factors xy.to.plot.melt.big.chart

```

library(ggplot2)
library(reshape2)
library(scales)
# A further developed version of this chart could be used in Environmental chapter too
xy.to.plot.melt.big.chart <- as.data.frame(matrix(nrow=0,ncol=8))
colnames(xy.to.plot.melt.big.chart) <-
c("Year","variable","value","Data.Type","Country","Location","Price.Level","Series.Groupi
ng.1")
#rm(xy.to.plot.melt.big.chart)
# add volcanic events
xy.to.plot.big.chart.vol.sulphate <-
df.envIRON[df.envIRON$Year %in% 1500:1800,c("Year","vol.Greenland.Suf.Level")]

```

```

xy.to.plot.melt.big.chart.vol.sulphate <- melt(xy.to.plot.big.chart.vol.sulphate,
id.vars="Year")
xy.to.plot.melt.big.chart.vol.sulphate$Data.Type <- "Volcanic Activity"
xy.to.plot.melt.big.chart.vol.sulphate$Country <- "Volcano.NH"
xy.to.plot.melt.big.chart.vol.sulphate$Product.Category.01 <- "Any"
xy.to.plot.melt.big.chart.vol.sulphate$Product.Category.02 <- "Any"
xy.to.plot.melt.big.chart.vol.sulphate$Location <- "NA"
xy.to.plot.melt.big.chart.vol.sulphate$Price.Level <- "NA"
xy.to.plot.melt.big.chart.vol.sulphate$Series.Grouping.1 <- "NA"
# add AMV
xy.to.plot.big.chart.amv <-
df.enviro[df.enviro$Year %in% 1500:1800,c("Year","AMV")]
xy.to.plot.melt.big.chart.amv <- melt(xy.to.plot.big.chart.amv, id.vars="Year")
xy.to.plot.melt.big.chart.amv$Data.Type <- "AMV"
xy.to.plot.melt.big.chart.amv$Country <- "AMV.Global"
xy.to.plot.melt.big.chart.amv$Product.Category.01 <- "Any"
xy.to.plot.melt.big.chart.amv$Product.Category.02 <- "Any"
xy.to.plot.melt.big.chart.amv$Location <- "NA"
xy.to.plot.melt.big.chart.amv$Price.Level <- "NA"
xy.to.plot.melt.big.chart.amv$Series.Grouping.1 <- "NA"
# add OWDA
xy.to.plot.big.chart.owda <-
df.enviro[df.enviro$Year %in% 1500:1800,c("Year","OWDA")]
xy.to.plot.melt.big.chart.owda <- melt(xy.to.plot.big.chart.owda, id.vars="Year")
xy.to.plot.melt.big.chart.owda$Data.Type <- "OWDA"
xy.to.plot.melt.big.chart.owda$Country <- "OWDA.All"
xy.to.plot.melt.big.chart.owda$Product.Category.01 <- "Any"
xy.to.plot.melt.big.chart.owda$Product.Category.02 <- "Any"
xy.to.plot.melt.big.chart.owda$Location <- "NA"
xy.to.plot.melt.big.chart.owda$Price.Level <- "NA"
xy.to.plot.melt.big.chart.owda$Series.Grouping.1 <- "NA"
# created in later script (named 09112 at time of writing this)

```

```

owda.custom.locations.df.melt2 <- owda.custom.locations.df.melt
owda.custom.locations.df.melt2$Data.Type <- "OWDA"
owda.custom.locations.df.melt2$variable <- "OWDA"
owda.custom.locations.df.melt2$Product.Category.01 <- "Any"
owda.custom.locations.df.melt2$Product.Category.02 <- "Any"
owda.custom.locations.df.melt2$Location <- "NA"
owda.custom.locations.df.melt2 <-
owda.custom.locations.df.melt2[,c("Year","variable","value","Data.Type","Country","Prod
uct.Category.01","Product.Category.02","Location")]
owda.custom.locations.df.melt2$Price.Level <- "NA"
owda.custom.locations.df.melt2$Series.Grouping.1 <- "NA"
BHM_Eu2k2_Recon.custom.locations.df.melt2 <-
BHM_Eu2k2_Recon.custom.locations.df.melt
BHM_Eu2k2_Recon.custom.locations.df.melt2$Data.Type <- "BHM_Eu2k2_Recon"
BHM_Eu2k2_Recon.custom.locations.df.melt2$variable <- "BHM_Eu2k2_Recon"
BHM_Eu2k2_Recon.custom.locations.df.melt2$Product.Category.01 <- "Any"
BHM_Eu2k2_Recon.custom.locations.df.melt2$Product.Category.02 <- "Any"
BHM_Eu2k2_Recon.custom.locations.df.melt2$Location <- "NA"
BHM_Eu2k2_Recon.custom.locations.df.melt2 <-
BHM_Eu2k2_Recon.custom.locations.df.melt2[,c("Year","variable","value","Data.Type","
Country","Product.Category.01","Product.Category.02","Location")]
BHM_Eu2k2_Recon.custom.locations.df.melt2$Price.Level <- "NA"
BHM_Eu2k2_Recon.custom.locations.df.melt2$Series.Grouping.1 <- "NA"
# xy.to.plot.big.chart.owda.paris <-
# df.enviro[df.enviro$Year %in% 1500:1800,c("Year","OWDA.Paris")]
# xy.to.plot.melt.big.chart.owda.paris <- melt(xy.to.plot.big.chart.owda.paris,
id.vars="Year")
# xy.to.plot.melt.big.chart.owda.paris$Data.Type <- "OWDA.France"
# xy.to.plot.melt.big.chart.owda.paris$Country <- "France"
# xy.to.plot.melt.big.chart.owda.paris$Product.Category.01 <- "Any"
# xy.to.plot.melt.big.chart.owda.paris$Location <- "NA"
#

```

```

# xy.to.plot.big.chart.owda.london <-
# df.envIRON[df.envIRON$Year %in% 1500:1800,c("Year","OWDA.London")]
# xy.to.plot.melt.big.chart.owda.london <- melt(xy.to.plot.big.chart.owda.london,
id.vars="Year")
# xy.to.plot.melt.big.chart.owda.london$Data.Type <- "OWDA.England"
# xy.to.plot.melt.big.chart.owda.london$Country <- "England"
# xy.to.plot.melt.big.chart.owda.london$Product.Category.01 <- "Any"
# xy.to.plot.melt.big.chart.owda.london$Location <- "NA"
# Add change in empire
xy.to.plot.big.chart.empire.change <-
regions.empires.summary[regions.empires.summary$Start !=
1500,c("Start","Location","Country")]
xy.to.plot.big.chart.empire.change$StartPlus1 <- xy.to.plot.big.chart.empire.change$Start
+ 1
xy.to.plot.big.chart.empire.change.melt <-
melt(xy.to.plot.big.chart.empire.change,id.vars=c("Location","Country"))
xy.to.plot.big.chart.empire.change.melt <-
xy.to.plot.big.chart.empire.change.melt[,c("value","Location","Country")]
colnames(xy.to.plot.big.chart.empire.change.melt) <- c("Year","Location","Country")
xy.to.plot.big.chart.empire.change.melt$value <- 1
xy.to.plot.big.chart.empire.change.melt$variable <- factor(1)
xy.to.plot.big.chart.empire.change.melt$Data.Type <- "EmpireChange"
#xy.to.plot.big.chart.empire.change.melt$Country <- "EmpireChange"
xy.to.plot.big.chart.empire.change.melt$Product.Category.01 <- "Any"
xy.to.plot.big.chart.empire.change.melt$Product.Category.02 <- "Any"
xy.to.plot.big.chart.empire.change.melt$Price.Level <- "Any"
xy.to.plot.big.chart.empire.change.melt$Series.Grouping.1 <- "Any"
# Add change in empire
xy.to.plot.big.chart.company.change <-
regions.companies.summary[regions.companies.summary$Start !=
1500,c("Start","Location","Country")]

```

```

xy.to.plot.big.chart.company.change$StartPlus1 <-
xy.to.plot.big.chart.company.change$Start + 1
xy.to.plot.big.chart.company.change.melt <-
melt(xy.to.plot.big.chart.company.change,id.vars=c("Location","Country"))
xy.to.plot.big.chart.company.change.melt <-
xy.to.plot.big.chart.company.change.melt[,c("value","Location","Country")]
colnames(xy.to.plot.big.chart.company.change.melt) <- c("Year","Location","Country")
xy.to.plot.big.chart.company.change.melt$value <- 1
xy.to.plot.big.chart.company.change.melt$variable <- factor(1)
xy.to.plot.big.chart.company.change.melt$Data.Type <- "CompanyChange"
#xy.to.plot.big.chart.company.change.melt$Country <- "CompanyChange"
xy.to.plot.big.chart.company.change.melt$Product.Category.01 <- "Any"
xy.to.plot.big.chart.company.change.melt$Product.Category.02 <- "Any"
xy.to.plot.big.chart.company.change.melt$Price.Level <- "Any"
xy.to.plot.big.chart.company.change.melt$Series.Grouping.1 <- "Any"
xy.to.plot.melt.big.chart.price2<-xy.to.plot.melt.big.chart.price # Dataframe was created
earlier (can be found in script name in project folder)
xy.to.plot.melt.big.chart.price2<-xy.to.plot.melt.big.chart.price
#[xy.to.plot.melt.big.chart.price$variable %in%
# c("Cod (Paris)","Herring (Paris)","Salted Cod (London)","Herring (London)"),]
xy.to.plot.melt.big.chart.price2<-
xy.to.plot.melt.big.chart.price[,c("Year","variable","value","Data.Type","Country","Product.
t.Category.01","Product.Category.02","City","Price.Level","Series.Grouping.1")]
colnames(xy.to.plot.melt.big.chart.price2) <-
c("Year","variable","value","Data.Type","Country","Product.Category.01","Product.Categ
ory.02","Location","Price.Level","Series.Grouping.1")
xy.to.plot.melt.big.chart<-
rbind(xy.to.plot.melt.big.chart.price2,
xy.to.plot.melt.big.chart.conflict, # created in another script
xy.to.plot.melt.big.chart.quantities, # Developed in chapter 6 scripts
xy.to.plot.melt.big.chart.vol.sulphate,
xy.to.plot.melt.big.chart.amv,

```



```

xy.to.plot.melt.big.chart.owda,
BHM_Eu2k2_Recon.custom.locations.df.melt2,
owda.custom.locations.df.melt2,
#xy.to.plot.melt.big.chart.owda.paris,
#xy.to.plot.melt.big.chart.owda.london,
xy.to.plot.big.chart.empire.change.melt,
xy.to.plot.big.chart.company.change.melt
)
#xy.to.plot.melt.big.chart<-xy.to.plot.melt.big.chart.conflict
all.countries.from.all.inputs <- unique(c(countries,
"Newfoundland/French","Globalish","TotalConflict",
"EmpireChange","CompanyChange","OWDA.All",
"Overall.BHM_Eu2k2_Recon","AMV.Global",
"Volcano.NH",
as.character(unique(xy.to.plot.melt.big.chart.quantities$Country))))
xy.to.plot.melt.big.chart <-
#xy.to.plot.melt.big.chart[xy.to.plot.melt.big.chart$Location %in%
c("England","Globalish"),]
#xy.to.plot.melt.big.chart[xy.to.plot.melt.big.chart$Location %in%
c("France","Newfoundland/French","Globalish"),]
xy.to.plot.melt.big.chart[xy.to.plot.melt.big.chart$Country %in%
all.countries.from.all.inputs,]
xy.to.plot.melt.big.chart.excl.na <-
xy.to.plot.melt.big.chart[!is.na(xy.to.plot.melt.big.chart$value),]

```

D.4. The Core Graph for Prices with Climate and Conflict Backdrop

The script is called "05151. Graph prices v Events (xy.to.plot.melt.big.chart)". This code
can be changed by adjusting certain variables, to change the likes of the commodity,
location and climate and environmental information that will be displayed.

```
require(ggplot2)
require(Hmisc)
require(ggrepel)
require(directlabels)
year.range <- 1500:1799
# For future use: citation("ggplot2")
# main de developed in script: 08010. df anthropological factors xy.to.plot.melt.big.chart
xy.plot <- xy.to.plot.melt.big.chart.excl.na
#xy.conflict <-
xy.to.plot.melt.big.chart.excl.na[xy.to.plot.melt.big.chart.excl.na$Data.Type ==
"Conflict",]
xy.events <- xy.to.plot.melt.big.chart.excl.na
empire.change.year <-regions.empires.summary[regions.empires.summary$Start !=
1500,]
company.change.year <-regions.companies.summary[regions.companies.summary$Start
!= 1500,]
# d gives the example of periods of well-known conflicts
#d<-read.csv(paste(Folder_CSVMs,"Chart Rectanges.csv",sep=""))
#d<-d[d$Location == "England",]
country.or.product.group <- "Country"
#country.or.product.group <- "Product.Category.01"
#xy.plot <- xy.plot[xy.plot$Product.Category.01 %in%
c("Rye","Beef","Chicken","Pork","Herring","Cod","Barley","Mutton"),]
#limit <- c("Beef","Pork","Lamb")
#limit <- c("Wheat")
#limit <- c("Cod","Herring")
#limit <- c("Cod","Herring","Beef","Wheat")
```

```

#limit <- c("Wheat","Barley","Rye")
limit <- "Spain"
#Location <- "Valencia" ; xy.plot <- xy.plot[xy.plot$Location %in% Location,]
#xy.plot <- xy.plot[xy.plot$variable != "Herring(Vienna) 01",]
xy.plot <- xy.plot[xy.plot$Year %in% year.range,]
xy.plot <- xy.plot[xy.plot[,country.or.product.group] %in% limit,]
#xy.plot <- xy.plot[xy.plot$Product.Category.01 %in% c("Cod","Herring","Beef","Wheat"),]
#xy.plot <- xy.plot[xy.plot$Product.Category.01 %in% c("Cod","Herring","Wheat","Beef"),]
xy.plot <- xy.plot[xy.plot$Location %in% c("Barcelona"),]
#xy.plot <- xy.plot[xy.plot$Data.Type %in% c("Price","Conflict"),]
#xy.conflict <- xy.conflict[xy.conflict$Location == limit,]
#exclude the stockfish from Munich, values seem to high and they dominate the charts
too much
#xy.plot <- xy.plot[!(xy.plot$variable %in% c("Stockfish (Munich)")),]
measure.b <- "variable"
#colour <- as.character(xy.plot[xy.plot$Data.Type == "Price",measure.b])
#xy.plot <- xy.plot[xy.plot$Data.Type %in% "Price",]
xy.plot <- xy.plot[xy.plot$Data.Type %in% c("Price","AMV","OWDA"),]
#xy.plot <- xy.plot[xy.plot[,country.or.product.group] %in% limit |
# xy.plot$Data.Type %in% c("Price","AMV","OWDA"),]
xy.plot$logValue <- log(xy.plot$value)
#xy.plot$plot.value <- xy.plot$value
xy.plot$plot.value <- xy.plot$logValue
#ylab = "Prices in Grams of Silver"
ylab = "Log Prices in Grams of Silver"
ylab = ""
xy.plot <-
merge(xy.plot,empire.change.year[,c("Start","Location","Empire","Empire.Change")],by.x
=c("Year","Location"),by.y=c("Start","Location"),all.x=T,all.y=T)
xy.plot$EmpireChange <- ifelse (is.na(xy.plot$Empire),NA,xy.plot$plot.value)

```

```

xy.plot <-
merge(xy.plot,company.change.year[,c("Start","Location","Company","Company.Change"
)],by.x=c("Year","Location"),by.y=c("Start","Location"),all.x=T,all.y=T)
xy.plot$CompanyChange <- ifelse (is.na(xy.plot$Company),NA,xy.plot$plot.value)
ymaxAll <-max((xy.plot[xy.plot$Data.Type == "Price","plot.value"]),na.rm=T)
yminAll <-min((xy.plot[(xy.plot$Data.Type == "Price"
& xy.plot$value > 0),"value"]),na.rm=T)
if (country.or.product.group == "Country"){
xy.events <- xy.events[xy.events$Country == limit,]
} else if (country.or.product.group == "Product.Category.01"){
xy.events <- xy.events[
xy.events$Country %in% c("TotalConflict","OWDA.All","Overall.BHM_Eu2k2_Recon",
"AMV.Global","Volcano.NH") |
xy.events$Data.Type %in% c("EmpireChange","CompanyChange")
,]
}
#xy.events <- xy.events[xy.events$Data.Type %in%
c("Price","AMV","OWDA","BHM_Eu2k2_Recon"),]
#xy.plot <- xy.plot[!is.na(xy.plot$Data.Type),]
# needed for the minor ticks
insert_minor <- function(major_labs, n_minor) {labs <-
c( sapply( major_labs, function(x) c(x, rep("", 4) ) ) )
labs[1:(length(labs)-n_minor)]}
show.empire.change = F
show.company.change = F
Data.Type.for.Background = "OWDA" # OWDA or Conflict or BHM_Eu2k2_Recon AMV V
show.background = T
Data.Type.for.Comparison = "AMV"
show.comparison.data = F
Data.Type.for.Comparison2 = "OWDA"
show.comparison.data2 = F
ggplot(xy.plot,aes(Year,plot.value,colour=variable,group=variable))+

```

```

#ggplot(xy.plot,aes(Year,plot.value,colour=variable,group=variable))+
geom_point(alpha=1,size=3)+
geom_line(alpha=1,size=2)+
{if(show.background){
geom_rect(data=xy.events[xy.events$Data.Type == Data.Type.for.Background,],
mapping=aes(xmin=Year,xmax=Year+1,ymin=-
Inf,ymax=Inf,alpha=value),fill="black",inherit.aes = F) }} +
scale_alpha_continuous(range = c(0,.5))+
{if(show.comparison.data){
geom_line(data=xy.events[xy.events$Data.Type == Data.Type.for.Comparison,],
mapping=aes(x=Year,y=value),size=3,colour="orange",alpha=.5) }} +
{if(show.comparison.data2){
geom_line(data=xy.events[xy.events$Data.Type == Data.Type.for.Comparison2,],
mapping=aes(x=Year,y=value),size=3,colour="blue",alpha=.5) }} +
{if(nrow(xy.events[xy.events$Data.Type == "EmpireChange",])>0&show.empire.change){
geom_rect(data=xy.events[xy.events$Data.Type == "EmpireChange",],
mapping=aes(xmin=Year,xmax=Year+1,ymin=-
Inf,ymax=Inf),fill="blue",alpha=.5,inherit.aes = F) }} +
{if(nrow(xy.events[xy.events$Data.Type ==
"CompanyChange",])>0&show.company.change){geom_rect(data=xy.events[xy.events$D
ata.Type == "CompanyChange",], mapping=aes(xmin=Year,xmax=Year+1,ymin=-
Inf,ymax=Inf),fill="orange",alpha=.5,inherit.aes = F) }}+
#geom_smooth(span=0.25,aes(colour=variable,group=variable),stat="smooth",method =
"loess",alpha=1,size=1,se=F,fullrange=F)+
#geom_dl(aes(label=variable),method="last.bumpup")+
#geom_dl(aes(label=variable),method="first.bumpup")+
#geom_label_repel(aes(label=ifelse(!is.na(Empire.Change),paste0(Empire.Change,".
(",Location,")"),NA),hjust=1, vjust=1),alpha=.9,size=4,colour="black")+
#geom_label_repel(aes(label=ifelse(!is.na(Company.Change),paste0(Company.Change,".
(",Location,")"),NA),hjust=1, vjust=1),alpha=.9,size=4,colour="black")+
# Red "Average" Trendline

```

```

#####stat_summary(aes(Year,plot.value),fun.data ="mean_sdl",fun.args = list(mult = 1),
geom = "line",alpha=.75,size=3,colour="red",inherit.aes = F)+
##stat_summary(aes(Year,plot.value,colour=Product.Category.01),fun.data
="mean_sdl",fun.args = list(mult = 1), geom = "line",alpha=1,size=3,inherit.aes = F)+
{if(nrow(xy.events[xy.events$Data.Type ==
"EmpireChange",])>0&show.empire.change){geom_point(aes(y=EmpireChange),alpha=1,s
ize=4,colour="blue")}}+
{if(nrow(xy.events[xy.events$Data.Type ==
"CompanyChange",])>0&show.company.change){geom_point(aes(y=CompanyChange),al
pha=1,size=4,colour="orange")}}+
theme_bw()+
#scale_x_continuous(name ="Year",breaks=seq(range.min,range.max,by=50))+
scale_x_continuous(name ="Year",breaks=seq(range.min,range.max,by=10),
labels = insert_minor( seq(range.min, range.max, by=50), 4 ),
minor_breaks = seq(range.min,range.max,by=10))+
theme(legend.position = "bottom",legend.text = element_text(size = 14),legend.title =
element_text(size = 14),
axis.text=element_text(size=14),axis.title=element_text(size=14,face="bold"))+
theme(axis.ticks.length=unit(.25, "cm"))+
#facet_grid(Data.Type~., scales = "free") +
#facet_grid(Product.Category.01~., scales = "free") +
theme(strip.text.y = element_text(size = 24, colour = "black", angle = -0))+
guides(colour=guide_legend(measure.b,ncol=4)) +
ylab(ylab)+
{NULL}

```

D.5. Conflict Analysis

First, the original conflict catalogue was modified in Excel. Columns were added to each country. For each conflict event, a 1 was added to the country column where a conflict was active. This version of the file was uploaded to R. Next the following script was run to create individual county indices.

D.5.1. Script Name: 05100. df Conflict (xy.to.plot.melt.big.chart.conflict)

```
#Script Start
library(ggplot2)
library(reshape2)
library(scales)
range.min <- 1500
range.max <- 1800
year.range <- range.min:range.max
df_Conflict_date_na.rm <- df_Conflict[which(!is.na(df_Conflict$EndYear)),]
# temp range
conflict.year.range = 1400:2000
# list of regions to study
countries <- c(unique(Big_DF_H$Country))
#countries <- c("England","France")
xy.to.plot <- as.data.frame(conflict.year.range)
colnames(xy.to.plot) <- "Year"
# Map Reduce
for (country in countries){
  if(country %in% colnames(df_Conflict_date_na.rm)){
    df_Conflict_date_na.rm.temp <-
    df_Conflict_date_na.rm[which(df_Conflict_date_na.rm[,country] ==1 ),]
    xy.to.plot.temp <- as.data.frame(table(Reduce(c, Map(
      seq, df_Conflict_date_na.rm.temp$StartYear,df_Conflict_date_na.rm.temp$EndYear))))
    colnames(xy.to.plot.temp) <- c("Year",country)
    xy.to.plot.temp$Year <- as.numeric(levels(xy.to.plot.temp$Year))[xy.to.plot.temp$Year]
    xy.to.plot <- merge(xy.to.plot, xy.to.plot.temp,by="Year",all.x=T,all.y=F)
  }
}
# Use similar to above to find total per year, but with no country limit
df.temp <- df_Conflict_date_na.rm[,colnames(df_Conflict_date_na.rm) %in% countries]
df.temp$sum <- apply(df.temp,1,FUN=function(x){sum(x,na.rm=T)})
df.temp <- df_Conflict_date_na.rm[which(df.temp$sum > 0 ),]
```

```

df.Conflict.Total.Europe <- as.data.frame(table(Reduce(c, Map(
  seq, df.temp$StartYear,df.temp$EndYear))))
colnames(df.Conflict.Total.Europe) <- c("Year","TotalConflict")
df.Conflict.Total.Europe$Year <-
as.numeric(levels(df.Conflict.Total.Europe$Year))[df.Conflict.Total.Europe$Year]
xy.to.plot <- merge(xy.to.plot, df.Conflict.Total.Europe,by="Year",all.x=T,all.y=F)
# end of that part
xy.to.plot <- xy.to.plot[which(xy.to.plot$Year %in% year.range),]
xy.to.plot.melt.2 <- melt(xy.to.plot, id.vars="Year")
xy.to.plot.melt.2[is.na(xy.to.plot.melt.2)] <- 0
#feed to a larger df of different data for graph
xy.to.plot.melt.big.chart.conflict <- xy.to.plot.melt.2
xy.to.plot.melt.big.chart.conflict$Data.Type <- "Conflict"
xy.to.plot.melt.big.chart.conflict$Product.Category.01 <- "Any.Conflict"
xy.to.plot.melt.big.chart.conflict$Product.Category.02 <- "Any.Conflict"
xy.to.plot.melt.big.chart.conflict$Price.Level <- "NA"
xy.to.plot.melt.big.chart.conflict$Series.Grouping.1 <- "NA"
xy.to.plot.melt.big.chart.conflict$Country <- xy.to.plot.melt.big.chart.conflict$variable
xy.to.plot.melt.big.chart.conflict$Location <- xy.to.plot.melt.big.chart.conflict$Country
xy.to.plot.melt.big.chart.conflict[xy.to.plot.melt.big.chart.conflict$Country ==
"TotalConflict","Product.Category.01"] <- "Any"
#Script End

```

D.6. OWDA Analysis

Working with R I have uploaded the entire OWDA and through a combination of packages I have taken a shape file to define country borders/area based on modern definitions, from this I created a raster of points for each country. The raster was created to match that of the grid co-ordinates in the OWDA. From this I aggregated all points for a country, for each year and averaged them providing a countrywide index by year for each country.

D.6.1. Script Name 05210. OWDA Set some Variables:

```

## remember: (y,lat,row), (x,lon,col)
library(RNetCDF)

```



```

#library(rworldmap)
library(raster)
nc <- open.nc(paste0(Folder_Dropbox,"Ludlow & Matthews/OWDA Data/owda.nc"))
ncr <- read.nc(nc,unpack=T)
names(ncr)
lon.min <- min(ncr$lon)
lon.max <- max(ncr$lon)
lat.min <- min(ncr$lat)
lat.max <- max(ncr$lat)
annual <- rep(NA,length(ncr$time))
# is home laptop version.string R version 3.6.1 (2019-07-05)?
owda.custom.locations.df <- data.frame("Year" = 0:2012)

```

D.6.2. Script Name 05211. OWDA Grid Co-Ord list per region

```

library(sp)
library(raster)
library(rgdal)
library(rmapshaper)
#library(tidyverse)
## http://drought.memphis.edu/OWDA/
## https://www.drought.gov/drought/data/category/pdsi-palmer-drought-severity-index
## https://www.ncdc.noaa.gov/paleo-search/study/19419
dx <- 0.5 ; dy <- 0.5 # y for lat & n row, x for lon & col
lat <- seq(lat.min, lat.max, dy)
lon <- seq(lon.min, lon.max, dx)
nx <- (lon.max - lon.min) / dx
ny <- (lat.max - lat.min) / dy
# make an empty grid instead so NA = Ocean
m <- matrix(NA, ncol=nx, nrow=ny)
r <- raster(m, xmin=lon.min,xmx=max(lon),ymn=lat.min,ymx=max(lat))
# Not sure if I need the following...
crs(r) <- "+proj=longlat +datum=WGS84 +no_defs +ellps=WGS84 +towgs84=0,0,0"

```

```

## comment out and limit for Ireland for now.
# EUstates <- c('AUT', 'BEL', 'BGR', 'HRV', 'CYP', 'CZE', 'DNK', 'EST',
# 'FIN', 'FRA', 'DEU', 'GRC', 'HUN', 'IRL', 'ITA', 'LVA',
# 'LTU', 'LUX', 'MLT', 'NLD', 'POL', 'PRT', 'ROU', 'SVK',
# 'SVN', 'ESP', 'SWE', 'GBR')
EUstates <- c('IRL')
### read a shapefile
### downloaded from:
https://www.arcgis.com/home/item.html?id=2ca75003ef9d477fb22db19832c9554f
library(rgdal)
shape <- readOGR(dsn = paste0(Folder_Dropbox,"Ludlow & Matthews/OWDA Data/R
Analysis/countries_shp"), layer = "countries")
shape_raster <- rasterize(shape, r,
field = 'NAME',
background = -9999,
update = TRUE)
#redefine "countries" in a more central place
countries <-
c("France","Poland","Germany","Spain","Netherlands","England","Sweden","Austria","Be
lgium")
shape[shape@data$NAME == "Ireland",]
shape[shape@data$NAME %in% c("France","Spain"),]
shape.raster.list <- list()
shape.raster.list.names <- c()
i<-1
for (country in countries){
country1 = country
if (country == "England"){country1 = "United Kingdom"}
shape.raster.list[[i]] <- rasterize(shape[shape@data$NAME == country1,],r,field=
'NAME',background = -9999,update=T)
shape.raster.list.names <- c(shape.raster.list.names, country)
i<-i+1

```

```

}
names(shape.raster.list) <- shape.raster.list.names
#shape_raster_Ireland <- rasterize(shape[shape@data$NAME == "Ireland"],r,field=
'NAME',background = -9999,update = TRUE)
#shape_raster_France <- rasterize(shape[shape@data$NAME == "France"],r,field=
'NAME',background = -9999,update = TRUE)
#shape_raster_Spain <- rasterize(shape[shape@data$NAME == "Spain"],r,field=
'NAME',background = -9999,update = TRUE)
#shape_raster_France_Spain <- rasterize(shape[shape@data$NAME %in%
c("France","Spain"),],r,field= 'NAME',background = -9999,update = TRUE)
#shape_raster_for_analysis <- shape_raster_Ireland
#shape_raster_for_analysis <- shape_raster_France
#shape_raster_for_analysis <- shape_raster_Spain
#shape_raster_for_analysis <- shape_raster_France_Spain
#shape_raster_for_analysis <- rasterize(shape[shape@data$NAME == "United
Kingdom"],r,field= 'NAME',background = -9999,update=T)

```

D.6.3. Script Name 05212. OWDA Main Drought Atlas Analysis

```

# add custom to "owda.custom.locations.df"
raster.to.matrix.and.custom.OWDA <- function(shape_raster_for_analysis1){
# take shapefile, convert to matrix, then reverse rows. Reverse rows matches order of
NetCDF
coord.matrix <- as.matrix(shape_raster_for_analysis1)
coord.matrix <- coord.matrix[seq(length(coord.matrix[,1]),1,-1),]
idx.col <- which(!is.na(coord.matrix),TRUE)[,"col"] ## 113
idx.rows <- which(!is.na(coord.matrix),TRUE)[,"row"] ## 87
df <- as.data.frame(matrix(,nrow=length(idx.rows),ncol=2));colnames(df) <- c("r","c")
df[,"r"] <- idx.rows
df[,"c"] <- idx.col
df.cord <- df
df.cord[,"r"] <- df[,"r"] * 0.5 + lat.min - 0.5
df.cord[,"c"] <- df[,"c"] * 0.5 + lon.min - 0.5

```

```

idx.val <- list()
for(i in 1:length(ncr$time)){
  val <- ncr$pdsi[i,,]
  for (j in 1:length(idx.col)){idx.val[[j]] <- val[idx.rows[j],idx.col[j]]}
  annual[j]<-mean(unlist(idx.val),na.rm=T)
}
annual
}
#Something needed here for an overall OWDA
for(i in 1:length(ncr$time)){
  val <- ncr$pdsi[i,,]
  #for (j in 1:length(idx.col)){idx.val[[j]] <- val[idx.rows[j],idx.col[j]]}
  annual[i]<-mean(unlist(val),na.rm=T)
}
owda.custom.locations.df[,"Overall.OWDA"] <- annual
#i=1
#custom.owda.list <- list()
for (raster.object.name in names(shape.raster.list)){
  temp <- raster.to.matrix.and.custom.OWDA(shape.raster.list[[raster.object.name]])
  owda.custom.locations.df[,raster.object.name] <- temp
  # i=i+1
}
#custom.owda.list[[1]]
require(reshape2)
owda.custom.locations.df.melt <- melt(owda.custom.locations.df, id.vars="Year")
owda.custom.locations.df.melt <-
owda.custom.locations.df.melt[owda.custom.locations.df.melt$Year %in% 1500:1800,]
colnames(owda.custom.locations.df.melt) <- c("Year","Country","value")
owda.custom.locations.df.melt <-
owda.custom.locations.df.melt[,c("Year","value","Country")]
# ### check one grid cell for validation... This seems to work
# annual.check <- rep(NA,length(ncr$time))

```

```

# j = 8
# idx.rows[j] * 0.5 + lat.min - 0.5
# idx.col[j] * 0.5 + lon.min - 0.5
# for(i in 1:length(ncr$time)){
# val <- ncr$pdsi[i,,]
# annual.check[i]<-val[idx.rows[j],idx.col[j]]
# }
#write.csv(annual, file = "annual.csv")
#write.csv(annual.check, file = "annual.check.csv")

```

D.6.4. Script Name 05213. OWDA Map check:

```

library(ggmap)
library(rgeos)
library(leaflet)
europe <- c(left = -12, bottom = 35, right = 30, top = 63)
coordPrice <- df.cord[,c("r","c")]
colnames(coordPrice) <- c("lat","lon")
map <- get_stamenmap(europe, zoom = 5, maptype = "watercolor")
p <- ggmap(map,size=c(500,500)) +
  geom_point(data = coordPrice, aes(x=lon, y=lat), color="red", size=3, alpha=1.0)
p

```

E. Appendix. Market Dynamics by Location

When developing the analysis for market integration, different analytic approaches were explored. One major question was if to analyse integration by each product, or by each location. Both approaches are necessary. Ultimately the analysis of market integration (on the short to medium term) in chapter 5 was based on each product as this allowed a more focused analysis that related directly to the research questions. However, it is still crucial to understand and explain how this varied from region to region. Thus, the analysis for reaction location was developed. It was made into an appendix (i.e., this appendix) to maintain a more focused flow to Chapter 5. But chapter 5 discusses some key observations that are dependent on the locations. This appendix studies each location, thrust (as will also be the case in Appendix 4), it allows a more extensive study, or starting point of study, for a particular region, if a reader or author would desire to do so.

E.1. Paris

Paris is the first location studied, as the French were amongst the earliest European fishers to arrive at the Grand Banks, returning with the new cod produce. It was one of the earliest regions to experience shifts in market dynamics as a result. Cod, herring, pork, beef, and chicken produce are compared below in Figure E.1. They share a common currency unit, converted from Denier in a variety of units of measure, to a common unit of grams of silver per kilogram of produce. The weight unit is not the same across commodities and active research is underway to generate a standard unit to further allow a comparison of price per unit.

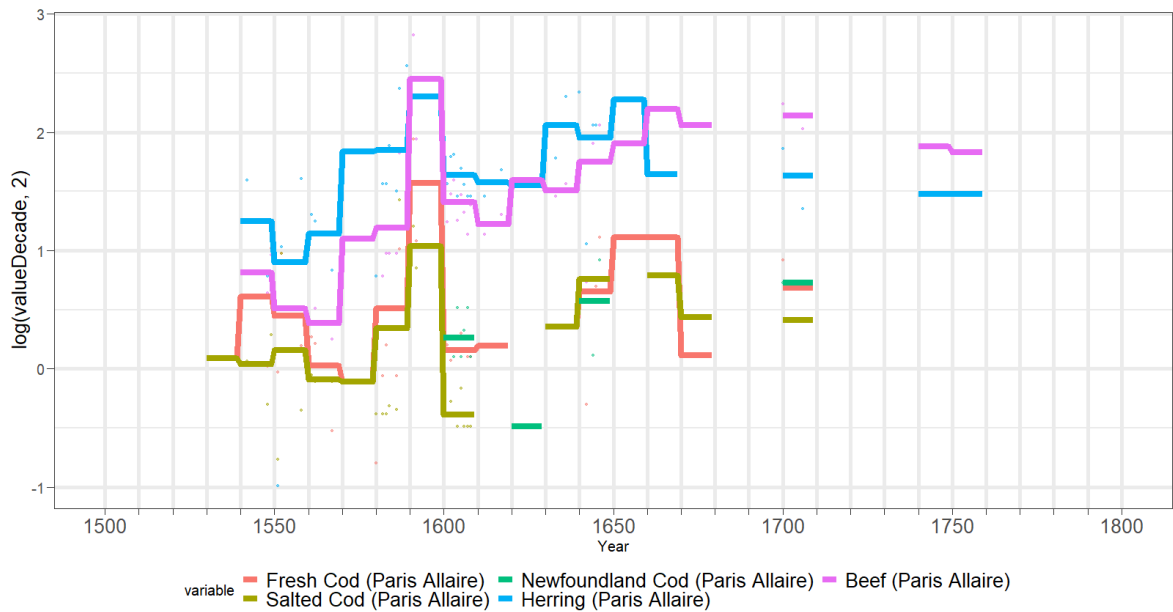


Figure E.1. Paris animal protein sources; cod, herring, pork, beef, and chicken.

Annual values are displayed with the thicker continuous line. The values are grouped and displayed by decadal average, and this is displayed with the lighter dotted line.

The prices displayed in Figure E.1 (above) are based on a report of price information that was drawn from over 70 supply contracts (discussed earlier and further studied in chapter two). The annual prices are displayed in Figure E.1 in grams of silver per kilogram of produce. Decadal values are also displayed with an average of the yearly values, thus providing the medium and long term trends. This averaging also limits the dominance of years with outlying prices (such as the high prices of 1592).

Chicken is usually the most expensive information, based on the above figure.

The majority of the price information is available for the later 1500s, less is available for between 1650 and 1750. The changes in all five products and the price increases are closely related, from the short term to the long term, this is evident as they increase and decrease in tandem most of the time. The magnitude of the changes are also similar, suggesting a common underlying inflation/deflation rate between them.

The price information begins in 1538 and in 1756 CE, displaying a long term price increase over this period. In the 1570s, the increases accelerated and this continues until almost the end of the century. In 1592, the prices hit a peak during a period of high prices, with prices

reaching almost double that of 1550. After this, the prices begin to fall and become quite stable for the first decade of the 1600s. Based on the information available, they gradually increase, peaking in the 1650s, then fall until the 1670s. Limited information is available from the 1650s to the end of the reporting period in 1756, though what is available shows prices are increasing up until the end of the reporting period. A study is underway to identify and analyse further sources in French archives.

These prices are not indicating commodity substitution, they do suggest however that the products are integrated in their respective markets and further that they are driven by common underlying factors, most likely the same factors that drove inflation.

Fish, beef, and chicken, in particular, vary with similar increases and decreases in the first few decades of the 1600s, pork prices are behaving slightly differently in the first decade of the 1600s. A more complete temporal span of prices could perhaps give more reason to indicate changing preferences. With more information on supply and demand, an improved image of the market will emerge.

The Coefficient of Variation (CV) results are displayed in Figure E.2 (below). They are limited because of the sparse availability of information. The individual markets were becoming increasingly integrated, as indicated by a trend of decreasing levels of volatility up to 1650. Following this, there is currently insufficient information to complete any further analysis.

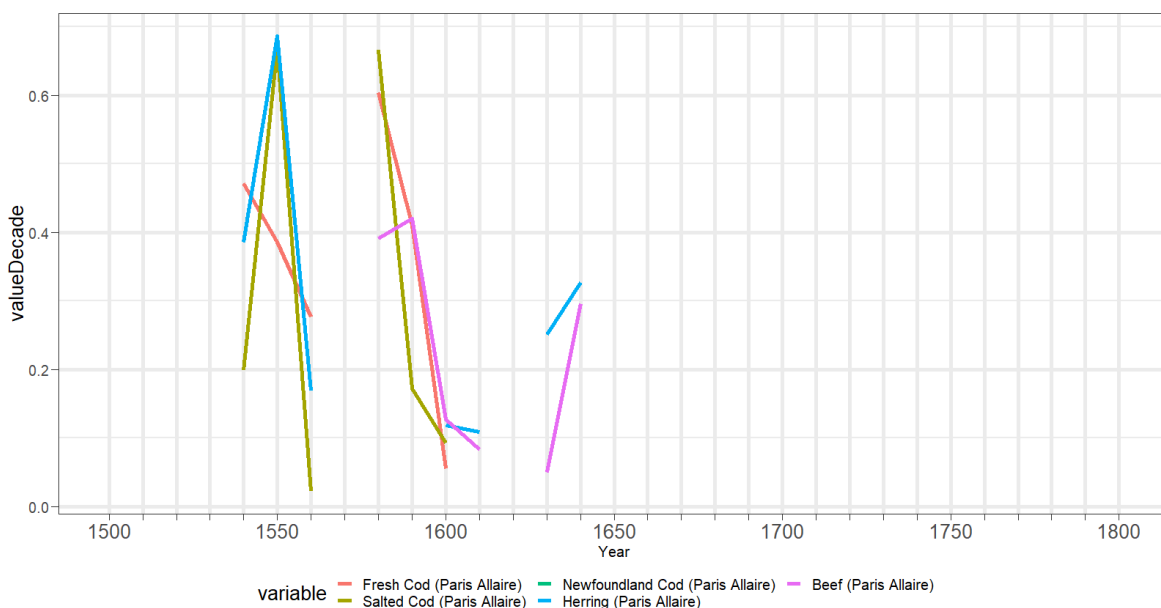


Figure E.2. Coefficient of Variation by decade for Paris.

E.2. Spain - Barcelona and Madrid

Fishers from Spain were amongst the first Europeans to visit the Grand Banks fishery and return with cod. Comparing the new cod products from this location against other staple foods in Barcelona indicates the volatility of this new market as it became established and how it further interacted with products in markets in the same region. In turn this indicates the changing preferences and commodity substitution that may have occurred. Further, some information (from another source) is included and contrasts Madrid.

The prices in Figure E.3 (below) are again log transformed and are all within Barcelona, and Madrid, thus providing the opportunity of contrasting two locations in a related region. Prices follow a similar long term increasing trend over the entire period, with a gradual increase up to around the mid-17th century, before starting to decrease until almost the mid-18th century, before resuming a gradual increase again. Also, many of the larger price changes are shared on the decadal level. In Barcelona, the 1650s was a decade where the prices for cod, herring and mutton all showed a large increase in price. The herring display an increase around the 1670s - this is particularly notable as it is not evident in the cod or sheep meat prices, and this might indicate a change in preference and commodity substitution. In the following decade, the 1680s, the pilchard prices returned to a more normal level, and the cod prices also decreased in that decade, possibly because of an emerging change in preference from fish to sheep, though it is difficult to state that based on this alone.

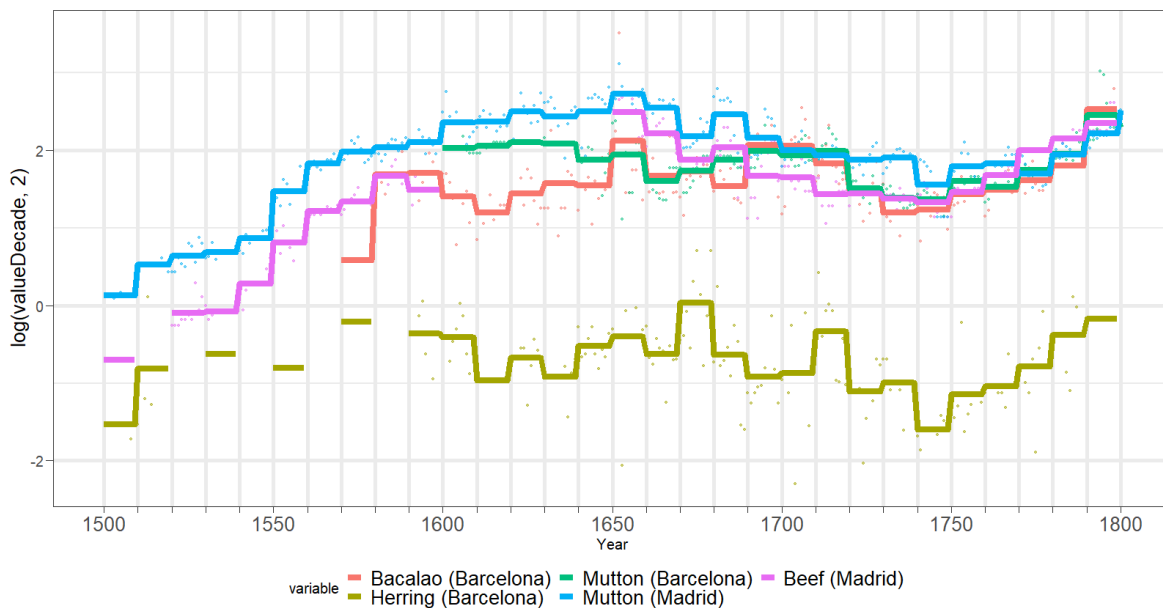


Figure E.3. Bacalao, pilchards and sheep meat products in Barcelona. The decadal values are represented and indicate medium to long term trends.

If there was a shift, this remained for much of the period that followed, as can be seen in Figure E.3. Through the 1710s, cod remained quite stable in price, while the pilchards and beef showed a significant increase and subsequent drop afterwards. But from the 1730s onwards, the commodities shared a common medium to long term price increase trend, indicative of stability between the commodities and no indication of commodity substitution from that point.

Over the long term, from the start of the period there is no major shift in the three products away from one another. Perhaps the herring lost value compared to sheep meat. This common medium to long term change represents common underlying factors, possibly exogenous, that drove price changes in all series, further this trend could resemble that of the inflation rate during the period. The cod prices though start around 1575, thus limiting what can be said of the prices around 1500.

The most prominent period of volatility relates to the cod and occurs in the 1650s (as shown in Figure E.4). The 1650s is a period of large price increases and more volatile prices for many locations, quite likely due to the high levels of conflict at the time. There is also an increase in volatility in the sheep meat market but to a lesser extent than the pilchards. For all products, prices returned to normal levels in the next decade, the 1660s, sheep meat stayed fairly stable until the 1780s. The two fish products followed different paths with

notable high points of volatility in the 1700s before returning again to a period of relative stability.

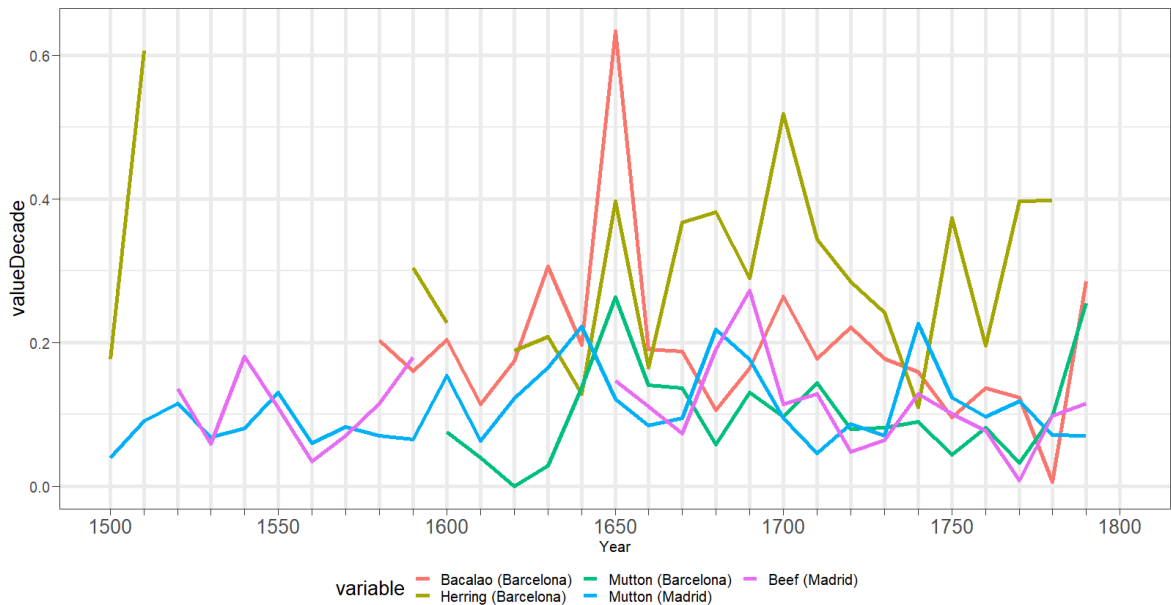


Figure E.4. Coefficient of Variation for prices in Barcelona.

E.3. London

The English did not start out as a significant player during the discovery of the Grand Banks fishery and were not believed to have been active there to a significant degree before 1565.⁴⁹³ When they did arrive, the returning cod produce influenced its markets such as London. As a distinct and separate location from mainland Europe, London can be expected to display different dynamics. Trade did exist between Spain, England, and Newfoundland in what was described by Peter Pope as a “Triangular Trade”, though this occurred later after the discovery of the Grand Banks by Europeans.⁴⁹⁴ Thus the markets will not have been completely isolated from one another. Also, factors exogenous to the London market, such as those that affected the Grand Banks, may have caused common price changes.

Prices remain the same for lengths of time, and this is largely influenced by the prices being set for periods of time in contracts agreed with the institutions they represent. In reality, the prices at an earlier stage of the supply chain, such as the wholesale markets, for

⁴⁹³ William H Lear. “History of fisheries in the Northwest Atlantic: the 500-year perspective,” *Journal of Northwest Atlantic Fishery Science* 23 (1998): 41-74.

⁴⁹⁴ Peter Pope. *Fish into Wine: The Newfoundland Plantation in the Seventeenth Century* (Chapel Hill: University of North Carolina Press, 2004).

example, most likely did not display this stability, and instead did experience far more price volatility, even perhaps on shorter intervals such as days, weeks and months. It would be fair to state, though, that this stability does indicate that there might have been some stability in the broader economy, but the statement should not be too strong.

The London price series in some cases have a large temporal span both prior and following the research period of this chapter. Over the span of each series there are with very few (or no) years missing, though it is possible the authors of the price series may have interpolated the missing years, as evident by straight lines on the graphs. (See **Figure E.5**).

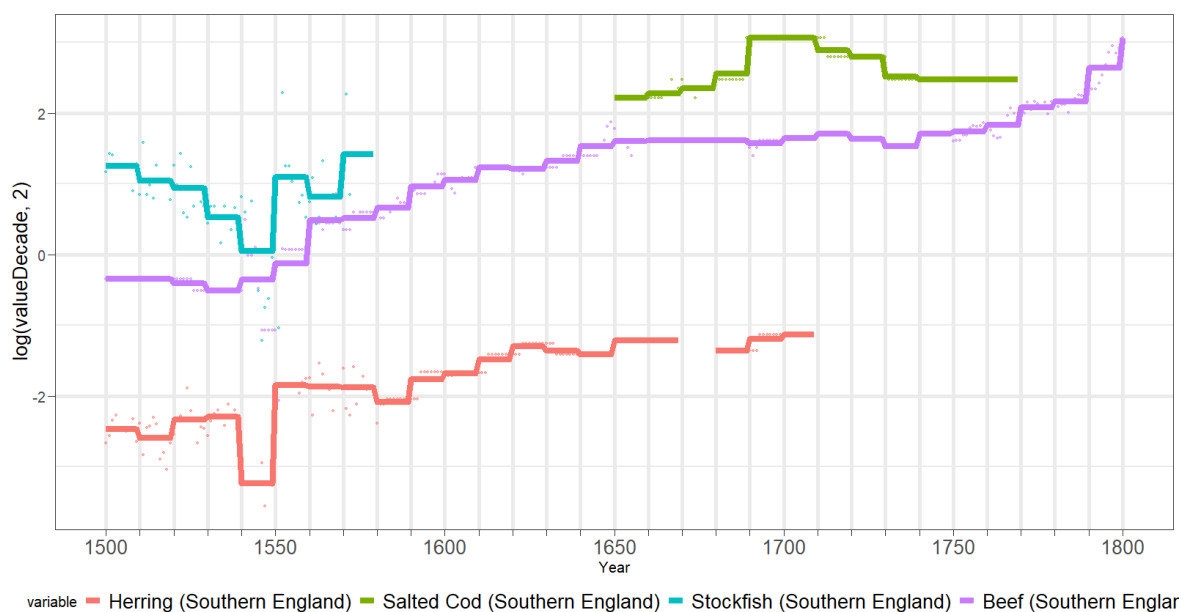


Figure E.5. Price series for fish and beef in London. Converted to prices in grams of silver.

All prices in Figure E.5 (i.e., those for herring, cod, and beef) follow similar long term trends over the period from 1400 to 1850. Prices for all these commodities gradually declined during the 15th century, continuing this trend up to the mid-16th century. This point was pivotal, and all commodity prices began to experience a gradual inflation for the following two to three centuries, some of this will have been influenced by the period of the General Crisis. The lack of long term price change, beginning in the mid-1600s, is in keeping with a hypothesis for decreasing demand for fish in Northern Europe,⁴⁹⁵ though the prices also

⁴⁹⁵ Poul Holm et al. "The North Atlantic Fish Revolution, c. AD 1500. Hypotheses, methodologies, and ways forward," (*Quaternary Research*, 2019), 1-38.

remained stable for beef, so further investigation of factors common to fish and beef could further explain this change.

The prices start to increase from the mid-1700s and at a faster rate, though this is moving beyond the bounds of this study and is simply noted here as an observation. The prices for the different commodities are quite tightly coupled during the study period of 1500 to 1700, not moving largely out of sync with one another over time. This suggests that the individual markets were highly integrated and bore strong relationships to one another. This could indicate the changing inflation rate in London.

Stockfish prices trailed off and disappeared in the 1570s and the salted cod arrived in the 1650s. This is evidence of commodity substitution or at least a change of preference from the stockfish for the new cod from the Grand Banks of Newfoundland. Cod prices are increasing in the lead up to the 1700s, with a very large increase in the 1690s. This higher price level remained into the first decade of the 1700s, before following a trend of price decreases up to the 1730s. Beef prices remained very stable from around the 1650s until around the 1720s, indicating beef products were part of a more stable and established market.

Evidence of commodity substitution is not clear. A search for further prices such as those for chicken and pork products could indicate if these products displayed any indication of commodity substitution. As it stands though, the prices show a stable market over the long term with possibly a transition from the Icelandic cod to the Newfoundland cod.

Higher volatility is evident in the earlier periods, especially in the lead up to the 1550s (as seen in **Figure E.6**). The stockfish prices were especially volatile at that time, recovering somewhat, then becoming very volatile in the 1570s, displaying the largest CV value, before the information stopped. Beef prices behaved similarly with high volatility in the 1540s and 1550s, though with lower CV values. After displaying its highest level of volatility in the 1540s, it decreased over the following decades to a low point in the 1610s. This makes the high volatility for stockfish in the 1570s more interesting, perhaps this volatility was related to the ending of the price series, with an unsettled market. After this the values increased and decreased but not to a very high degree, meaning on the long term they continued on a trend of more stability, showing a much lower CV value in the 1570s before beef price

series covered the entire 300 year period and stayed quite stable for the remainder of the period up to 1800. There were some increases such as the 1640s and later part of the 1700s but not as notable as earlier in the period.

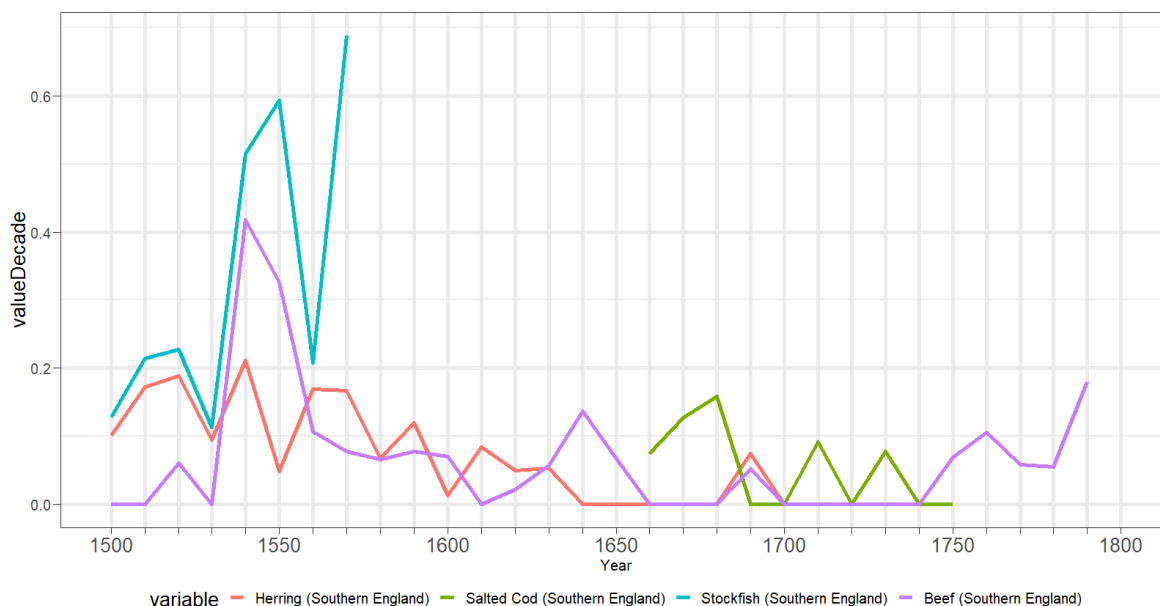


Figure E.6. Coefficient of Variation for fish and beef in London.

The overall lower volatility in beef indicates it was a part of an established and integrated market, thus agreeing what was earlier observed in the discussion of Figure E.5. Herring was very different to beef, it also maintained low volatility levels that further decreased over the study period, though it became especially stable leading up to the mid-1600s and afterwards. Possibly this related to some character of the prices, if they were fixed, or the price series could contain some interpolations (specifically interpolations that fill a gap with a straight line). Salted cod was volatile when the prices became available in the 1660s and more so in the 1670s, before showing some lower degrees of volatility, though as stated before, this is because the prices display little change, which in turn reflects an actuality or interpolated price information. It could also indicate that some markets were volatile in their infancy but quickly established themselves and thus became more integrated. As already mentioned, the character of the English sources will be further explored to understand if they are influencing the CV calculations.

E.4. Amsterdam

A sample of the extensive collection of price information is shown below in Figure E.7. These log transformed prices are all showing the now familiar gradual long term price increase seen in other locations, including a levelling off in the second part of the period. This collection of meat and fish prices. The wholesale prices (herring in green and stockfish in pink) are more variable and lower than their later market counterparts.

Meat and stockfish (non-wholesale) share very similar prices per kilogram of produce. Wholesale stockfish “suffered” a more pronounced price drop than many other products in the mid-1700s, suggesting the stockfish market was less integrated and more prone to shock, perhaps. Another possibility is it was shocked by an event that was more influential on the stockfish than the terrestrial meat market.

Looking at the non-wholesale herring and stockfish prices, they appear to be different in value by around the range of 2 in the logged units, that indicates the stockfish are about 4 times the price of the herring (each change of 1 indicates a doubling of price, thus an increase of 2 units suggested a quadrupling of price, i.e., so $2^2 = 4$). This is interesting because in some ways, a dried stockfish product is four times as full of calories as herring, so possibly they have a similar value when the grams of protein per kilogram of produce is taken into account. In the later half of the study period, the wholesale version of these prices is available, and in this case the price differential is around 1, meaning the stockfish were about twice the price of herring. During the mid-1700s, in the second half, both saw a drop in price, and this ratio of price difference became less. It is possible that during that time, maybe an influx of cod from Newfoundland (different from this cod product) was causing a dip in the demand and prices for stockfish.

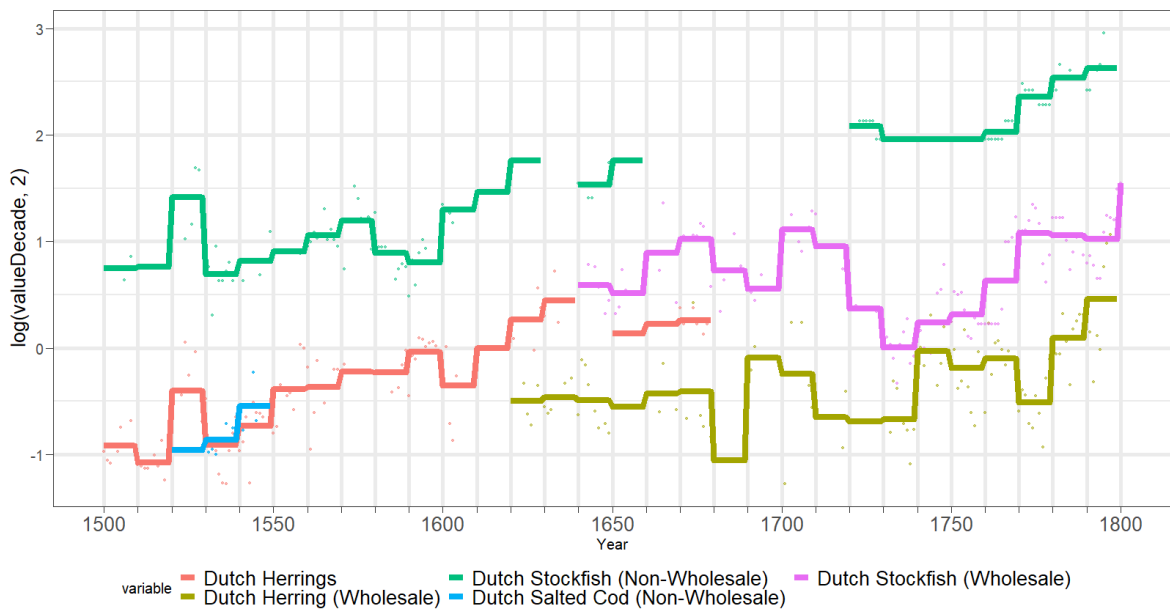


Figure E.7. Amsterdam prices.

As for the variability in the prices (Figure E.8 below), there is a trend of increased price variability in the lead up to and during the 18th century, (possibly familiar from other locations too). The wholesale cod and herring prices being the more volatile, as expected for wholesale markets. The meat and salted cod are more stable in the non-wholesale market, possibly the stockfish prices are the more volatile of the two, indicating the meat market might have been more stable and established.

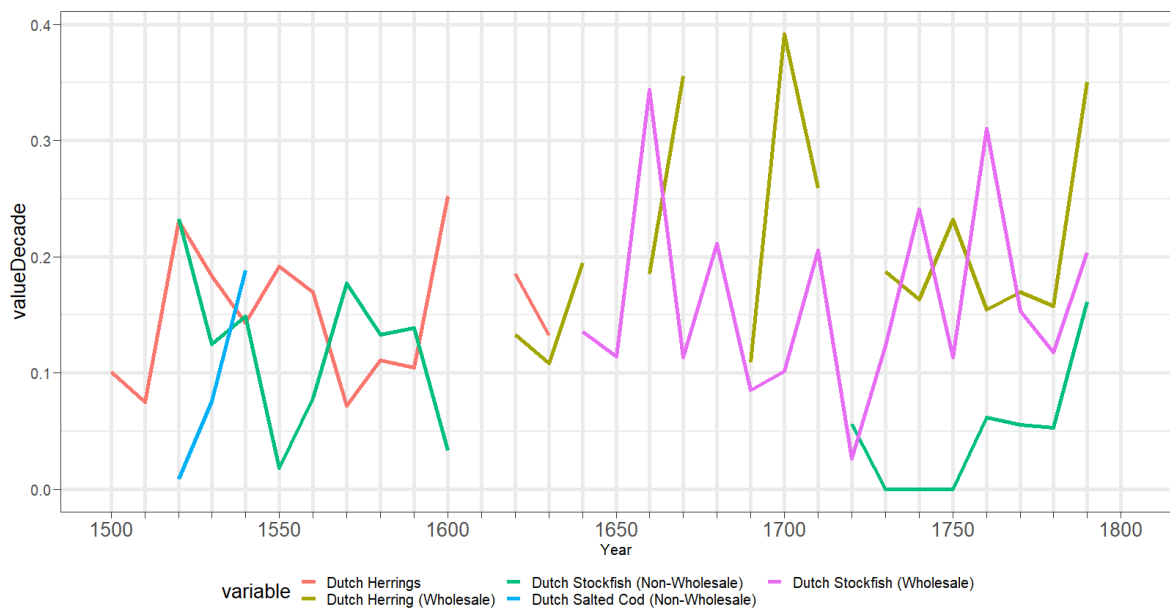


Figure E.8. CV for Amsterdam prices.

E.5. Gdańsk

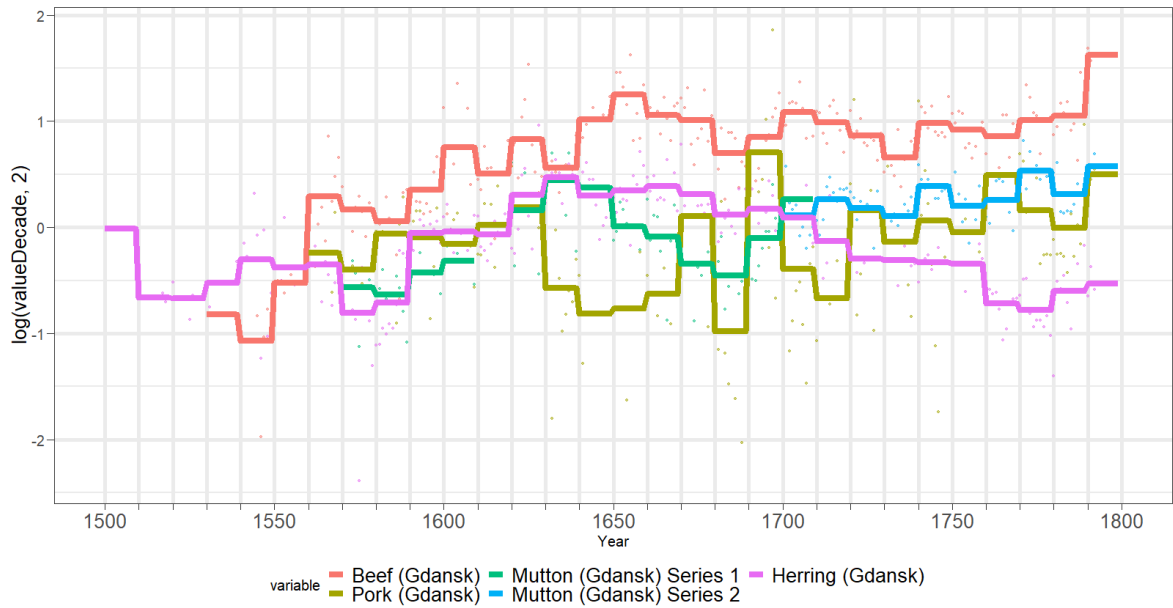


Figure E.9. Gdańsk prices.

Herring price decreased slightly between 1500 and 1800.

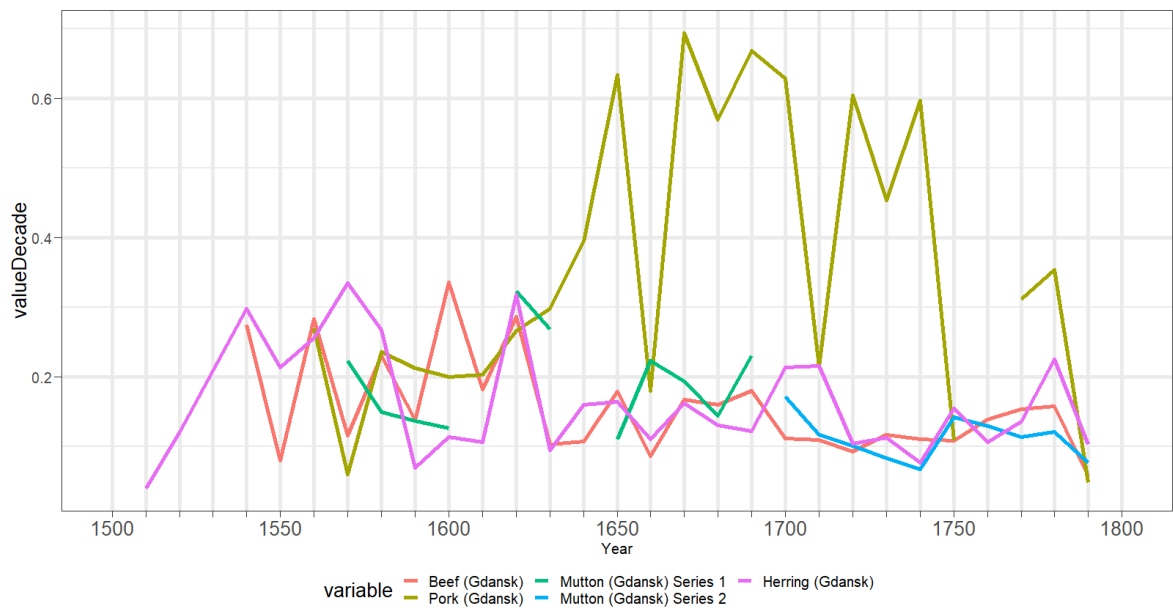


Figure E.10. Gdańsk price CVs.

E.6. Nuremberg

Bauernfeind's prices for rye, herring, and salt (Figure E.11 below) are available from 1500 to 1650. In this case, rye and salt are included to compare against herring in the absence of

other more suitable commodity information for the location. The prices are showing a gradual long term increase, but they did drop in the 1640s, before the information finished. Herring prices did deviate from the other two commodities in the 1630s, dropping considerably for that decade before recovering.

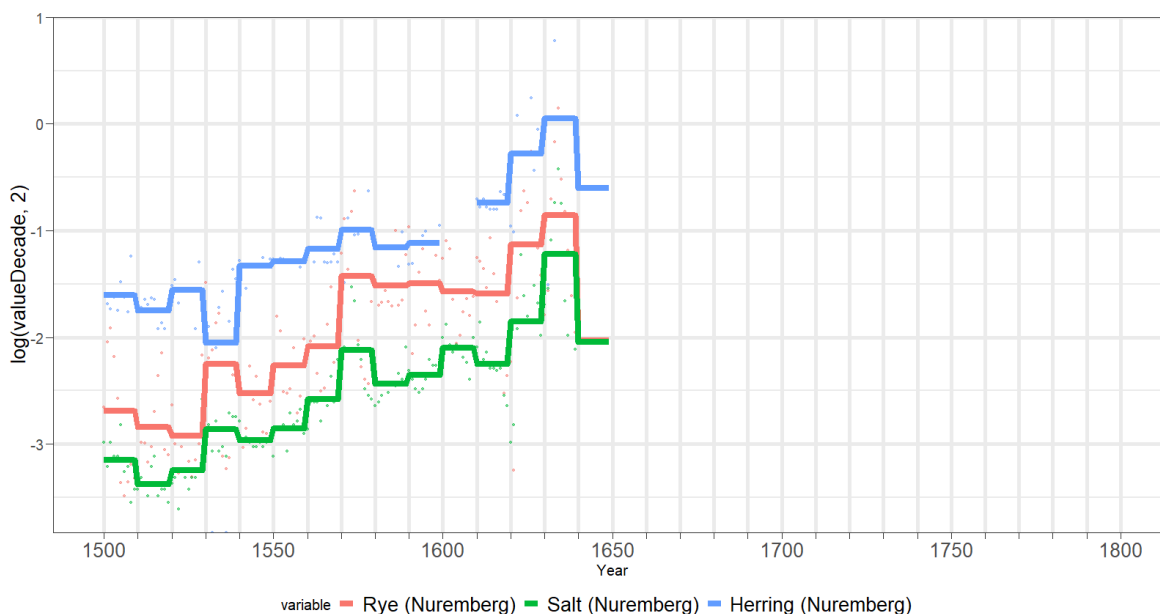


Figure E.11. Nuremberg prices.

Herring prices did show more variability than the other two commodities (as shown in Figure E.12 below), especially in the 1530s, but especially at the end of the period in the 1580s. In other decades, they were below that of rye and usually similar to salt.

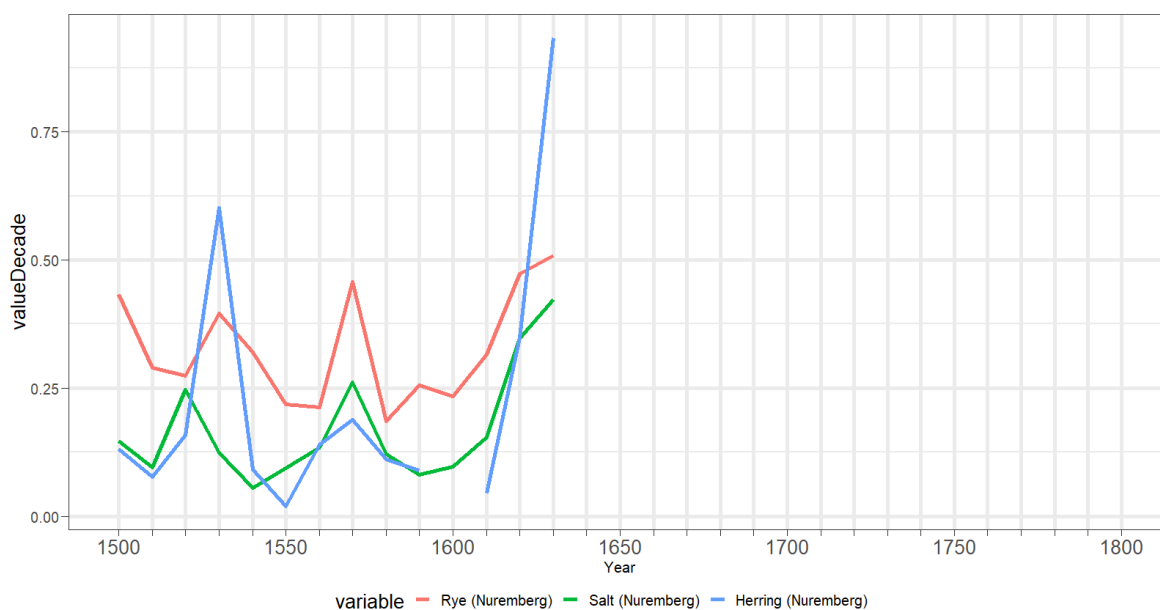


Figure E.12. Nuremberg price CVs.

E.7. Frankfurt

Frankfurt prices include herring. For comparison beef and mutton are included (Figure E.13 below). Prices for herring were usually below that of the two terrestrial meats, though not very different for much of the period. There was a notable deviation with a large price drop for herring and increase in prices for mutton in the first decade of the 1600s. Perhaps this was a shock to markets at the time, one that caused diverging reactions in prices. Such a reaction could be evidence that one product was substituting another. There is limited herring information in the 1700s, but in the earlier decades from the 1710s to 1740s, it is quite possible herring had lost significant relative value when compared to terrestrial meats. Possibly this was related to a trend of higher meat consumption and preferred among the wealthier of the time.

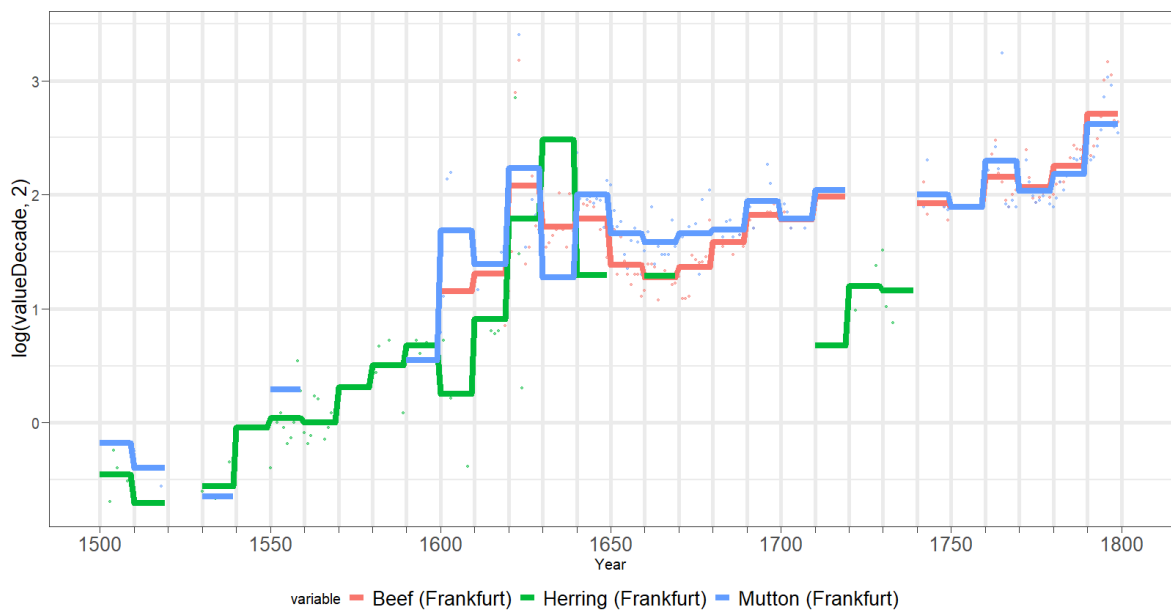


Figure E.13. Frankfurt prices.

The volatility of the prices is shown below in Figure E.14 through the CV. It is difficult to say much about the herring market. Possibly it was less volatile than other markets in the period before the 1620s. By the 1720s/30s, it might have become more volatile than other markets, but it is not certain because of the lack of information for other commodities for the same interval in that time. A more volatile herring market could indicate that preference for herring was changing, and with the prices being relatively lower in that time than other commodities, it is possible that it was becoming less popular in the region. There

is nothing to indicate that a relative price decrease was caused by an increase in herring supply at that time, this is unlikely to be a driver.

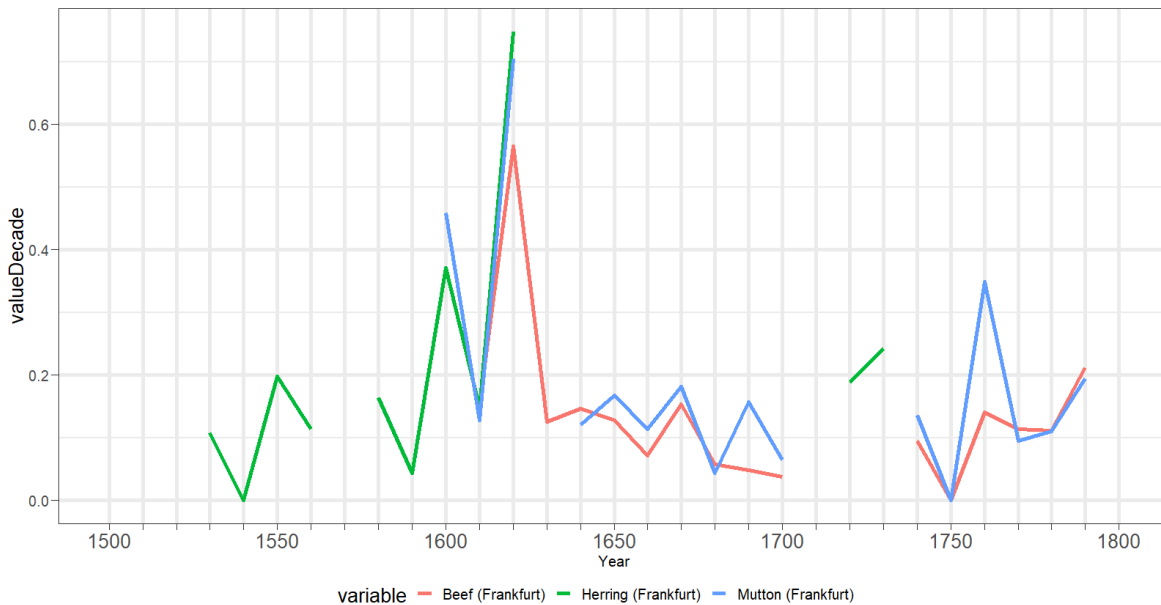


Figure E.14. Frankfurt price CVs.

E.8. Munich

Munich includes prices for both herring and stockfish, while beef is included for comparison (Figure E.15 below). Herring is a much cheaper product than the other two (when prices are available from around 1500 to the mid-1600s, while stockfish is quite expensive. Beef sits somewhat in the middle price-wise. When there is an overlap of cod and herring prices, cod is around 8 times as expensive (based on the chart below, they are different in a range of around 3 units, as this is a log scale, this equates to a price ratio difference of $2^3 = 8$).

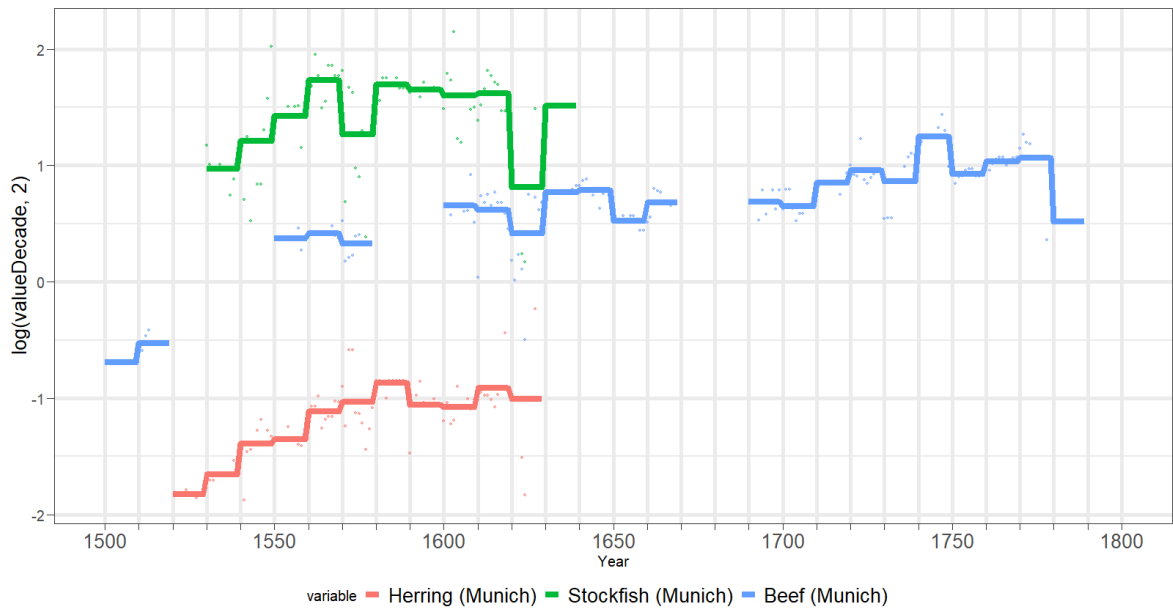


Figure E.15. Munich prices.

Based on Figure E.16 (below), beef prices were the most stable prices much of the time. Stockfish and herring shared similar levels of variability when prices are available from around the 1530s to the 1620s. Though stockfish showed slightly more variability than herring for much of this period before herring prices became slightly more volatile for the last few decades. Possibly both fish markets display higher volatility than beef because they are less stable markets.

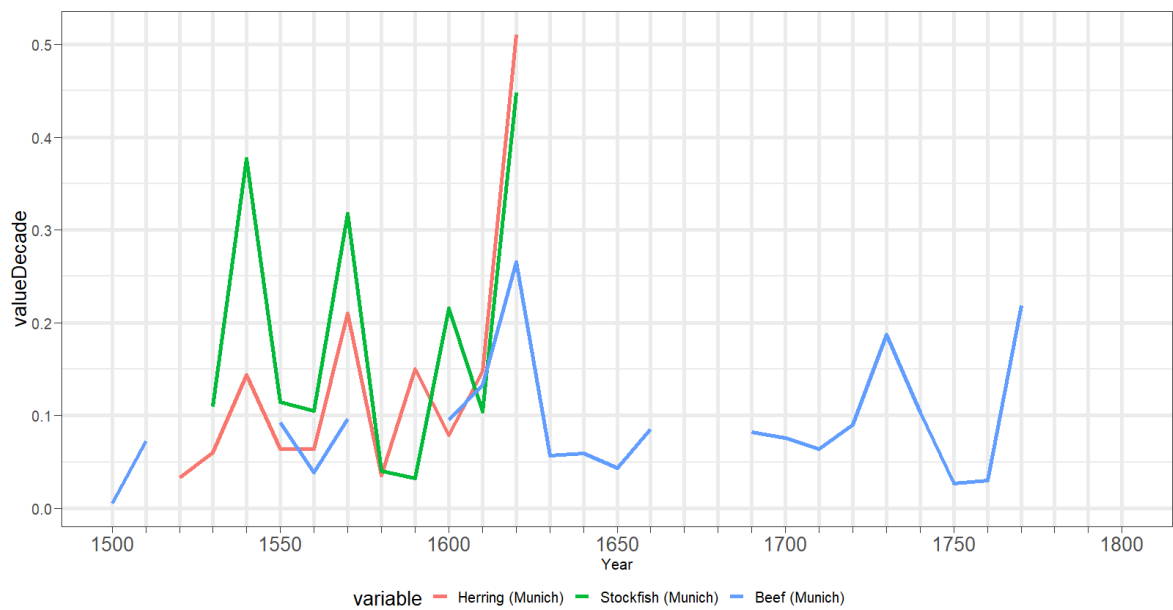


Figure E.16. Munich price CVs.

E.9. Vienna

The information for Vienna covers herring and stockfish, beef is included for comparison. As was the case in Munich, for much of the time, herring was cheapest, stockfish the more expensive with beef sitting somewhere in between. There are two series for stockfish, the one that is referred to in sources as “cheap” spent time around the same price as the other stockfish. But stockfish (non-cheap) did deviate to over twice as expensive at times in the 1700s. Cheap stockfish shares prices that are similar to beef. Stockfish prices are limited and difficult to compare to either beef or herring. But herring prices have good coverage, and they tend to follow beef prices for much of the period (when they are available). Thus, herring market was integrated and quite stable relative to the likes of beef. Even the fracturing of stockfish into two different products could indicate some sort of lack of integration of the markets, with herring sold more as a homogeneous product.

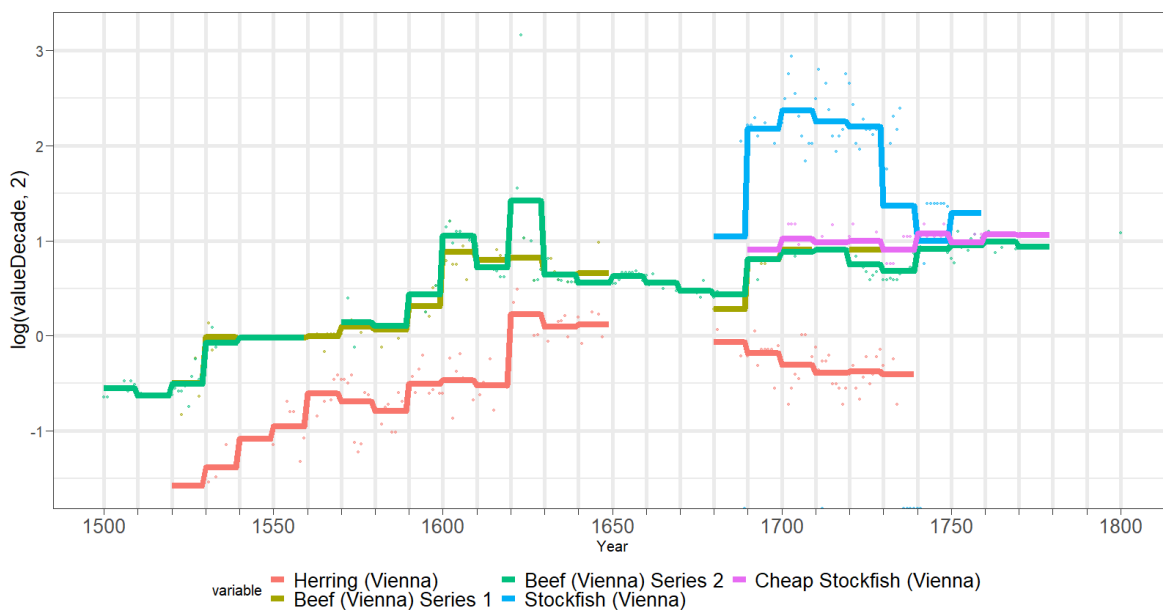


Figure E.17. Vienna prices.

Stockfish showed very high price volatility, with a value of almost 2 in the late 1600s, this is one of the highest CV values in any region studied in this thesis at any time. This could be caused by anomalous records, distorting the CV. Though, it is also possible this was due to a specific event in Vienna at the time. On the other hand, the herring was not very volatile in price, but a bit more than the apparently more stable beef prices. Though beef prices

became quite volatile around the 1620s, a time when both this product and herring prices increased substantially.

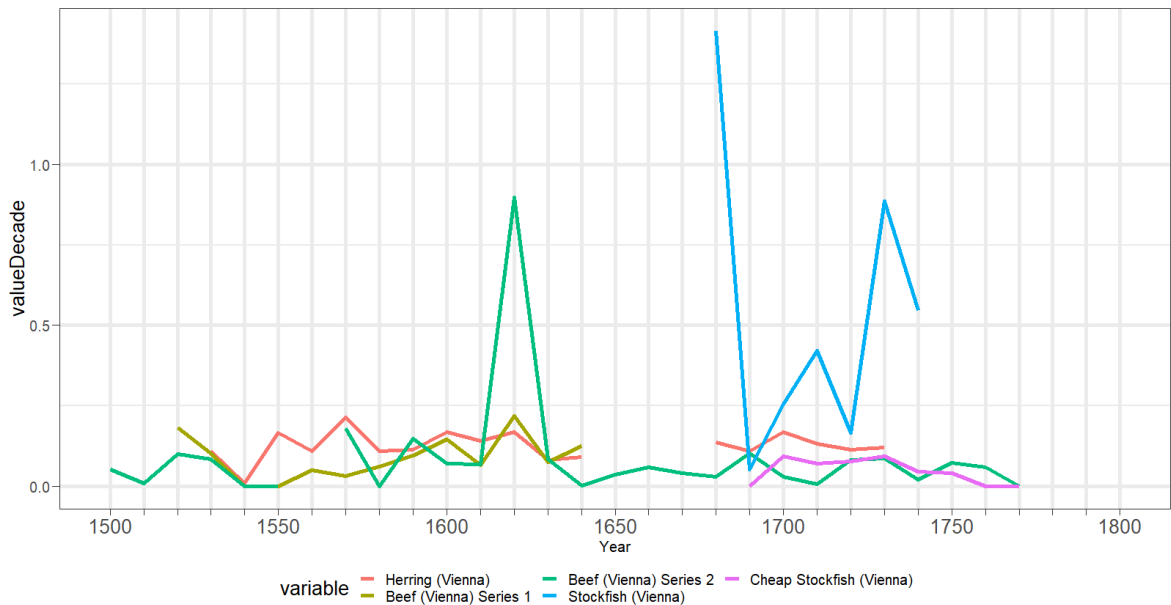


Figure E.18. Vienna price CVs.

E.10. Stockholm

Stockholm herring prices give a perspective of the dynamics of Scandinavian markets, situated in a peripheral and distant location in Europe. The prices cover the period from around the 1630s to the 1740s.

Prices cover herring, pork, and oxen (Figure E.19 below). They all display a net increase over the course of the entire time period, i.e., a long term price increase. The medium and long term changes for both series are similar, indicating both sets of prices were driven by the same underlying factors that are also represented by inflation. There is no clear indication of commodity substitution.

Strömming herring was the cheapest product, over half the prices of the sill herring. Sill shared similar prices to beef. Pork was a more expensive product than the rest, though it is difficult to stage this with certainty because of the limited information that is available.

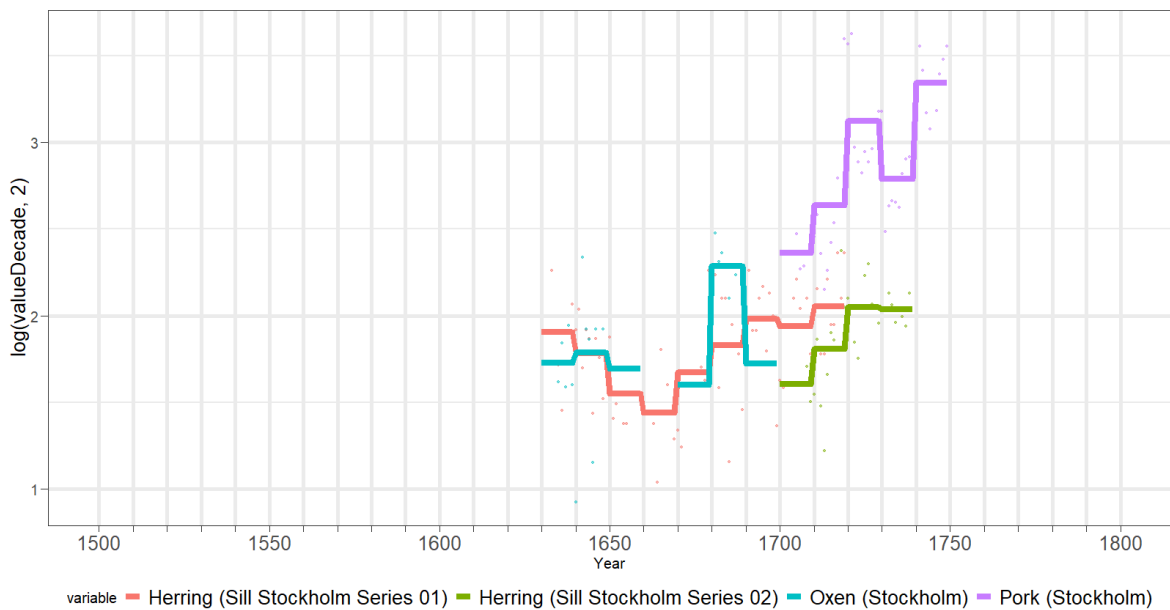


Figure E.19. Price series for herring and oxen in Stockholm.

The CV levels (Figure E.20 below) are quite mixed. For both series they appear to increase from relatively low volatility in the 1580s and then increase dramatically in the 1590s.

Most of the CV values stay in a range of 0.1 to 0.2, these being familiar values from many of the other locations and products already studied. The 1710s show the largest spikes in values, reaching over 0.5 for the stromming. In the following decade the values dropped to the more normal levels seen prior to 1710. This notably large CV value is indicating an event that was influential on various products throughout the Stockholm market.

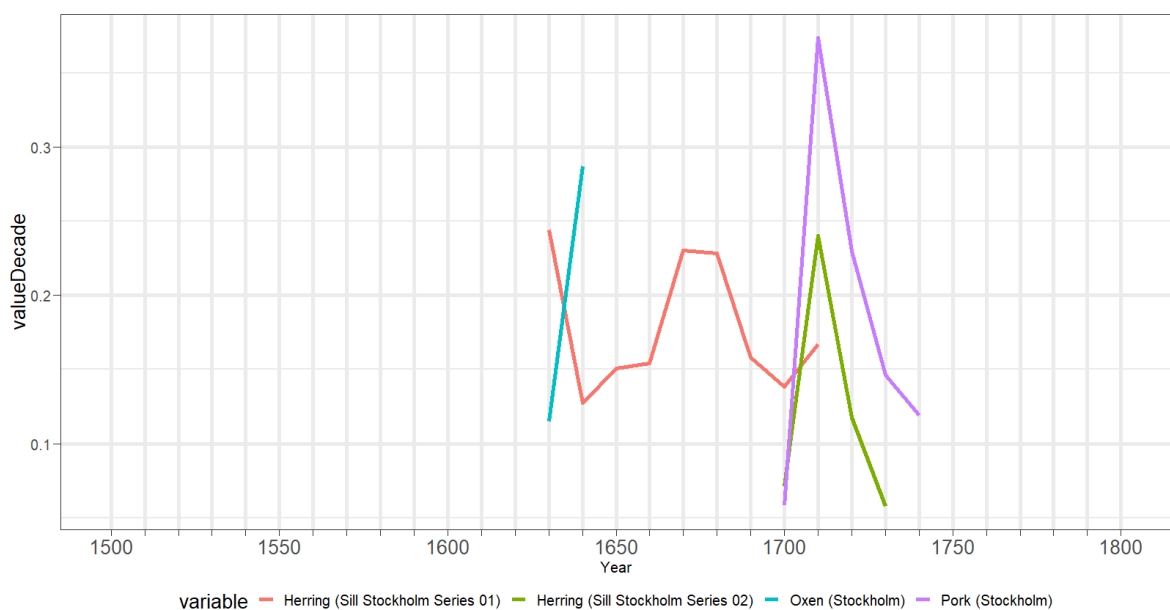


Figure E.20. Coefficient of Variation for herring and oxen in Stockholm.

F. Appendix. Conflict Levels by Location

While Developing the analysis for Chapter 6 (i.e., conflict), each location needed to be studied to understand what was unique, or common, when compared to other locations. This section explores the majority of the locations and price information that was introduced in earlier chapters. A decision was made to make this material an appendix to allow a more focused discussion in the core conflict chapter, and the chapter instead focused on some core observations for Europe and some locations. (Similar to the reasons for developing Appendix 3.) This appendix is rich in detail that could foster or encourage research of each location.

The structure of this appendix, such as the Habsburg Empire, is not necessary. Other approaches could be employed, it has been included in this instance to provide some grouping of the vast amounts of information that were available.

F.1. British Empire - Southern England

The prices below (Figure F.1) represent those paid for cod, herring, beef, wheat, and bread in Southern England. These commodities are following similar long-term trends to one another, such as the now familiar increases during the Price Revolution, which is followed by a period of relatively stationary prices.

The red trendline in this instance represents the average price per year of these five commodities. This is a price index for Southern London (similar to the product indices described in Chapter 6). It is analogous to a Consumer Price Index (CPI), which is based on an average basket of goods that could also include a weighting for the quantities of how much of each commodity was consumed. The index here is a simpler indicator, serving the purposes of displaying to what degree the prices related to one another.

In the 1540s there was a large decrease in prices, with a full recovery in the 1550s. The price decrease is followed by high levels of conflict. These conflicts revolve around England against Scotland and France. There are also a number of rebellions.

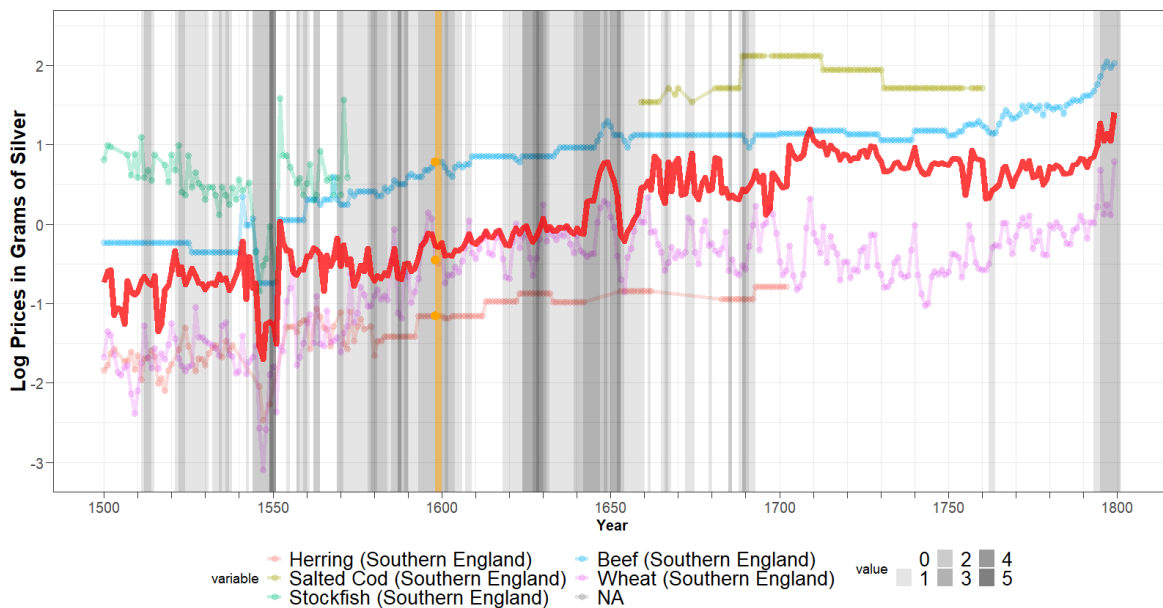


Figure F.1. English prices (log transformed) for herring, stockfish, salted cod, wheat, and beef.⁴⁹⁶ They are compared to conflict.

A number of so-called revolutions are hypothesised to have occurred in England during the study period, many of which are termed as economic revolutions. Stuart Jenks describes a “Distribution Revolution” that occurred prior to the study period. The Distribution Revolution describes new developments in the markets in London, influenced by the Hanseatic League, including a stratification of the markets into urban wholesale and rural retail.⁴⁹⁷ This included more integration between the various levels of the markets, described as “vertically integrated” by Jenks. Perhaps this influenced the prices increases associated with the Price Revolution. Following this period, the Consumption Revolution was said to have occurred in England during the 18th century.⁴⁹⁸ This came with the increased consumption and variety of goods and products, including luxury goods, by people from many different economic and social backgrounds. Prices show more stability during this time, and inflation was low or absent.⁴⁹⁹ This may have led to lower prices for much of the population.

⁴⁹⁶ The Great Debasement drove the price drop in the lead up to 1550. Prices received from this debasement a number of years later.

⁴⁹⁷ Stuart J Jenks. “15. The Missing Link: The Distribution Revolution of the 15th Century,” in *Textiles. The Medieval Economy: Production, Trade, Consumption of Textiles, 8th to 16th Centuries*, ed. Angela Ling Huang and Carsten Jahnke (2015).

⁴⁹⁸ Neil McKendrick, John Brewer and John Harold Plumb. *The Birth of a Consumer Society: The Commercialization of Eighteenth-Century England* (Indiana University Press, 1982), 9-10.

⁴⁹⁹ *Ibid*, 137.

There is evidence that prices in Southern England were more volatile during times of elevated conflict. For example, around 1550, when England was in conflict with the French and Scottish. The Thirty Years' War (1618 to 1648) involved England from around 1624.⁵⁰⁰ Towards the end of this war, prices increase sharply, and then decrease sharply in the following years, eventually returning to levels that might occur with a more ordinary level of inflation. Marine fish product prices, when available at this time, do not appear to share this trend to the same degree as other products, though this at least in part due to limitations on the price information being agreed contract or set-prices. As another example, at the end of the study period, increased prices occur, it is possible that this was influenced by the French Revolutionary War with England. This effect influenced all the prices, and was not unique to the marine fish produce, thus suggesting all products were similarly influenced. Conflict levels between France and England deserve special notices, as they are similar in both countries (France is discussed later). This is because both countries were involved in the same conflicts, but on opposing sides. For example, the Anglo-French War (1557 to 1559), the Italian War of (1551 to 1559), and the France-England war from 1548 to 1550.

Looking at dominant merchants during the study period, the Hanseatic League in London were in a good position at the start of the beginning of the 16th century, maintaining one of its four central Kontors in what is now known as the London Steelyard. There was also competition from the City of London. Hansa dominance continued for the majority of that century, with King Edward IV of England reconfirming privileges in the Treaty of Utrecht (1474). Over a century later, in 1598, Queen Elizabeth I ordered the closing of Steelyard and forbade the Hanseatic League from trading and expelled them.⁵⁰¹ Thus English merchants were more dominant from around the turn of the 17th century. This appears to have little influence on the prices. This could indicate that neither the Hanseatic league nor the English merchants were involved in trading the commodities included in Figure F.1 (above) for this time. Thus, it is difficult to understand if this change of trading company influenced other parts of the market.

⁵⁰⁰ Ronald G Asch. *The Thirty Years War* (Macmillan Publishers Limited, 1997), 73.

⁵⁰¹ Dollinger Philippe. *The German Hansa* (1970).

F.2. France - Paris

Conflict featured heavily in France in the early modern period. Prices and conflict levels for France are shown below in Figure F.2. As was the case in England, for most products the price increased in the first half of the study period. This was common to both the marine produce and other terrestrial meats. The French Wars of Religion, nine in total, occurred from 1562 and 1598. They were civil wars and were influential on the prices. For example, during the Siege of Paris in 1590, prices displayed substantial increases. This influenced all prices though, rather than the marine fish or other commodities.

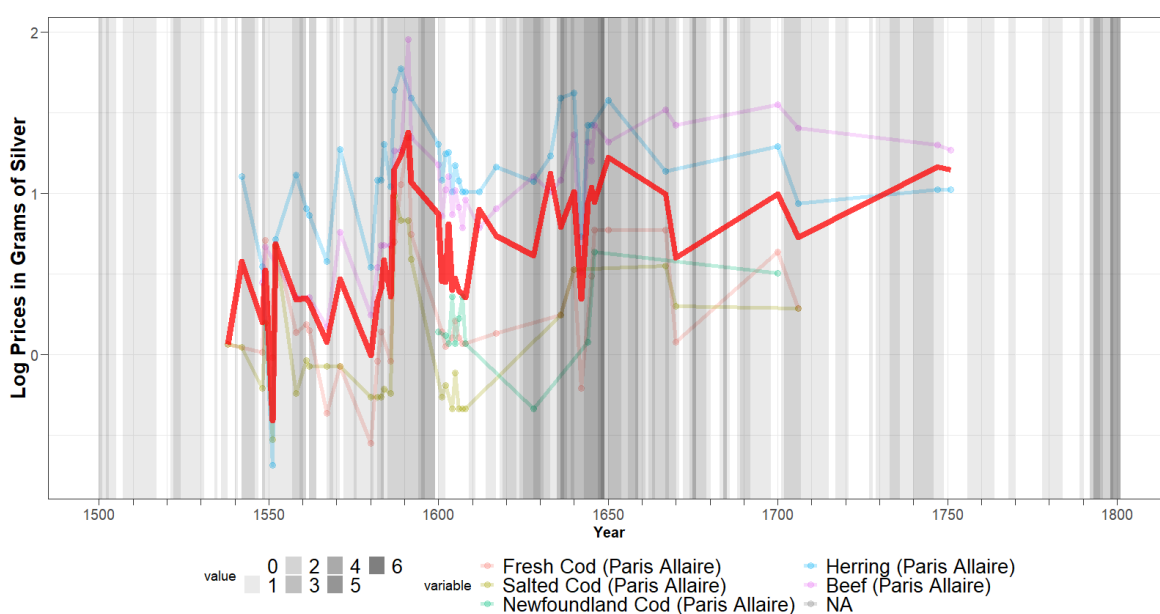


Figure F.2. Prices in Paris (log transformed) and compared to conflict. Cod, herring, and beef are included and compared to conflict. (Wheat prices have not been included as they disproportionately distort the graph).

The French were involved in conflicts with a number of European nations, England featured quite a bit as noted earlier. Also, in the lead up to 1650, from 1635 to 1648 the Franco-Spanish War occurred. The Seven Years' war from 1756 to 1763 left France with a loss of colonies.⁵⁰² In the absence of price information for marine fish though, it is not possible to state what influence this might have had. Prices did increase towards the end of the 1700s, and this might well have been due to Napoleon and the French Revolution, beginning in 1789 and lasting until 1799 and Napoleonic Wars (1803 - 1815).

⁵⁰² James C Reilly. *The Seven Years War and the Old Regime in France: The Economic and Financial Toll* (Princeton University Press, 1986), 223.

France was stable in the sense that there were no major changes in the ruling empire of the trading companies, which suggest such events would not have influenced price changes.

F.3. Habsburg Empire and The Holy Roman Empire

The Habsburg Empire was at the head of the Holy Roman Empire for the majority of the research period.⁵⁰³ The empire spanned many parts of Western Europe, both north and south as well as parts of Central Europe. At different times, this included The Netherlands, Belgium, Spain, Germany, and parts of Poland. Each of which is studied later in this section. Though Spain is studied separately to represent southern Europe.

During the study period, the Hanseatic League was influential in many of the locations that spanned the Holy Roman Empire and beyond, in particular from the 13th to 16th centuries. It maintained its four main kontors (i.e., trading locations) in Novgorod, Bruges, Bergen, and London. Thus, its influence spanned Northern Europe, and from the West to Eastern extremes and beyond. The league was weakened by the beginning of the 14th century. The Hanseatic League's influence waned though as national and country borders became prominent in the 15th and 16th centuries. The Novgorod kontor was gone, the Bergen one was not important. The Hanseatic League kontor of Bruges moved to Antwerp in the mid-1500s.⁵⁰⁴ As noted earlier, the English kontor was closed at the end of the century. Also, when Bruges, Antwerp and Holland all became part of the Duchy of Burgundy, they tried to take over the monopoly of trade from Hansa. Because of this, some Hansa markets moved from Bruges, transferred to Amsterdam. In some regards this is the opposite of globalisation, with isolationism developing as many nations began to set up their own trading companies. The last (formal) meeting of the league occurred in 1669 and only nine members attended. Only three members remained until the end in 1862, Lübeck, Hamburg and Bremen.⁵⁰⁵ The German Empire was created shortly after this under the rule of Kaiser Wilhelm I.

⁵⁰³ Peter H Wilson. "Bolstering the Prestige of the Habsburgs: the End of the Holy Roman Empire in 1806," *The International History Review* 28, no. 4 (2006): 709-736, 709-10.

⁵⁰⁴ Add this as an event to be displayed on the chart(s).

⁵⁰⁵ This is why only Lübeck, Hamburg, and Bremen retain the words "Hanseatic City" in their official German title.

There was much conflict during the study period involving regions controlled by the Holy Roman Empire and the Habsburg Empire, much of which was influenced by religion. In 1517 Martin Luther began the Protestant Reformation. This led to religious tensions until the Peace of Augsburg (1555). The Protestant Reformation brought social and political change, which extended to merchants and is credited to a degree with the rise of Dutch and English merchants. There was pressure on trade routes, due to religious affiliations associated with merchants' groups. In the following century, more difficulties arose. The "Defenestration of Prague" in 1618 set in motion the events of the Thirty Years' War, with dramatic scenes of protestants throwing Catholics out of windows. The war concluded with the Peace of Westphalia (1648), which was part of the end and decline of the Holy Roman Empire. As noted in the last section, Napoleon was also instrumental in the demise of the Holy Roman Empire.

F.3.1. Austria - Vienna

Austria was at the centre of the Habsburg Empire and the Holy Roman Empire during much of the research period, with the Habsburg monarchy situated there. They were the incumbents of the Duchy of Austria from 1278 to 1453 and moved to the title of Archduchy of Austria from 1453 to 1564. In later times, the monarchy in Austria came to prominence after the Thirty Years' War from 1618 to 1648. It was established with Austria's rise to power in that time.

Prices for Vienna are below (Figure F.3) for herring, beef, and stockfish. The conflict levels were lower in the 1500s, becoming higher in the 1600s and 1700s. The elevation in conflict begins around the start of the Thirty Years' War in 1618. Prices are following the familiar long term pattern seen in other locations of the increase during the price revolution and stationarity from the 1600s onward. Prices are available for beef and herring during the Thirty Years War, and they displayed a dramatic increase for a number of years during that time, before returning to ordinary levels. With this common trend of price movement for beef and herring, they could have been good substitutes for one another, in particular, during that period, when stress on food prices were high.

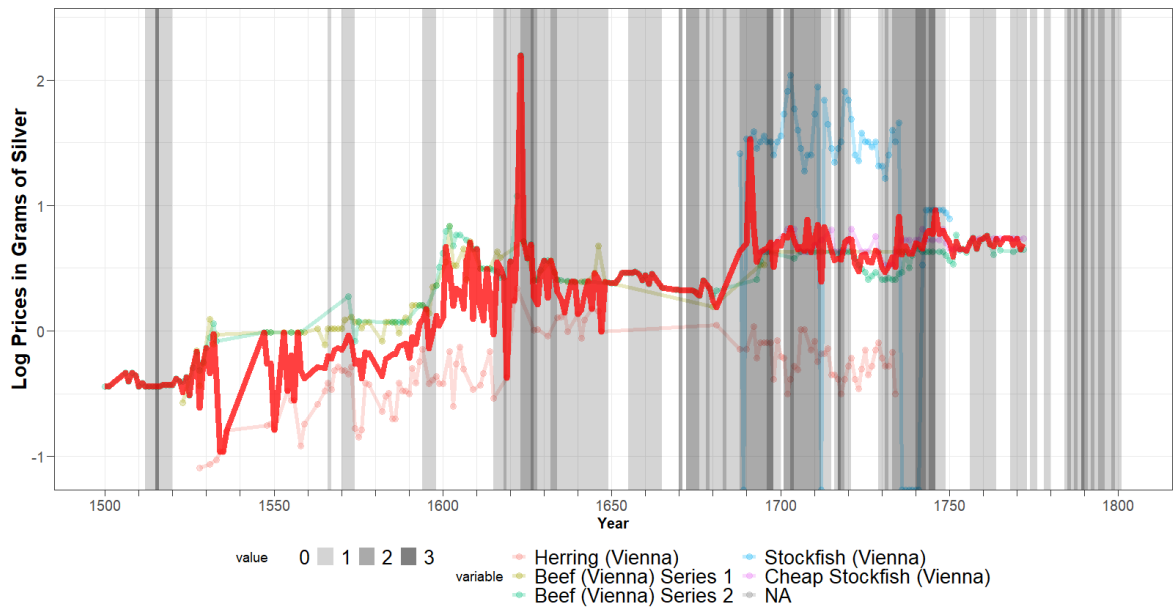


Figure F.3. Vienna prices (log transformed) and compared to conflict levels. Covers herring, cod, beef, and stockfish.

F.3.2. The Netherlands - Amsterdam

The Dutch were a prominent trading nation, and one also involved in much conflict during the study period, as discussed earlier. There was tension between the Dutch and the Hanseatic League, as evident by the Dutch-Hanseatic War from 1438 to 1441. The Dutch eventually formed their own trading companies, which became quite prominent. For example, in 1602, the Dutch East India Company was established (Verenigde Oostindische Compagnie or VOC).

Table below (Figure F.4) contains prices for Amsterdam and surrounding regions in the Netherlands. They cover herring, stockfish and salted fish, meat, and wheat. Some series are for wholesale markets and others for hospitals. The conflict levels in this location were elevated in the late 1500s, which was largely due to the Eighty Years' War (1566-1648).

Prices in Amsterdam follow a gradual increase through most of the study period. This is somewhat different from other locations, where most regions saw stationary prices over the long-term in the aftermath of the Thirty Years' War. This reflects a degree of stability in Dutch markets, and reasonably stable growth. The Dutch experienced what is referred to as the Dutch Golden Age, which broadly spanned the 17th Century. This might have

influenced the price inflation, through gradual economic growth. In this time the Dutch were prominent in trade, science, military, and art.⁵⁰⁶

The period of the Eighty Years' War displayed some inflation over the entire period though, thus suggesting conflict did not cause price stagnation. The trendline in Figure F.4 is also more volatile in that time, this is evidence that in the short term, conflict might have been causing less stability in the markets. Overall, the gradual increase in prices in the aftermath of the Thirty Years' War does suggest the Dutch were in a good position economically, better than many other nations.

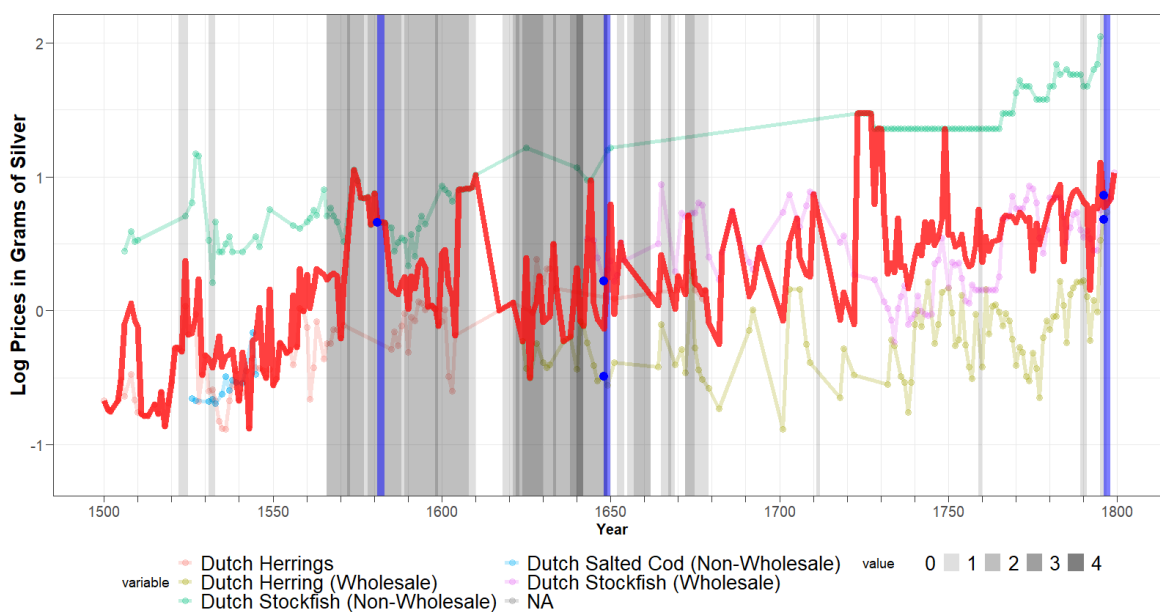


Figure F.4. Prices in Amsterdam with conflict levels in grey. Covers herring, stockfish, salted cod, meat, and wheat. Netherlands conflict levels in grey.

F.3.3. Belgium - Antwerp

Belgium was not an independent nation, as it is today, at the beginning of the 1500s. It was under Habsburg influence and part of the Netherlands following the study period within the 1800s.

The prices for Antwerp are below (Figure F.5), and are limited to herring in this case, around 1700. For conflict, only the Thirty Years' War is shown, rather than attempting to figure out what conflicts the modern-day provinces of Belgium were involved in historically. Perhaps

⁵⁰⁶ Some regions in Europe had a period of prosperity in the aftermaths of the warfare in the previous century and into the first half of the 17th century.

because Belgium was part of the Netherlands during the study period, some similarities in price might be expected. But this is not clearly the case. Antwerp prices do follow the trend of increases of the Price Revolution, but the prices do drop dramatically in the years before the Thirty Years' war, before increasing dramatically during the war. In this instance, herring price may have been influenced, in the form of the price volatility, in that time.

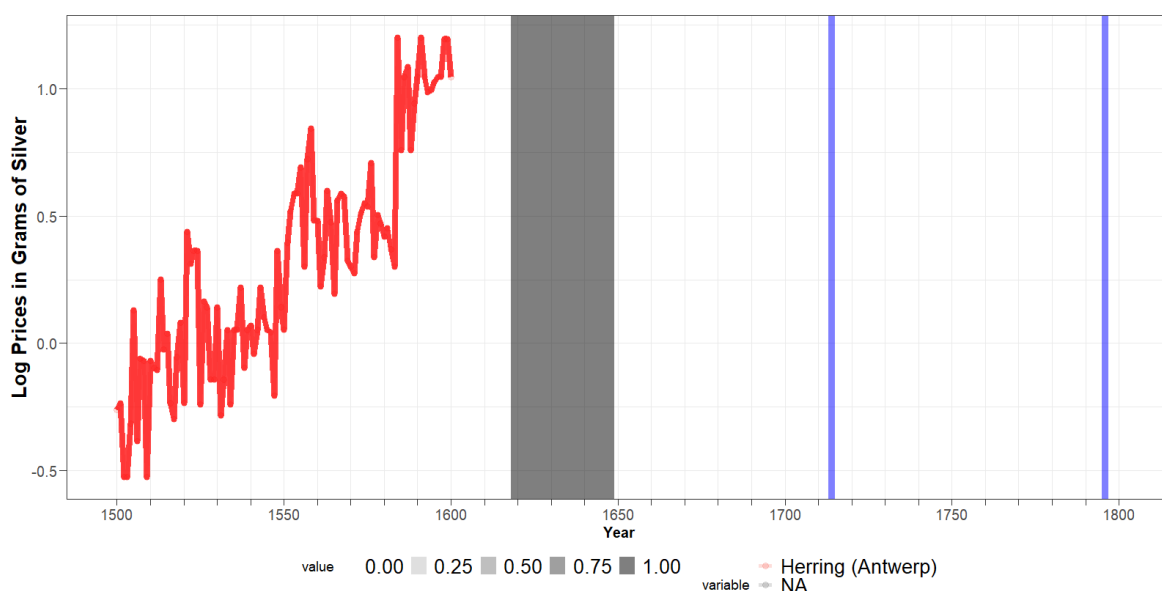


Figure F.5. Prices in Antwerp for herring. Conflict levels are not especially indicated on this chart, as Belgium was not a country at the time, and further refinement is needed to indicate the associated conflict levels.

F.3.4. Germany - Munich, Frankfurt, and Nuremberg

In the case of Germany, price series are available for more than one location. This section discusses Munich and Nuremberg, both located in modern day Bavaria. The conflict levels are very low at the start of the period, they increase from around the beginning of Thirty Years' War, continuing after the mid-17th century until the early 18th century.

Table below (Figure F.6) includes price series for Munich for herring, stockfish, beef, wheat, and rye. Based on the trendline, prices experienced a larger decrease during the first half to three quarters of the 17th century than was observed in other regions. This is largely due to the lack of information on stockfish in that time, which would have increased the average trend for price. Prices appear influenced by conflict, with a large drop and recovery in the early 1620s, but this is not unique to the marine products either. Looking over the period of the Thirty Years' War, wheat, rye, and herring do display similar price changes,

suggesting they could replace one another. Beef prices were more stable, thus suggesting a somewhat separate market from these, one that was also able to endure difficulties arising from conflict.

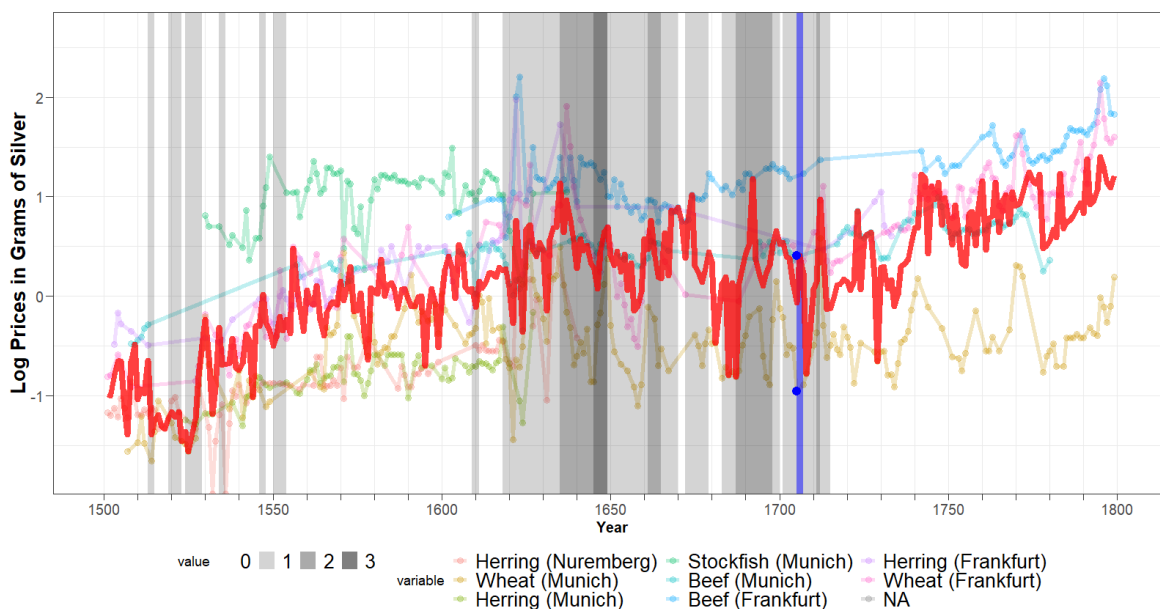


Figure F.6. Prices in Nuremberg, Munich and Frankfurt compared to conflict levels. Nuremberg (herring), Munich (wheat, herring, beef, and stockfish) and Frankfurt (beef, herring, and wheat). They are compared to conflict levels.

Price information for herring, salt, and rye in Nuremberg (Figure F.7) is available from around 1500 and ends in 1640, thus it is not possible to discuss how prices increased in the period of conflict after this point. It is evident though that Nuremberg was experiencing the common trend of price increases that relate to the Price Revolution in other locations. The Thirty Years' War came with price volatility. Around the start of the war, prices dropped substantially for all three commodities, this was followed by a number of steep increases and decreases, meaning they were highly volatile up to 1640. These fluctuations are similar to what was seen in Munich in that time, but perhaps they are more extreme in the case of Nuremberg. Because changes were similar for each product, this indicates that herring was not behaving in an isolated or different fashion than rye or salt. So again, this similarity in herring prices does suggest it could have substituted other commodities, seeing as the relative difference in commodity prices stayed quite similar.

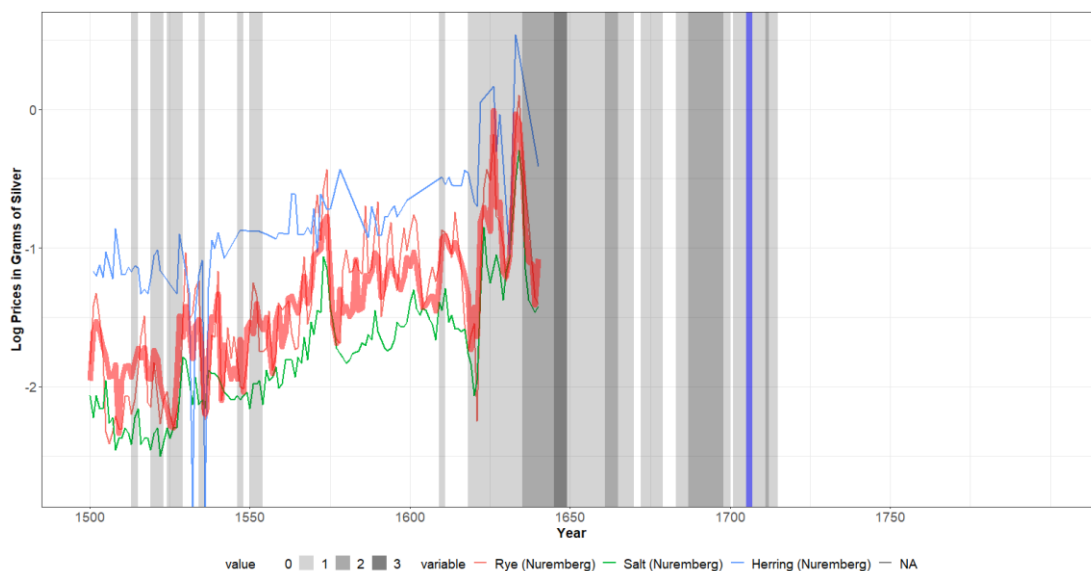


Figure F.7. Prices in Nuremberg for herring, salt, and rye. They are compared to conflict levels.

F.3.5. Summary

These locations do share common long-term price increases, in particular gradually increasing over the period of the Price Revolution, and levels of relative stationarity in the aftermath. Prices do appear to become more volatile during periods of conflict than in periods of relative peace, the most common being the Thirty Years' War. The periods of increased conflict differ between regions. For example, the Dutch experienced more conflict in the latter parts of the 16th century than Germany. And as such, Dutch prices were more volatile in that late 16th period.

F.4. Poland - Gdańsk

Poland went through a number of changes of control in the early modern period. It was part of the Polish-Lithuanian Commonwealth from 1569 to 1795. In this latter part of this period, Poland was partitioned by the Habsburgs of Austria, the Kingdom of Prussia, and the Russian Empire. These occurred around 1772, 1790 and 1795.

Figure F.8 includes price information for Gdańsk, covering beef, pork, and herring. It displays reasonably consistent levels of conflict for Poland. It was elevated though around the time of the Thirty Years' War. Prices increased quite sharply early in the Thirty Years' War, before dropping substantially, and recovering. Possibly this happened again by the end of the war. So, the prices were volatile in that time.

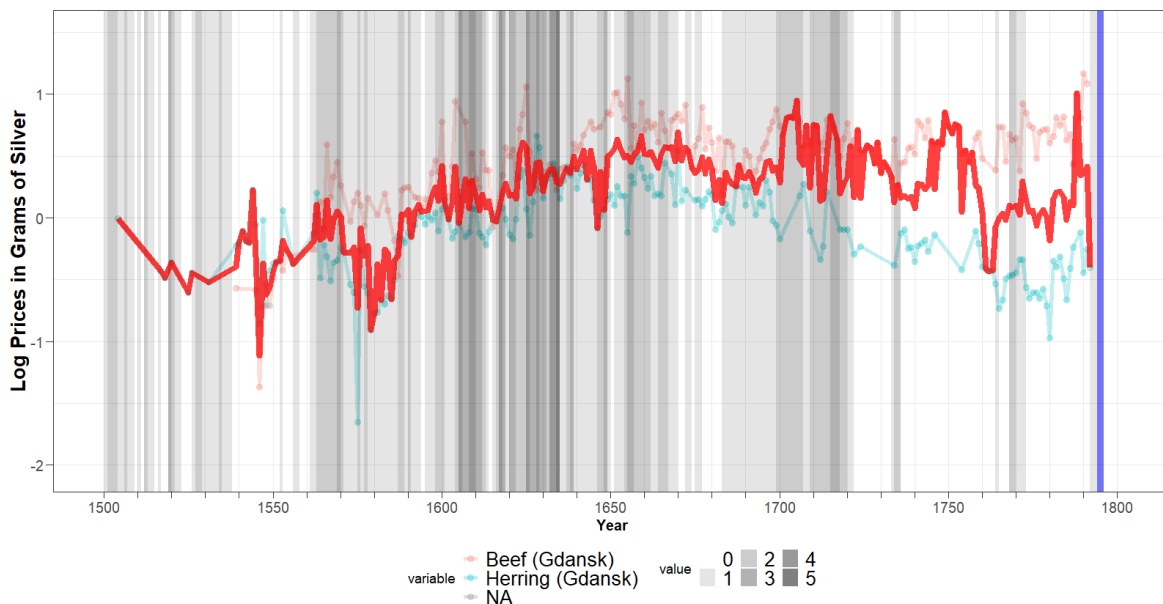


Figure F.8. Prices in Gdańsk for beef, herring, and pork. They are compared to conflict levels.

F.5. Spain - Barcelona, Madrid, and Valencia

In the early part of the research period, Spain was under control of Habsburg Spain, lasting from 1516 to around 1707. The Spanish Habsburgs reign came to an end in 1707 with the Nueva Planta decrees, which declared Spain as a unified state. Giving good geographical coverage of Spain, Barcelona, Madrid, and Valencia are each discussed separately.

F.5.1. Barcelona

Price information for Barcelona (Figure F.9) includes bacalao, herring, sheep meat and wheat. The familiar trend of increasing prices in the 1500s and early 1600s is not as apparent in this instance for the individual price-series, suggesting markets in Barcelona behaved differently. Bacalao prices are available from the last quarter of the 1500s.

As for change of rulers, the change at the beginning of the 1700s, from Habsburg Spain to the Spanish Bourbons, does not show any significant price changes immediately. A number of years later, there is a large price drop and subsequent recovery. This is quite pronounced for both bacalao and herring, and less so for mutton.

Regarding conflict, Feliu observed prices of bacalao remain remarkably similar to that of wheat until the War of Separation (Guerra de Separación de Cataluña 1641-1655), there is

a much higher growth in bacalao prices for a time after this.⁵⁰⁷ What is also notable in that time is the high bacalao price is contrasted by a large decrease in the herring prices, as shown on Figure F.9 below. Thus, herring prices behaved differently to bacalao during that period of conflict, suggesting that perhaps the cod was becoming more desirable than herring, leading to higher prices, or there were difficulties in importing it. It is also possible that abundant and cheap herring might have come with lower prices. This would have made it a good substitute for the more expensive cod produce.

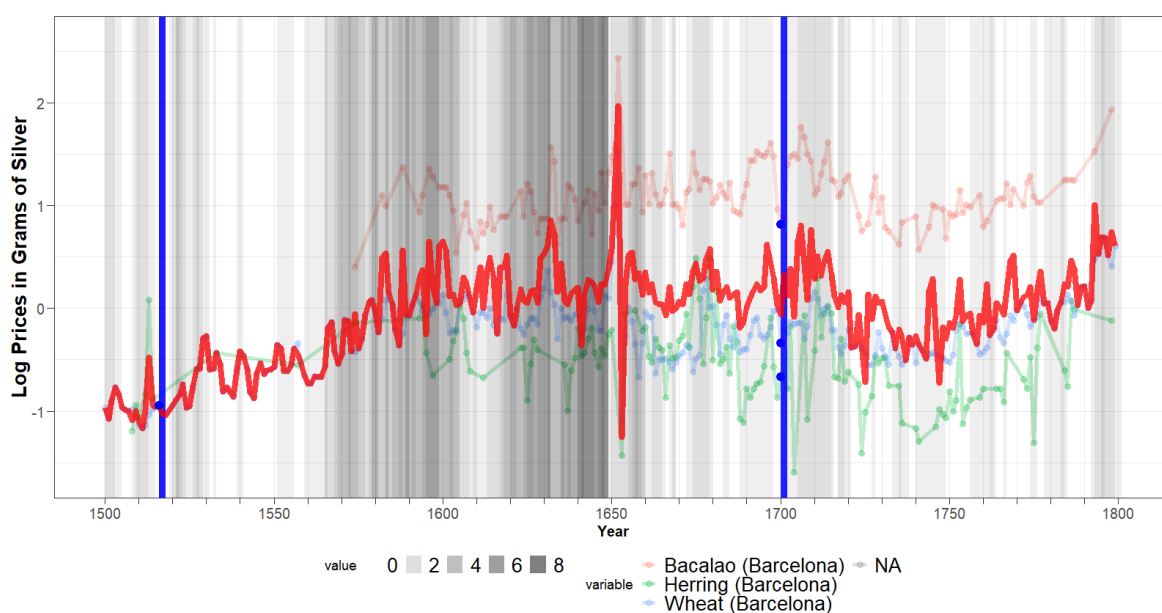


Figure F.9. Prices in Barcelona for bacalao, herring and mutton. They are compared to conflict levels.

F.5.2. Madrid

Prices in Madrid are telling a different story than Barcelona, or at least a clearer one, because of the larger availability of price information (Figure F.10). It is clearer that Madrid is experiencing the familiar trend of price increase for the first half of the early modern, but it is not as stationary in the latter half. In fact, it experiences price decreases up until the early 1700s before starting to increase again until the end of the study period. The prices in this instance include “dried fish”, mutton, wheat, beef, and eggs. It is not certain if the “dried fish” product is cod, however, dried fish usually refers to this. It is behaving similar to other products (mutton, beef, eggs and wheat).

⁵⁰⁷ Gaspar Feliu. *Precios y Salarios en la Cataluña Moderna*. vol. 2. (Madrid: Banco de España, 1991), 121.

The elevated levels of conflict around 1550 to 1650 may have been influential on the price increases, similar to other locations studied so far. Though the dried fish was following similar trends to the other commodities, this suggested they shared similar markets and could have substituted for one another at times.

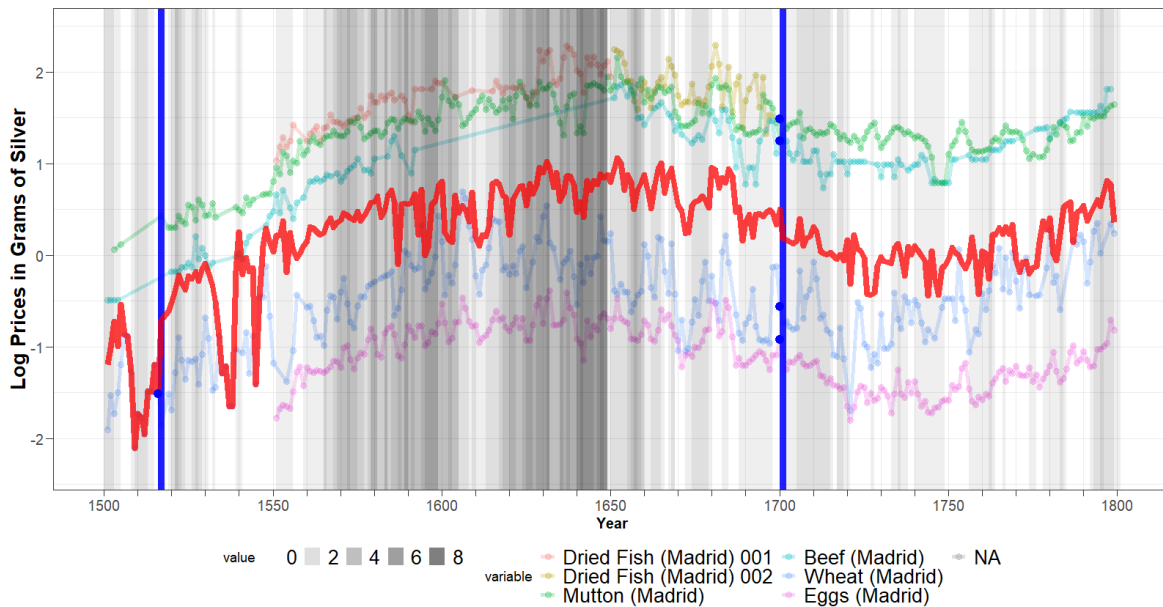


Figure F.10. Madrid prices compared to conflict levels. (Sardines, dried fish, mutton, wheat, eggs, and wheat) compared to conflict leaves and other events.

F.5.3. Valencia

Prices in Valencia for mutton, sardines and wheat are shown below (Figure F.11). They do not include cod or herring, but the sardines are available for comparison. As a small pelagic fish, they might have behaved similar in the market as the likes of herring. Over these commodities, prices are behaving similar to Barcelona and Madrid, with similar medium to long-term price changes.

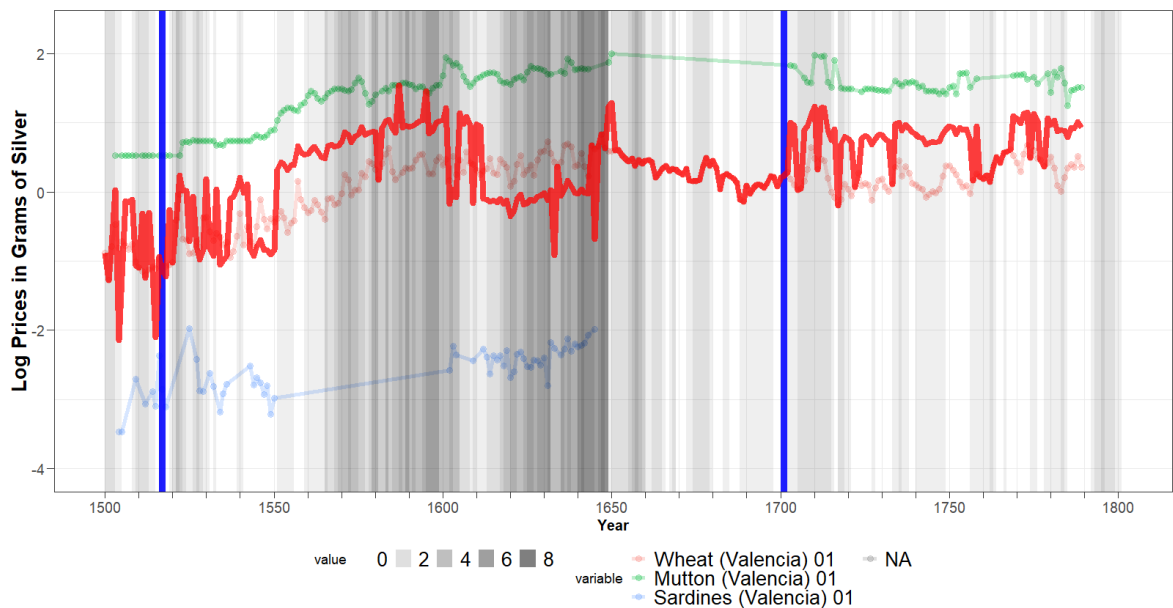


Figure F.11. Prices in Valencia compared to conflict levels. (Wheat, mutton, and sardines).

F.5.4. Summary

Prices were more stationary over the entire study period in Madrid than Barcelona, indicating that Madrid might have had more stable and integrated markets. Assuming that the dried fish was cod, in both locations cod produce was similar in price to mutton.

F.6. Sweden - Stockholm

At the start of the study period, Sweden was part of the Kalmar Union, which lasted from 1397 to 1523, this Union also included Denmark and Norway. Between 1523 to 1611 modern Sweden was formed, and from 1648, Sweden became an empire.

Chart below (Figure F.12) shows prices for Stockholm. Price information is available from a point during the Thirty Years' War, for over a century ending around 1750. At the start of this, the oxen prices were more volatile than the marine fish prices.

Prices were going through a long-term decline in that time, continuing until a point around the 1670s, before a recovery started. Also, with regard to conflict, during the Scanian War (1674 and 1679) commodity price fluctuations in all commodities can be seen. Later, all products came with elevated prices during the times of elevated conflict in the early 1700s. Possibly this was due to the Second Northern War (1700 to 1721) and the British-Swedish War (1715 to 1721). The Swedish empire ended in 1721 as a result of the Great Northern

War that began in 1700 and lasted until 1721. As can be seen in Figure F.12, levels of conflict were elevated in that time, and prices did see a sharp increase in the late 1710s to early 1720s. Thus, this elevated level of conflict came with elevated prices. This looks to have happened to all products though, with nothing unique to the herring. So again, this could make the herring a good substitute for other products.

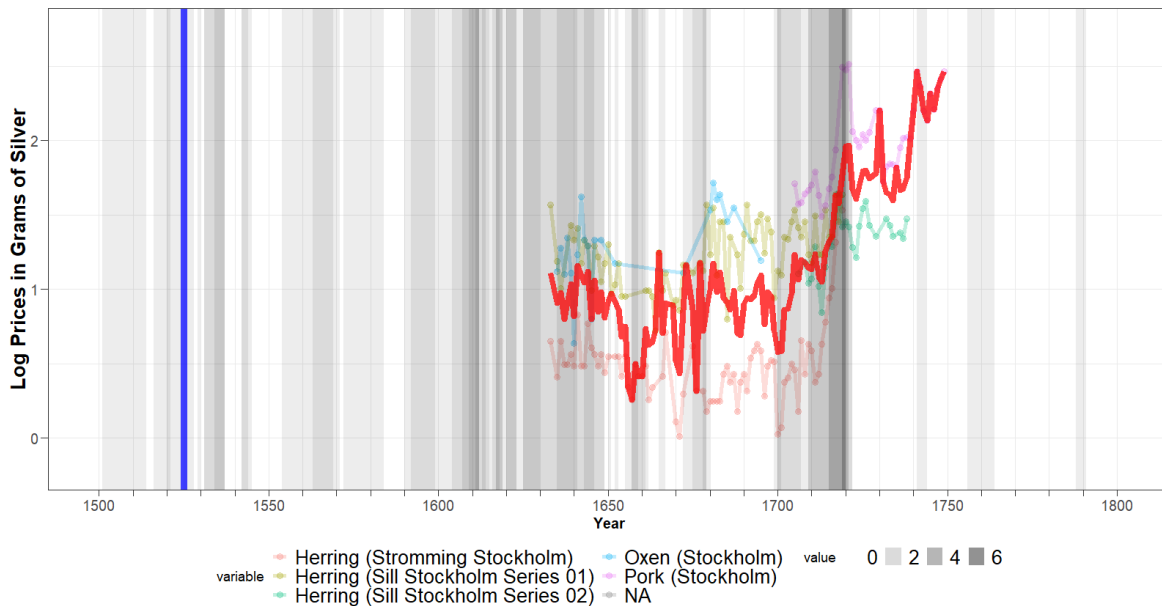


Figure F.12. Prices for Stockholm. (Stromming, sill, pork, and oxen).

Bibliography

- Alheit, Jürgen, and Eberhard Hagen. "Long-Term Climate Forcing of European Herring and Sardine Populations." *Fisheries Oceanography* 6, no. 2 (1997): 130-39.
- Allaire, Bernard. "Internal Norfish Report Ten: Total Catches (1500-1950)." Unpublished project report, (2019).
- . "Internal Norfish Report Two: Landing, Price and Packaging in Bordeaux Fish Trade 1530s-1580s." Unpublished project report, (2017).
- . "Internal Norfish Report One: Fish and Commodity Prices in Food Supply Contracts in Paris (1538-1756)." Unpublished project report, (2017).
- Allen, Robert C. "Consumer Price Indices, Nominal/Real Wages and Welfare Ratios of Building Craftsmen and Labourers, 1260-1913." (2008).
- . "The Great Divergence in European Wages and Prices from the Middle Ages to the First World War." *Explorations in Economic History* 38, no. 4 (2001): 411-47. doi: 10.1006/exeh.2001.0775.
- . "Agricultural Output and Productivity in Europe, 1300 - 1800. Discussion Paper No. 98-14." Unpublished manuscript, Department of Economics. The University of British Columbia, (1998).
- Allen, Richard C., and Robert W. Unger. "The Allen-Unger Global Commodity Prices Database: Social and Economic History." *Research Data Journal for the Humanities and Social Sciences* 1, (2019): 1-10. doi: 10.1163/24523666-00401006.
- Alogoskoufis, George, and Ron Smith. "On Error Correction Models: Specification, Interpretation, Estimation." *Journal of Economic Surveys* 5, no. 1 (1991): 97-128. doi: 10.1111/j.1467-6419.1991.tb00128.x.
- Ames, Glenn Joseph. *The Globe Encompassed: The Age of European Discovery, 1500-1700*. Pearson Prentice Hall, 2008.
- Anderson, Katharine. "Does History Count?" *Endeavour* 30, no. 4 (Dec 2006): 150-5.
- Andrews, Kenneth R., Kenneth Raymond Andrews, and Jeffrey Alan Gray. *Trade, plunder and settlement: Maritime enterprise and the genesis of the British Empire, 1480-1630*. Vol. 5. Cambridge University Press, 1984.

- Asch, Ronald G. *The Thirty Years War*. Macmillan Publishers Limited, 1997.
- Barkham, Selma. "Burgos Insurance for Basque Ships, 1542-1592: Maritime Policies from Spain." *Archivaria* 11 (1980).
- Barrett, James, Alison M. Locker, and Callum M. Roberts. "The Origins of Intensive Marine Fishing in Medieval Europe: The English Evidence." *The Royal Society* 271, no. 1556, (2004), 2417-21. doi: 10.1098/rspb.2004.2885.
- Barrett, James, Roelf Beukens, Ian Simpson, Patrick Ashmore, Sandra Poaps, and Jacqui Huntley. "What Was the Viking Age and When Did It Happen? A View from Orkney." *Norwegian archaeological review Huntley* 33, no. 1 (2000). doi: 10.1080/00293650050202600.
- Bashir, Faraj, and Hua-Liang Wei. "Handling Missing Data in Multivariate Time Series Using a Vector Autoregressive Model-Imputation (Var-Im) Algorithm." *Neurocomputing* (2017).
- Bateman, Victoria N. *Markets and Growth in Early Modern Europe*. Routledge, 2015.
- . "The Evolution of Markets in Early Modern Europe, 1350–1800: A Study of Wheat Prices." *The Economic History Review* 64, no. 2 (2011): 447-71.
- Bauernfeind, Walter. *Materielle Grundstrukturen Im Spätmittelalter Und der Frühen Neuzeit: Preisentwicklung Und Agrarkonjunktur Am Nürnberger Getreidemarkt Von 1339 Bis 1670. Vol. 50*. Nürnberg Stadtarchiv Nürnberg Korn und Berg, 1993.
- Baulant, Micheline. "Les Prix des Grains à Paris de 1431-1788", *Annales: E.S.E.*, 23 (1968).
- Beaugrand, Grégory, and Philip C. Reid. "Long-term changes in phytoplankton, zooplankton and salmon related to climate." *Global Change Biology* 9, no. 6 (2003): 801-817. <http://drought.memphis.edu/OWDA/>.
- Bevan, Andrew. *Stone Vessels and Values in the Bronze Age Mediterranean*. Cambridge University Press, 2007.
- Beveridge, William. *Prices and Wages in England from the Twelfth to the Nineteenth Century*. London: Longmans Green & Co. Ltd., 1939. Reprint, London: Frank Cass & Co. Ltd., 1966.

- Blockmans, Wim, Mikhail Krom, and Justyna Wubs-Mrozewicz, eds. *The Routledge Handbook of Maritime Trade Around Europe 1300-1600: Commercial Networks and Urban Autonomy*. Taylor & Francis, 2017.
- Blom, Philipp. *Nature's Mutiny: How the Little Ice Age of the Long Seventeenth Century Transformed the West and Shaped the Present*. Picador, 2019.
- Bolster, Jeffrey, W. *The Mortal Sea: Fishing the Atlantic in the Age of Sail*. Harvard University Press, 2012.
- Bradley, Raymond S. *Paleoclimatology: Reconstructing Climates of the Quaternary*. 3rd ed. Amsterdam: Elsevier, 2015.
- Bradley, Raymond S., and Phil D. Jones. *Climate Since A.D. 1500*. Rev. ed. (Routledge, 1995).
- Braudel, Fernand. *Civilization and Capitalism, 15th-18th Century*. Vol I, *The Structure of Everyday Life*. University of California Press, 1979.
- . *Civilization and Capitalism, 15th-18th Century*. Vol II, *The Wheels of Commerce*. University of California Press, 1979.
- . *Civilization and Capitalism, 15th-18th Century*. Vol III, *The Perspective of the World*. University of California Press, 1979.
- Braudel, Fernand, and Frank Spooner. "Prices in Europe from 1450 to 1750." In *The Cambridge economic history of Europe 4*, 374-486. Cambridge University Press, 1967.
- Brázdil, Rudolf, Christian Pfister, Heinz Wanner, Hans Von Storch, and Jürg Luterbacher. "Historical Climatology in Europe – The State of the Art," *Climatic Change*, 70 (2005): 363-430.
- Brecke, Peter. "Violent conflicts 1400 AD to the present in different regions of the world." In *1999 Meeting of the Peace Science Society, unpublished manuscript*. 1999.
- Brown, Henry Phelps, and Sheila V. Hopkins. *A Perspective of Wages and Prices*. London and New York: Methuen, 1981.
- Bulbeck, David, Anthony Reid, Lay Hong Tan and Yiqi Wu. *Southeast Asian Exports Since the 14th Century: Cloves, Pepper, Coffee, and Sugar*. Leiden, The Netherlands: KITLV Press, 1998.

- Butler, James Davie. *Codfish, its Place in American History*. Madison: Wisconsin, 1897.
- Camenisch, Chantal, and Ch. Rohr. "When the Weather Turned Bad. The Research of Climate Impacts on Society and Economy During the Little Ice Age in Europe. An Overview." *Cuadernos de Investigación Geográfica* 44, no. 1 (2018): 99-114.
- Campbell, Bruce M.S. *The Great Transition, Climate, Disease and Society in the Late-Medieval World*. Cambridge: Cambridge University Press, 2016.
- Carr, Edward Hallett. *What Is History?* New York: Knopf, 1962.
- Carrard, Philippe. "Figuring France: The Numbers and Tropes of Fernand Braudel." *Diacritics* 18, No. 3, (1988): 2-19.
- Casado Alonso, Hilario. "La Pêche À Terre-Neuve Et Le Commerce International: Deux Activités Complémentaires Au Xvie Siècle." *Annales de Bretagne et des Pays de l'Ouest*, no. 120-2, (2013): 111-32.
- Caswell, Hal. *Matrix Population Models*. Wiley Online Library, 2001.
- Chew, Sing C. *The Recurring Dark Ages: Ecological Stress, Climate Changes, and System Transformation*. Rowman Altamira, 2006.
- Chikamoto, Megumi O, Axel Timmermann, Masakazu Yoshimori, Flavio Lehner, Audine Laurian, Ayako Abe-Ouchi, Anne Mouchet, Fortunat Joos, Christoph C. Raible, Kim M. Cobb. "Intensification of Tropical Pacific Biological Productivity Due to Volcanic Eruptions." *Geophysical Research Letters* 43, no. 3 (2016): 1184-92. Doi: 10.1002/2015GL067359.
- Clark, G. N. "Review of Inquiry into the History of Prices in Holland. Vol. I, Wholesale Prices at the Exchange of Amsterdam, 1585-1914, Rates of Exchange at Amsterdam, 1609-1914, N. W. Posthumus." *The English Historical Review* 63, no. 248 (1948): 379-81.
- Chok, Nian Shong. *Pearson's Versus Spearman's and Kendall's Correlation Coefficients for Continuous Data*. Master's Thesis, University of Pittsburgh, 2010.
- Clark, Gregory. "The Price History of English Agriculture, 1209-1914." *Research in Economic History* 22 (2004): 41-124.
- Clemmer, Gina. *The GIS 20: Essential Skills*. Esri Press, 2010.

- Cole, Arthur H., and Ruth Crandall. "The International Scientific Committee on Price History." *The Journal of Economic History* 24, no. 3 (1964): 381–88. doi:10.1017/S0022050700060903.
- Cook, Edward R., Richard Seager, Yochanan Kushnir, Keith R. Briffa, Ulf Büntgen, David Frank, Paul J Krusic, et al. "Old World Megadroughts and Pluvials During the Common Era." *Science Advances* 1, no. 10 (2015): e1500561. DOI: 10.1126/sciadv.1500561.
- Cosgel, Metin M. "The Socio-Economics of Consumption" in *The Elgar Companion to Social Economics*, edited by John B. Davis, Wilfred Dolfsma. Cheltenham: Edward Elgar Publishing Ltd, 2008: 121-36.
- Crawley, Michael J. *Statistics. An Introduction Using R*, 2nd ed. Chichester: Wiley, 2015.
- Cronon, William. "A Place for Stories: Nature, History, and Narrative." *The Journal of American History* 78, no. 4 (1992): 1347-76.
- Curtis, Daniel R., and Jessica Dijkman. "The Escape from Famine in the Northern Netherlands: A Reconsideration Using the 1690s Harvest Failures and a Broader Northwest European Perspective." *The Seventeenth Century* 34, no. 2. 2017: 1-30. DOI: 10.1080/0268117X.2017.1410494.
- Daly, Aoife. "Timber, Trade and Tree-Rings. Dendrochronological Analysis of Structural Oak Timber in Northern Europe, C. AD 1000 to Ad 1650." PhD diss., University of Southern Denmark, 2007.
- Davies, Brian J. *Warfare in Eastern Europe, 1500-1800*. Brill, 2012.
- Davidson, Thomas. *Chambers Twentieth Century Dictionary of the English Language*. London: W. and R. Chambers, 1903.
- Davis, Lance E., Robert E Gallman, and Karin Gleiter. *In Pursuit of Leviathan: Technology, Institutions, Productivity, and Profits in American Whaling, 1816-1906*. University of Chicago Press, 2007.
- Day, John. *The Medieval Market Economy*. Wiley-Blackwell, 1987.
- de Boor, Carl. *A Practical Guide to Splines, Revised Edition, Vol. 27 of Applied Mathematical Sciences*. Mechanical Sciences, New York: Springer, 2001.

- De La Villemarque, Jacqueline Hersart. *French Cod Fishing from 1500 to 1950: Statistics, Climate, Society*. (1995).
- de Vries, Jan. *The Economy of Europe in an Age of Crisis, 1600-1750*. Cambridge University Press, 1976.
- . *European Urbanization, 1500-1800*. Routledge, 2013.
- . “The Economic Crisis of the Seventeenth Century after Fifty Years.” *Journal of Interdisciplinary History* 40, no. 2 (2009): 151-94.
- de Vries, Jan, and Ad van der Woude. *The First Modern Economy*. Cambridge: Cambridge University Press, 1997.
- de Zwart, Pim, and Jan Luiten van Zanden. *The Origins of Globalization: World Trade in the Making of the Global Economy, 1500-1800*. Cambridge University Press, 2018.
- Deutsch, Curtis, Aaron Ferrel, Brad Seibel, Hans-Otto Pörtner, and Raymond B Huey. “Climate Change Tightens a Metabolic Constraint on Marine Habitats.” *Science* 348, no. 6239 (2015): 1132-35.
- Degroot, Dagomar. *The Frigid Golden Age: Climate Change, The Little Ice Age, and the Dutch Republic, 1560–1720*. Cambridge University Press, 2018.
- DeVries, Kelly. *Joan of Arc: A military leader*. The History Press, 2011.
- Dewald, Jonathan, ed. *Europe 1450 to 1789: Encyclopedia of the Early Modern World*. 5 vols. 2004.
- Dollinger, Philippe. *The German Hansa*. Bristol: Western Printing Services Ltd., 1964.
- Edvinsson, R., T. Jacobson, and D. Waldenström. *Exchange Rates, Prices, and Wages, 1277-2008*. Ekerlids Förlag, 2010.
- Elsas, Moritz John. *Umriss einer Geschichte der Preise und Löhne in Deutschland*. Vol 1. (Leiden, 1936).
- . *Umriss einer Geschichte der Preise und Löhne in Deutschland*. Vol 2, Part 1. (Leiden, 1940).
- . *Umriss einer Geschichte der Preise und Löhne in Deutschland*. Vol 2, Part 2. (Leiden, 1949).

- Enghoff, I. B. "Fishing in the Baltic Region from the 5th Century BC to the 16th Century AD: Evidence from Fish Bones." *Archaeofauna* 8 (1999): 41-85.
- . "Fishing in the Southern North Sea Region Form the 1st to the 16th Century AD: Evidence from Fish Bones." *Archaeofauna* 9 (2000): 59-132.
- Erdkamp, Paul. *The Grain Market in the Roman Empire: A Social, Political and Economic Study*. Cambridge University Press, 2005.
- Fagan, Brian M. *Fishing: How the Sea Fed Civilization*. Yale University Press, 2017.
- Fairchilds, Cissie. "Consumption in Early Modern Europe. A Review Article." *Comparative Studies in Society, and History* 35, no. 4 (1993).
- Feavearyear, Albert Edgar. *Pound Sterling: A history of English money*. Oxford: Clarendon Press, 1931.
- Federico, Giovanni. "Market Integration from Measurement to Economic Analysis: A Survey of the Recent Literature." (*Discussion Paper No. DP12902*, unpublished manuscript, April 2018). (<https://ssrn.com/abstract=3184207>).
- . "How much do we know about market integration in Europe?" *The Economic History Review* 65, no. 2, (2012): 470-97. Doi: 10.1111/j.1468-0289.2011.00608.x.
- Feliu, Gaspar. *Precios Y Salarios En La Cataluña Moderna. Estudios de Historia Económica*. 2 Vols. Banco de España - Servicio de Estudios. 1991.
- Findlay, Ronald, and Kevin H. O'Rourke. *Power and Plenty: Trade, War, and the World Economy in the Second Millennium*. Princeton University Press, 2009.
- Flavin, Susan. *Consumption and Culture in Sixteenth-Century Ireland: Saffron, Stockings and Silk*. Vol 13. Boydell & Brewer Ltd, 2014.
- Frandsen, Karl-Erik. "The Scale and Politics of Danzig's Salted Herring Trade in the Late Sixteenth Century." *International Journal of Maritime History* 16, no. 2 (2004).
- Frank, Kenneth T, Brian Petrie, Jae S. Choi, and William C. Leggett. "Trophic Cascades in a Formerly Cod-Dominated Ecosystem." *Science* 308, no. 5728 (2005): 1621-23. DOI: 10.1126/science.1113075.

- Frey, Albert R. "A Dictionary of Numismatic Names: Their Official and Popular Designations." *American Journal of Numismatics (1897-1924)* 50 (1916): v-311.
- Frost, Robert I. *The Northern Wars: War, State and Society in Northeastern Europe, 1558-1721*. Routledge, 2001.
- Fynn-Paul, Jeff. *War, Entrepreneurs, and the State in Europe and the Mediterranean, 1300-1800*. Brill, 2014.
- Furtak, Tadeusz. *Ceny W Gdańsku W Latach 1701-1815. Badania z Dziejów Społecznych i Gospodarczych*, nr. 22. Lwow: Skład Główny: Kasa im. J. Mianowskiego, 1935.
- Gardiner, Mark. "The Character of Commercial Fishing in Icelandic Waters in the Fifteenth Century" in *Cod and Herring the Archaeology and History of Medieval Sea Fishing*, edited by James H. Barrett and David C. Orton. Oxford: Oxbow, 2016.
- Garrison, Tom S. *Essentials of Oceanography*. Cengage Learning, 2012.
- . *Oceanography: An Invitation to Marine Science*. Nelson Education, 2015.
- Gelman, Andrew, and Jennifer Hill. *Data Analysis Using Regression and Multilevel/Hierarchical Models*. Cambridge University Press, 2006.
- Gillis, John R. *The Human Shore: Seacoasts in History*. University of Chicago Press, 2012.
- Gøbel, Erik. "The sound toll registers online project, 1497–1857." *International Journal of Maritime History* 22, no. 2 (2010): 305-324.
- Gibson, Charles. "An Historical Event and Its Interpretation: The Castilian Grain Crisis of 1506-1507." 2, *Social Science History*, no. 2 (1978): 230-47.
- Grafe, Regina. *Distant Tyranny: Markets, Power, and Backwardness in Spain, 1650-1800*. Princeton University Press, 2012.
- . "Popish Habits vs. Nutritional Need: Fasting and Fish Consumption in Iberia in the Early Modern Period." *Discussion Papers in Economic and Social History* No. 55. University of Oxford, Department of Economics, 2004.
- Gruber, Marvin H. J. *Matrix Algebra for Linear Models*. John Wiley & Sons, 2013.
- Gunnarsson, Gisli. *Monopoly Trade and Economic Stagnation- Studies in the Foreign Trade of Iceland 1602-1787*. Doctoral Universitetet i Lund. 1983.

- Gyllenbok, Jan. *Encyclopaedia of Historical Metrology, Weights, and Measures*. 3 vols. Cham: Birkhäuser, 2018.
- Hackett Fischer, David. *The Great Wave: Price Revolutions and the Rhythm of History*. New York: Oxford University Press, 1996.
- Hamilton, Earl J. *War and Prices in Spain, 1651-1800*. Cambridge: Harvard University Press, 1947.
- . *American Treasure and the Price Revolution in Spain, 1501-1650*. Cambridge: Harvard University Press, 1934.
- Harris, Bob. "Scotland's Herring Fisheries and the Prosperity of the Nation, c. 1660–1760." *Scottish Historical Review* 79, no. 1 (2000): 39-60.
- Hart-Davis, Adam. *History: The Definitive Visual Guide: From the Dawn of Civilization to the Present Day*. Dorling Kindersley, 2007.
- Harsgor, Michael. "Total history: the Annales school." *Journal of Contemporary History* 13, no. 1 (1978): 1-13.
- Hatcher, John. *Modelling the Middle Ages: The History and Theory of England's Economic Development*. Oxford: Oxford University Press, 2001.
- Hauser, Henri. *Recherches et documents sur l'histoire des prix en France depuis 1500 à 1800*. Parigi: Les Presses Modernes, 1936.
- Hayes, Patrick W., Al Matthews, Bernard Allaire, and Poul Holm. "European Naval Diets in the Sixteenth Century: A Quantitative Method for Comparative and Nutritional Analysis." *Historical Methods: A Journal of Quantitative and Interdisciplinary History* 52, no. 4 (2019): 195-212. DOI: 10.1080/01615440.2019.1580170.
- Heaton, Herbert. "The Cod Fisheries: The History of an International Economy by Harold A. Innis." *The Canadian Historical Review* 22, no. 1 (1941): 60-3.
- Heller, Henry. *Labour, Science and Technology in France, 1500-1620*. Cambridge, 2002.
- Hersart de la Villemarqué, Jacqueline. "La Pêche Morutiere Française De 1500 À 1950 Statistiques, Climat Et Société." *Reperes Ocean* 11, (1995).

- Hitzbleck, Herbert. "Die Bedeutung des Fisches für die Ernährungswirtschaft Mitteleuropas in vorindustrieller Zeit: unter besonderer Berücksichtigung Niedersachsens." PhD diss., Georg-August-Universität, 1971.
- Hobsbawm, Eric. "The Crisis of the Seventeenth Century." *Past and Present* 5, no. 6 (1954).
- Hocquet, Jean-Claude. "Les Pêcheries Médiévales." In *Histoire des pêches maritimes en France*. Toulouse, 1987: 36-129.
- Hoffmann, Richard C. *The Cambridge History of Medieval Philosophy*. Cambridge University Press, 2014.
- . "A Brief History of Aquatic Resource Use in Medieval Europe." *Helgoland Marine Research* 59, no. 1 (2005): 22.
- Hoffman, Philip T., Gilles Postel-Vinay, and Jean-Laurent Rosenthal. *Priceless Markets: The Political Economy of Credit in Paris, 1660-1870*. Chicago: University of Chicago Press, 2000.
- Holden, Joseph. *An Introduction to Physical Geography and the Environment*. Pearson Education, 2005.
- Holm, Poul, Francis Ludlow, Cordula Scherer, Charles Travis, Bernard Allaire, Cristina Brito, Patrick W. Hayes, Al Matthews, Kieran J. Rankin, Richard J. Breen et al. "The North Atlantic Fish Revolution (ca. AD 1500)." *Quaternary Research* (2019): 1-15.
- Holm, Poul et al. "A Revolution in Fish Supplies. 1500 to 1800 CE". (unpublished).
- Holm, Poul. "Commercial Sea Fisheries in the Baltic Region C. Ad 1000-1600." In *Cod and Herring the Archaeology and History of Medieval Sea Fishing*, edited by James H. Barrett and David C. Orton. Oxford: Oxbow, 2016.
- Holm, Poul. "Catches and Manpower in the Danish Fisheries, C. 1200-1995." *Studia Atlantica* 1 (1996): 177-206.
- Holm, Poul, Marta Coll, Alison MacDiarmid, Henn Ojaveer, and Bo Poulsen. "HMAP Response to the Marine Forum." *Environmental History* 18, no. 1 (2012): 121-26.
- Holm, Poul, David J Starkey, and Jón T Thór, eds. *The North Atlantic Fisheries, 1100-1976 National Perspectives on a Common Resource. Vol 1, Studia Atlantica*. Esbjerg: Fiskeri-og Søfartsmuseet, 1996.

- Hopkins, Sheila V. "Seven Centuries of Building Wages." *Economica* 22, no. 87 (1955): 195-206.
- Howard, Michael C. "Fernand Braudel on Capitalism: A Theoretical Analysis." *Réflexions Historiques* (1985): 469-83.
- Hutchinson, William F., Mark Culling, David C. Orton, Bernd Hänfling, Lori Lawson Handley, Sheila Hamilton-Dyer, Tamsin C. O'Connell, Michael P. Richards, and James H. Barrett. "The Globalization of Naval Provisioning: Ancient DNA and Stable Isotope Analyses of Stored Cod from the Wreck of the Mary Rose, Ad 1545." *Royal Society Open Science* 2, no. 9 (2015): 150199.
- Hsiao, Cheng. *Analysis of Panel Data*. Cambridge University Press, 2014.
- Innis, H.A. *The Cod Fisheries: The History of an International Economy*. University of Toronto Press, 1954.
- Israel, Jonathan Irvine. *The Dutch Republic: Its Rise, Greatness, and Fall, 1477-1806*. Vol. 321. Oxford: Clarendon Press, 1995.
- Jacks, David S., Kevin H. O'Rourke, and Jeffrey G. Williamson. "Commodity Price Volatility and World Market Integration since 1700." *Review of Economics and Statistics* 93, no. 3 (2011): 800-13.
- Jacobs, A., and H. Richter, "Die Grosshandelspreise in Deutschland von 1792-1934." Sonderheft des Instituts fuer Konjunkturforschung, no. 37 (Berlin, 1935).
- Jansson, Arne, Lennart Palm, and Johan Söderberg. *Dagligt Bröd I Onda Tider: Priser Och Löner I Stockholm Och Västsverige 1500-1770*. Götene: Institutet för Lokalhistorisk Forskning, 1991.
- Jaques, Tony. *Dictionary of Battles and Sieges*. 3 Vols. Greenwood Publishing Group, 2007.
- Jeffrey, Wooldridge. *Econometric Analysis of Cross Section and Panel Data*. Cambridge: MIT Press, (2010).
- Jenks, Stuart. "Dies Distributions Revolution Des 15. Jahrhunderts." *Hanse Geschichtsblätter (English: Hanseatic History)*. Trier: Porta Alba Verlag, 2015.

- Jenks, Stuart. "The Missing Link: The Distribution Revolution of the 15th Century." In *Textiles. The Medieval Economy: Production, Trade, Consumption of Textiles, 8th-16th Centuries*, edited by Angela Ling Huang and Carsten Jahnke, 2015.
- Jody, Iosias. *Franco-Spanish War (1635-1659)*. Cred Press, 2011.
- Jones, Evan T., "England's Icelandic Fishery in the Early Modern Period." In *England's Sea Fisheries. The Commercial Sea Fisheries of England and Wales since 1300*, edited by David J. Starkey, Chris Reid, and Neil Ashcroft. London: Chatham, 2000.
- Jones, Donald W. *Economic Theory and the Ancient Mediterranean*. John Wiley & Sons, 2014.
- Jonsson, Gudmundur. "Changes in Food Consumption in Iceland, 1770–1940." *Scandinavian Economic History Review* 46, no. 1 (1998): 24-41.
- Jónsson, Jon. "Fisheries Off Iceland, 1600-1900." *ICES Marine Science Symposia* 198, (1994): 3-16.
- Kearney, Kelly A., Desiree Tommasi, and Charles Stock. "Simulated Ecosystem Response to Volcanic Iron Fertilization in the Subarctic Pacific Ocean." *Fisheries Oceanography* 24, no. 5 (2015): 395-413.
- Kelly, Patrick. *The Universal Cambist and Commercial Instructor: Being a Full and Accurate Treatise on the Exchanges, Monies, Weights and Measures of All Trading Nations and Their Colonies; with an Account of Their Banks, Public Funds, and Paper Currencies. Vol. 1*. Lackington, Allen, and Co: London, 1821.
- Kenna, Ralph, and Pádraig Mac Carron. "Maths Meets Myths." *Physics World* 29, no. 6 (2016): 22.
- Kindleberger, Charles P. *Economic laws and economic history*. Cambridge University Press, 1997.
- Kiple, Kenneth F., and Kriemhild Coneè Ornelas, eds. *The Cambridge World History of Food*. Cambridge: Cambridge University Press, 2000.
DOI:10.1017/CHOL9780521402149.
- Kirk, Roger E. *Experimental Design*. Wiley Online Library, 1982.
- Klais, Riina. "Hindcasting North Atlantic plankton production." Unpublished project report, (2016).

- Knecht, Robert Jean. *The French Wars of Religion 1559-1598*. Routledge, 2014.
- Koopman, Siem Jan, and Lennart Hoogerheide. "Analysis of Historical Time Series with Messy Features." In *A history of market performance: From Ancient Babylonia to the modern world*. Edited by R. J. van der Spek, R. J. van Leeuwen, and J. L. van Zanden. (London: Routledge, 2015), 45-67.
- Kowarik, Alexander, and Matthias Templ. "Imputation with R Package Vim." *Journal of Statistical Software* 74, no. 7 (2016): 1-16.
- Kurlansky, Mark. *Cod: A Biography of the Fish That Changed the World*. Vintage Canada, 2011.
- Lamb, Hubert H. *Climate, History and the Modern World*. 2nd ed . (Routledge, 1995).
- Lear, William H. "History of Fisheries in the Northwest Atlantic: The 500-Year Perspective." *Journal of Northwest Atlantic Fishery Science* 23 (1998): 41-74.
- Lennon, Colm. *Sixteenth-Century Ireland (New Gill History of Ireland 2): The Incomplete Conquest - Irish Landlords and the Extension of English Royal Power*. Vol. 2. Gill and Macmillan Ltd, 2005.
- Li, Lillian M. *Fighting Famine in North China: State, Market, and Environmental Decline, 1690s-1990s*. Stanford: Stanford University Press, 2007.
- Lu, Mengshi, Simin Huang, and Zuo-Jun Max Shen. "Product Substitution and Dual Sourcing Under Random Supply Failures." *Transportation Research Part B: Methodological* 45, no. 8 (2011): 1251-1265.
- Luterbacher, Jörg et al. "European Summer Temperatures since Roman Times." *Environmental Research Letters* 11, no. 2 (2016). Online access to database: <https://www.ncdc.noaa.gov/paleo-search/study/19600>.
- Luterbacher, Jürg, and Christian Pfister. "The Year without a Summer." *Nature Geoscience* 8, no. 4 (2015): 246.
- Lütkepohl, Helmut. *New Introduction to Multiple Time Series Analysis*. Springer Science & Business Media, 2005.
- Lyman Roelker, Nancy. *One King, One Faith: The Parlement of Paris and the Religious Reformations of the Sixteenth Century*. University of California, 1996.

- MacNeil, Heather. *Trusting Records: Legal, Historical and Diplomatic Perspectives*. London: Kluwer Academic Publishers, 2000.
- MacNeil, Heather. "Trusting Records as Historical Evidence: Modern Historical Methods." In *Trusting Records: Legal, Historical and Diplomatic Perspectives*. Dordrecht, London and Boston: Kluwer Academic Publishers, 2000: 57-85.
- Maddison, Angus. *Contours of the World Economy 1-2030 Ad: Essays in Macro-Economic History*. Oxford University Press, 2007.
- Malanima, Paolo. *Pre-Modern European Economy: One Thousand Years (10th-19th Centuries)*. Vol. 5. Brill, 2009.
- Máñez, Kathleen Schwerdtner, and Bo Poulsen. *Perspectives on Oceans Past*. Springer, 2016.
- Manning, Joseph G., Francis Ludlow, Alexander R. Stine, William R. Boos, Michael Sigl, and Jennifer R. Marlon. "Volcanic Suppression of Nile Summer Flooding Triggers Revolt and Constrains Interstate Conflict in Ancient Egypt." *Nature communications* 8, no. 1 (2017): 1-9.
- Mannion, John. "Review of 'Fish into Wine: The Newfoundland Plantation in the Seventeenth Century' by Peter E. Pope." *Journal of Historical Geography* 31, no. 4 (2005): 803-04.
- Masschaele, James. "Transport costs in medieval England." *Economic History Review* (1993): 266-279.
- Matthews, John A., and Keith R. Briffa. "The 'Little Ice Age': Re-Evaluation of an Evolving Concept." *Geografiska Annaler: Series A, Physical Geography* 87, no. 1 (2005): 17-36.
- Mayhew, Nicholas. "Prices in England, 1170-1750." *Past & Present* 219, no. 1 (2013): 3-39.
- McCreery, Cindy. *Ports of the World: Prints from the National Maritime Museum, Greenwich, C. 1700-1870*. Philip Wilson Pub Ltd, 1999.
- McIntyre, Alasdair D., ed. *Life in the World's Oceans - Diversity, Distribution, Abundance*. Oxford: Wiley-Blackwell, 2010.

- McKendrick, Neil, John Brewer, and John Harold Plumb. *The Birth of a Consumer Society: The Commercialization of Eighteenth-Century England*. Indiana University Press, 1982.
- McNeill, John Robert, and Alan Roe. *Global Environmental History: An Introductory Reader*. Routledge, 2013.
- Mehta, Cyrus R., and Pralay Senchaudhuri. "Conditional Versus Unconditional Exact Tests for Comparing Two Binomials." *Cytel Software Corporation* 675 (2003).
- Mendels, Franklin F. "Proto-Industrialization: The First Phase of the Industrialization Process." *The journal of economic history* 32, no. 1 (1972): 241-61.
- Metcalf, David M. "The Currency of Deniers Tournois in Frankish Greece." *Annual of the British School at Athens* 55 (1960): 38-59.
- Michell, A. R. "The European Fisheries in Early Modern History." In *The Cambridge Economic History of Europe Volume 5: The Economic Organization of Early Modern Europe*. Cambridge: Cambridge University Press, 1977: 133-84.
- Miljkovic, Dragan. "The Law of One Price in International Trade: A Critical Review." *Applied Economic Perspectives and Policy* 21, no. 1 (1999): 126-139.
- Mitchell, Brian R., and Phyllis Deane. *Abstract of British Historical Statistics*. Cambridge, 1971.
- Mollat, Michel. *Le Commerce Maritime Normand À La Fin Du Moyen Age: Étude D'histoire Économique Et Sociale*. Plon, 1952.
- Monge, Gaspard, Jean-Dominique Cassini, Pierre Bertholon, J. H. Hassenfratz, Charles Joseph Panckoucke, Antoinette-Pauline Agasse, Louis-Pierre Couret de Villeneuve, and Antoine Guénard Demonville. *Méthodique, Encyclopédie: Dictionnaire de physique*. Paris: Imprimeur-Libraire, rue des Poitevins, no. 6 (1822).
- Morby, John E. *Dynasties of the World: A Chronological and Genealogical Handbook*. Oxford University Press, 1989.
- Morgan, Kevin, Terry Marsden, and Jonathan Murdoch. *Worlds of Food: Place, Power, and Provenance in the Food Chain*. Oxford University Press, 2006.
- Moritz, Steffen, and Thomas Bartz-Beielstein. "ImputeTS: Time Series Missing Value Imputation in R." *The R Journal* 9, no. 1 (2017): 207-18.

- Morineau, Michel. "Old, New but True Economic History... Comptes Rendus Et Commentaires." *Revue d'histoire Moderne et Contemporaine* 32, no. 3 (1985): 451-80.
- Mozaffarian, Dariush, Irwin Rosenberg, and Ricardo Uauy. "History of Modern Nutrition Science - Implications for Current Research, Dietary Guidelines, and Food Policy." *BMJ* 361 (2018).
- Nall, John Greaves. *Great Yarmouth and Lowestoft*. Longmans, Green, Reader & Dyer, 1866.
- Nedkvitne, Arnved. *Mens Bønderne Seilte Og Jægterne For. Nordnorsk Og Vestnorsk Kystøkonomi 1500-1730*. Oslo: Universitetsforlaget, 1988.
- Nedkvitne, Arnved. *The German Hansa and Bergen 1100-1600*. Köln: Böhlau Verlag, 2014.
- North, Douglass C, and Robert Paul Thomas. *The Rise of the Western World: A New Economic History*. Cambridge University Press, 1973.
- O'Rourke, Kevin H., and Jeffrey G. Williamson. "After Columbus: Explaining Europe's Overseas Trade Boom, 1500–1800." *The Journal of Economic History* 62, no. 2 (2002): 417-56.
- Officer, Lawrence H. "The Purchasing Power Parity Theory of Exchange Rates: A Review Article." *Staff Papers* 23, no. 1 (1976): 1-60.
- Orton, David, James Morris, and Alan Pipe. "Catch Per Unit Research Effort: Sampling Intensity, Chronological Uncertainty, and the Onset of Marine Fish Consumption in Historic London." *Open Quaternary* 3, no. 1 (2017).
- Orton, David C., and James H. Barrett. *Cod and Herring; the Archaeology and History of Medieval Sea Fishing*. Oxford: Oxbow Books, 2016.
- Özmucur, Süleyman, and Şevket, Pamuk. "Did European Commodity Prices Converge During 1500–1800." in *The New Comparative Economic History: Essays in Honor of Jeffrey G. Williamson*, edited by Timothy, J. Hatton, O'Rourke, Kevin, and Alan, M. Taylor. Cambridge, MA and London: The MIT Press, 2007.
- Paine, Lincoln. *The Sea and Civilization: A Maritime History of the World*. Atlantic Books Ltd, 2014.

- Palmer, Wayne C. *Meteorological drought*. Vol. 30. US Department of Commerce, Weather Bureau, 1965.
- Pamuk, Şevket. "The Black Death and the Origins of the Great Divergence Across Europe, 1300–1600." *European Review of Economic History* 11, no. 3 (2007): 289-317.
- Parker, Geoffrey. *Global Crisis: War, Climate Change and Catastrophe in the Seventeenth Century*. Yale University Press, 2013.
- . "Crisis and Catastrophe: The Global Crisis of the Seventeenth Century Reconsidered." *The American Historical Review* 113, no. 4 (2008).
- Parker, Geoffrey, and Lesley M. Smith, eds. *The General Crisis of the Seventeenth Century*. Psychology Press, 1997.
- Parrott, David. *The Business of War: Military Enterprise and Military Revolution in Early Modern Europe*. Cambridge University Press, 2012.
- Parry, John Horace. *Trade and Dominion: The European Overseas Empires in the Eighteenth Century*. Vol. 13. New York: Praeger, 1971.
- Parry, John Horace. "Transport and Trade Routes" in *The Cambridge Economic History of Europe*. Edited by E. E. Rich and C. H. Wilson. Cambridge University Press, 1967: 155-219.
- Pausata, Francesco S.R., Leon Chafik, Rodrigo Caballero, and David S Battisti. "Impacts of High-Latitude Volcanic Eruptions on ENSO and AMOC." *Proceedings of the National Academy of Sciences* 112, no. 45 (2015): 13784-8.
- Pelc, Julian. *Ceny W Gdańsku W Xvi I Xvii Wieku*. Warszawa: Instytut Popierania Polskiej Twórczości Naukowej, 1937.
- Pfaff, Bernhard. "VAR, SVAR and SVEC models: Implementation within R Package VARS." *Journal of Statistical Software* 27, no. 4 (2008): 1-32.
- Pfister, Christian. "Climatic Extremes, Recurrent Crises and Witch Hunts: Strategies of European Societies in Coping with Exogenous Shocks in the Late Sixteenth and Early Seventeenth Centuries." *The Medieval History Journal* 10, no. 1-2 (2006): 33-73.
- Pfister, Christian, Rudolf Brázdil, and Marianus Barriendos. "Reconstructing Past Climate and Natural Disasters in Europe Using Documentary Evidence." *PAGES News*, 10 (2002), 6-8.

- Phelps Brown, E. H., and Sheila V. Hopkins. "Seven Centuries of the Prices of Consumables, Compared with Builders' Wage-Rates." *Economica* 23, no. 92 (1956): 296-314.
- Piketty, Thomas, and Arthur Goldhammer. *Capital in the Twenty-First Century*. Harvard University Press, 2014.
- Plat, Sir Hugh. *Sundrie Nevv and Artificiall Remedies against Famine*. Peter Short, dwelling on Breadstreet hill, at the signe of the Starre, 1596.
http://famineanddearth.exeter.ac.uk/displayhtml.html?id=fp_00165_en_sundriene_wandartificiallremedies.
- Pope, Peter. "Fish into Wine: The Newfoundland Plantation in the Seventeenth Century." *Newfoundland Studies* 24, no. 1 (2009): 157-9.
- . *Fish into Wine: The Newfoundland Plantation in the Seventeenth Century*. Chapel Hill: University of North Carolina Press, 2004.
- . "Early Estimates: Assessment of Catches in the Newfoundland Cod Fishery, 1660-1690." *Marine Resources and Human Societies in the North Atlantic since 1500* (1995): 9-40.
- Popper, Karl Sir. *The Open Society and Its Enemies*. Routledge, 2012.
- Posthumus, Nicolaas W. *Inquiry into the History of Prices in Holland, Vol. 1: Wholesale Prices at the Exchange of Amsterdam 1585-1914 and Rates of Exchange at Amsterdam 1609-1914*. Leiden: EJ Brill, 1946.
- . *Inquiry into the History of Prices in Holland. Vol. 2*. Leiden: EJ Brill, 1964.
- Poulsen, Bo. *Dutch Herring: An Environmental History, c. 1600-1860*. Amsterdam University Press, 2008.
- Poulsen, Bo, Poul Holm, and Brian R. MacKenzie. "A Long-Term (1667–1860) Perspective on Impacts of Fishing and Environmental Variability on Fisheries for Herring, Eel, and Whitefish in the Limfjord, Denmark." *Fisheries Research* 87, no. 2-3 (2007): 181-95.
- Poulsen, René Taudal, and Poul Holm. "What Can Fisheries Historians Learn from Marine Science? The Concept of Catch per Unit Effort (CPUE)." *International Journal of Maritime History* 19, no. 2 (2007): 89-112.

- Pribram, Alfred Francis. *Materialen zur Geschichte der Preise und Löhne in Oesterreich. Vol. 1.* Vienna: Carl Ueberreuters Verlag, 1938.
- Prowse, Daniel. *A History of Newfoundland and Labrador.* Boulder Publications, Portugal-Cove-St. Philip's Newfoundland, 1895.
- Puma, Michael, Satyajit Bose, So Young Chon, and Benjamin I. Cook. "Assessing the Evolving Fragility of the Global Food System." *Environmental Research Letters* 10, no. 2 (2015), 024007.
- Quinn, David B., Alison M. Quinn, and Susan Hillier, eds. *Newfoundland from Fishery to Colony. Northwest Passage Searches.* Vol. 4. New York: Arno Press, 1979.
- Raleigh, Clionadh, Hyun Jin Choi, and Dominic Kniveton. "The Devil Is in the Details: An Investigation of the Relationships between Conflict, Food Price and Climate across Africa." *Global Environmental Change* 32 (2015): 187-99.
- Rao, Mukund Palat, Benjamin I. Cook, Edward R. Cook, Rosanne Dorothy D'Arrigo, Paul J. Krusic, Kevin J. Anchukaitis, Allegra N. LeGrande, Brendan Buckley, N. K. Davi, C. Leland, Kevin. L. Griffin. "European and Mediterranean Hydroclimate Responses to Tropical Volcanic Forcing over the Last Millennium." *Geophysical research letters* 44, no. 10 (2017): 5104-5112.
- Rathbone, Dominic. "Earnings and Costs: Living Standards and the Roman Economy (First to Third Centuries Ad)." In *Quantifying the Roman Economy: Methods and Problems* (2009). DOI:10.1093/acprof:oso/9780199562596.003.0015.
- Riechelmann, Dana F. C., and Marjolein T. I. J. Gouw-Bouman. "A Review of Climate Reconstructions from Terrestrial Climate Archives Covering the First Millennium Ad in Northwestern Europe." *Quaternary Research* 91, no. 1 (2019).
- Rich, Edwin Ernest, and Charles Henry Wilson. *The Cambridge Economic History of Europe. Vol. 5, The Economic Organization of early modern Europe.* Cambridge University Press, 1977.
- Riffenburgh, Beau. *The Men Who Mapped the World: The Treasures of Cartography.* Seven Oaks, The Carlton Publishing Group, 2011.
- Riley, James C. *The Seven Years War and the Old Regime in France: The Economic and Financial Toll.* Princeton University Press, 1986.

- Robert, Christian, and George Casella. *Introducing Monte Carlo Methods with R*. Springer
New York: Science and Business Media, 2010. DOI: 10.1007/978-1-4419-1576-4.
- Rodger, Nicholas A. M. *The Safeguard of the Sea: A Naval History of Britain, 660-1649*.
Vol. 1. WW Norton & Company, 1999.
- Rogers, James E. Thorold. *A History of Agriculture and Prices in England, from the Year
after the Oxford Parliament (1259) to the Commencement of the Continental War
(1793)*. Oxford, 1866.
- Rorke, Martin. "The Scottish Herring Trade, 1470–1600." *Scottish Historical Review* 84, no.
2 (2005).
- Rubin, Donald B. *Multiple Imputation for Nonresponse in Surveys*. Vol. 81. John Wiley and
Sons, 1987/2004.
- Sandler, Martin W. *Atlantic Ocean: The Illustrated History of the Ocean That Changed the
World*. Sterling Publishing Company, 2008.
- Scheidel, Walter. *The Great Leveller: Violence and the Global History of Inequality from
the Stone Age to the Present*. Oxford University Press, 2017.
- Schumacker, Randall E., and Richard G. Lomax. *A Beginner's Guide to Structural Equation
Modelling*. Psychology Press, 2004.
- Seber, George A.F., and Alan J. Lee. *Linear Regression Analysis*. Vol. 936. John Wiley &
Sons, 2012.
- Sella, Domenico. *European Industries, 1500-1700*. Collins Clear-Type Press, 1971.
- Shaw, Christine, and Michael Mallett. *The Italian Wars 1494-1559: War, State And Society
In Early Modern Europe*. 2nd Ed. Routledge, 2007.
- Shone, Ronald. *An Introduction to Economic Dynamics*. Cambridge University Press, 2001.
- Sicking, Ludovicus Henricus Joannes. *Zeemacht En Onmacht: Maritieme Politiek in De
Nederlanden, 1488-1558*. De Bataafsche Leeuw, 1998.
- Sigl, Michael, M. Winstrup, J. R. McConnell, K. C. Welten, G. Plunkett, F. Ludlow, Ulf.
Büntgen, M. Caffee, N. Chellman, D. Dahl-Jensen et al. "Timing and Climate Forcing
of Volcanic Eruptions for the Past 2,500 Years." *Nature* 523, no. 7562 (2015): 543-
49.

- Starkey, David J., J. Thór, and I. Heidbrink. *A History of the North Atlantic Fisheries Volume 1: From Early Times to the Mid-Nineteenth Century*. Bremen: Verlag HM Hauschild (2009).
- Stephensen, Oddgeir, and Jón Sigurðsson. *Lovsamling for Island*. Kjöbenhavn: Höst (1853).
- Swain, Harriet. *Big Questions in History*. Random House, 2006.
- Taylor, Alan M. "Potential Pitfalls for the Purchasing-Power-Parity Puzzle? Sampling and Specification Biases in Mean-Reversion Tests of the Law of One Price." *Econometrica* 69, no. 2 (2001): 473-98.
- Toulouse, Sarah, "Marine Cartography and Navigation in Renaissance France." In *The History of Cartography, vol. 3, Cartography in the European Renaissance*, edited by David Woodward. Chicago: University of Chicago Press, 2007.
- Touchard, Henri. *Le Commerce Maritime Breton À La Fin Du Moyen Âge*. Vol. 1. Paris: Belles lettres, 1967.
- Travis, Charles, and Alexander von Lünen, eds. *The Digital Arts and Humanities: Neogeography, Social Media and Big Data Integrations and Applications*. Springer, 2016.
- Travis, Charles, and Poul Holm. "The Digital Environmental Humanities - What Is It and Why Do We Need It? The Norfish Project and Smartcity Lifeworlds." In *The Digital Arts and Humanities*, 187-204. Springer, 2016.
- Turgeon, Laurier. "Codfish, Consumption, and Colonization: The Creation of the French Atlantic World During the Sixteenth Century." In *Bridging the Early Modern Atlantic World: People, Products, and Practices on the Move*, edited by C. Williams, 33-56. Aldershot: Ashgate, 2009.
- . *The Era of the Far-Distant Fisheries: Permanence and Transformation (Circa 1500 - 1850)*. Translated by Aspi Balsara. St John's: Memorial University of Newfoundland, 2005.
- . "Bordeaux and the Newfoundland Trade During the Sixteenth Century." *International Journal of Maritime History* 9, no. 2 (1997): 1-28.

- — —. “Pour Redécouvrir Notre 16e Siècle: Les Pêches À Terre-Neuve D’après Les Archives Notariales De Bordeaux.” *Revue d’histoire de l’Amérique française* 39, no. 4 (1986): 523-49.
- Turner, Sara A. *Dietary Reconstruction in Medieval Holbæk, Denmark Using Dental Microwear and Macrowear, Isotopic Analyses, and Dental Caries*. Anthropology Theses. Georgia State University, (2013).
- Usher, Abbott Payson. “The General Course of Wheat Prices in France: 1350-1788.” *The Review of Economic Statistics* (1930): 159-169.
- van Bochove, Christiaan Jan. *The Economic Consequences of the Dutch. Economic Integration around the North Sea, 1500-1800*. Amsterdam University Press, 2008.
- van Bochove, Christiaan. “De Hollandse Haringvisserij Tijdens De Vroegmoderne Tijd.” *Tijdschrift voor Sociale en Economische Geschiedenis* 1, no. 1 (2004): 3-27.
- van Buuren, Stef and Karin Groothuis-Oudshoorn. “Mice: Multivariate Imputation by Chained Equations in R.” *Journal of Statistical Software* 45, no. 3 (2011): 1-67.
- van der Wee, Herman. *The Growth of the Antwerp Market and the European Economy 14.-16. Centuries*. The Hague: Martinus Nijhoff Publishers, 1963.
- Van der Spek, Robartus J., Bas van Leeuwen, Francois de Callatay, and A. Wilson. “Quantifying the Integration of the Babylonian Economy in the Mediterranean World Using a New Corpus of Price Data, 400-50 BC.” unpublished manuscript, 2013.
- van Lottum, Jelle. *Across the North Sea: The Impact of the Dutch Republic on International Labour Migration, C. 1550-1850*. Vol. 1. Amsterdam University Press, 2007.
- van Sittert, Lance. “The Other Seven Tenths.” *Environmental History* 10, no. 1 (2005): 106-9.
- van Tielhof, Milja. “The Rise and Decline of the Amsterdam Grain Trade” in *Food supply, Demand and Trade: Aspects of the Economic Relationship between Town and Countryside (Middle Ages - 19th century)*, Isd, 2012: 85-99.
- van Zanden, Jan Luiten. “Taking the Measure of the Early Modern Economy: Historical National Accounts for Holland in 1510/14.” *European Review of Economic History* 6, no. 2 (2002): 131-63.

- Vickers, Daniel. "The Price of Fish: A Price Index for Cod, 1505-1892." *Acadensis* 25, no. 2, (1996): 92-104.
- Vilar, Pierre. *La Catalogne Dans L'Espagne Moderne: Recherches Sur Les Fondements Économiques Des Structures Nationales*. Vol. 1. Sevpen, 1962.
- — —. "Remarques Sur L'histoire Des Prix 1." Paper presented at the Annales. Histoire, Sciences Sociales, *Unpublished conference paper* (1961).
- von Stromer, Wolfgang. "Nuremberg in the International Economics of the Middle Ages." *Business History Review* 44, no. 2 (1970): 210-225.
- Walsham, Alexandra. "The Social History of the Archive: Record-Keeping in Early Modern Europe." *Past & Present* 230, no. supp 11 (2016): 9-48. DOI: 10.1093/pastj/gtw033.
- Wang, Jianglin, Bao Yang, Fredrik Charpentier Ljungqvist, Jürg Luterbacher, Timothy J. Osborn, Keith R. Briffa, and Eduardo Zorita. "Internal and External Forcing of Multidecadal Atlantic Climate Variability over the past 1,200 years." *Nature Geoscience* 10, no. 7 (2017): 512-517.
- Wätjen, Hermann. *Zur Statistik Der Holländischen Heringsfischerei Im 17 Und 18. Jahrhundert*. Duncker u. Humblot, 1910.
- White, Sam. *A Cold Welcome: The Little Ice Age and Europe's Encounter with North America*. Harvard University Press, 2017.
- — —. *The Climate of Rebellion in the Early Modern Ottoman Empire*. Cambridge: Cambridge University Press, 2011.
- White, Hayden. "The Question of Narrative in Contemporary Historical Theory." *History and Theory* 23, no. 1 (1984): 1-33.
- Wickham, Hadley. "ggplot2." *Wiley Interdisciplinary Reviews: Computational Statistics* 3, no. 2 (2011): 180-185.
- Williams, Caroline A, ed. *Bridging the Early Modern Atlantic World: People, Products, and Practices on the Move*. Ashgate Publishing Ltd., 2009.
- Wilson, Peter H. "Bolstering the Prestige of the Habsburgs: The End of the Holy Roman Empire in 1806." *The International History Review* 28, no. 4 (2006): 709-736.

- Winchester, Simon. *Atlantic: Great Sea Battles, Heroic Discoveries, Titanic Storms, and a Vast Ocean of a Million Stories*. Harper Collins, 2010.
- Winer, Ben James, Donald R. Brown, and Kenneth M. Michels. *Statistical Principles in Experimental Design*. Vol. 2. New York: McGraw-Hill, 1971.
- Wubs-Mrozewicz, Justyna, and Stuart Jenks eds. *The Hanse in Medieval and Early Modern Europe*. Leiden: Brill, 2012.
- Wubs-Mrozewicz, Justyna. "Fish, Stock and Barrel. Changes in the Stockfish Trade in Northern Europe, C. 1360–1560." In *Beyond the Catch*, edited by L. Sicking and D. Abreu-Ferreira, Leiden: Brill, 2009: 187-208.
- Yoder, Cassidy. "Diet in Medieval Denmark: A Regional and Temporal Comparison." *Journal of Archaeological Science* 37, no. 9 (2010): 2224-36.
- . "Let Them Eat Cake? Status-Based Differences in Diet in Medieval Denmark." *Journal of Archaeological Science* 39, no. 4 (2012): 1183-93.
- Zupko, Ronald Edward. *A Dictionary of Weights and Measures for the British Isles: The Middle Ages to the Twentieth Century*. Vol. 168. American Philosophical Society, 1985.
- . *British Weights & Measures: A History from Antiquity to the Seventeenth Century*. Madison: University of Wisconsin Press, 1977.

Websites

- "Biography of Posthumus, Nicolaas Wilhelmus." Biografisch Woordenboek van het Socialisme en de Arbeidersbeweging in Nederland (BWSA). Accessed August 8 2020. <https://socialhistory.org/bwsa/biografie/posthumus>.
- "Burgernomics: The Big Mac index. Our Interactive Currency Comparison Tool." The Economist. Accessed August 11 2020. <https://www.economist.com/news/2020/07/15/the-big-mac-index>.
- "Chicken eggs 5 Sizes Conversion Plus Nutrients Values." ConvertTo.com. Accessed November 29 2020. <http://convert-to.com/720/chicken-eggs-5-sizes-conversion-plus-nutrients-values.html>.
- "Cod (*Gadus morhua*)." European Commission. Accessed 29 November 2020. https://ec.europa.eu/fisheries/marine_species/wild_species/cod_en.

- “Conflicts and Wars.” Centre for Global Economic History, Utrecht University. Accessed November 8 2020. <http://www.cgeh.nl/data#conflict>.
- “Conflicts and Wars Database.” Centre for Global Economic History, Utrecht University. Accessed November 8 2020. <http://www.cgeh.nl/sites/default/files/Conflict%20Catalog%2018%20vars.xls>.
- “Five Ways to Compute the Relative Value of a U.K. Dollar Amount, 1270 to Present.” <https://www.measuringworth.com/calculators/ukcompare/>.
- “Global Price and Income History Group.” Accessed August 14 2020. <http://gpih.ucdavis.edu/index.html>.
- “Global Price and Income History: Southwest Europe Paris 1380-1870.” Accessed August 14 2020. https://gpih.ucdavis.edu/files/Paris_1380-1870.xls.
- “Great Fish Market. oil painting by Jan Brueghel the Elder in the Alte Pinakothek.” Accessed November 28 2020. Munich: <https://www.wikidata.org/wiki/Q1548676>.
- “History of Marine Animal Populations (HMAP).” HMAP. <http://www.hull.ac.uk/hmap/>.
- Haines, M., ed. 'Newfoundland, 1698-1833' in M.G Barnard and J.H Nicholls (comp.) HMAP Data Pages (<https://hydra.hull.ac.uk/resources/hull:2156>).
- Pope, Peter, ed. 'Newfoundland, 1675-1698' in M.G Barnard and J.H Nicholls (comp.) HMAP Data Pages (<https://hydra.hull.ac.uk/resources/hull:2157>).
- “Oceans Past Platform Cost Action IS1403.” <https://www.tcd.ie/history/opp/>.
- “market, n.” OED Online. Oxford University Press. Accessed October 13. 2020. <https://www-oed-com.elib.tcd.ie/view/Entry/114178?rskey=amBTKJ&result=1&isAdvanced=false>.
- “The Battle of the Herrings.” Gallica.bnf.fr. Accessed November 30 2020. <https://gallica.bnf.fr/ark:/12148/btv1b105380390/f118>.
- “The Hooping of Herring Barrels”. Engraving by Adolf van der Laan based on a drawing by Sieuwert van der Meulen, published by Pieter Schenk in Amsterdam, dated 1720-1730. <https://www.maritiemdigitaal.nl/index.cfm?event=search.getdetail&id=106017468>.

Hammer, Øyvind. "Past Software." <https://folk.uio.no/ohammer/past/>.

Hayes, Patrick, Al Matthews, Bernard Allaire, and Poul Holm. "European Naval Diets Database.xlsx. Figshare." Dataset. Accessed November 8th 2020. <https://doi.org/10.6084/m9.figshare.6446345.v5>.

"The International Council for the Exploration of the Sea (ICES)." ICES. <http://www.ices.dk/marine-data/Pages/default.aspx>.

"The International Institute of Social History (IISG)." IISG. <http://www.iisg.nl/hpw/>.

"The IISH List of Datafiles of Historical Prices and Wages." The International Institute of Social History. Accessed August 8 2020. <http://www.iisg.nl/hpw/>.

"The IISH List of Datafiles of Historical Prices and Wages – Europe." The International Institute of Social History. Accessed August 8 2020. <http://www.iisg.nl/hpw/data.php#europe>.

"The Mighty Cod." The World's Fair. <https://worldsfare.wordpress.com/2008/12/12/the-mighty-cod/>. Accessed November 24 2020.

Olsen, Ole Theodor. "Herring (Clupia Harengus), 1883. Pictorial map, 46 cm x 36 cm." David Rumsey Map Collection. Accessed June 20 2020. <https://www.davidrumsey.com/luna/servlet/s/3wx7n1>.

Reed, Frank. "The Centennia Historical Atlas: Academic Research Edition." Clockwork Mapping: Jamestown RI. Accessed November 8th 2020. <http://historicalatlas.com/>.

Roser, Max. "War and Peace." OurWorldInData.org. Accessed November 8th 2020. <https://ourworldindata.org/war-and-peace>.

"US Department of Agriculture (USDA)." <https://www.usda.gov/>.

"US Department of Agriculture (USDA) Herring." <https://fdc.nal.usda.gov/fdc-app.html#/food-details/782531/nutrients>.

"US Department of Agriculture (USDA) Beef." <https://fdc.nal.usda.gov/fdc-app.html#/food-details/174032/nutrients>.

"US Department of Agriculture (USDA) Chicken." https://www.fsis.usda.gov/shared/PDF/Chicken_Turkey_Nutrition_Facts.pdf.

“US Department of Agriculture (USDA) Pork.” <https://fdc.nal.usda.gov/fdc-app.html#/food-details/167820/nutrients>.

Vagnon, Emmanuelle. “Map in Focus: Pierre De Vaulx’s Marine Chart, 1613. French Ambitions in America.” *Géoconfluences: Geography Resources for Teachers*. Accessed November 8 2020. <http://geoconfluences.ens-lyon.fr/informations-scientifiques/a-la-une/carte-a-la-une/carte-marine-de-locean-atlantique-par-pierre-de-vaulx-1613>.

Digitised Sources

“Letters and Papers, Foreign and Domestic, Henry VIII.” Vol. IV, pt. II, 1526-8, no. 5101. Accessed November 29 2020.

<https://babel.hathitrust.org/cgi/pt?id=msu.31293104681808&view=1up&seq=1177>

Digitised version: Accessed November 29 2020. <https://www.british-history.ac.uk/letters-papers-hen8/vol4/pp2208-2254>.

Grants

“Market Integration and the Welfare of Europeans (INMARWEL).” European Research Council (ERC) Advanced Grant No. 230484, (2009-2013).