An Econometric Analysis of Irish Households' Food Expenditure Patterns: Tobit, Double-Hurdle and Infrequency of Purchase Approaches

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This thesis is dedicated to the memory of my beloved sister, Louise.

DECLARATION

I declare that this thesis, submitted to Trinity College for the degree of Doctor in Philosophy (Ph.D.), has not been submitted as an exercise for a degree at this or any other university. All research contained herein is entirely my own.

I also authorise the Library of Trinity College Dublin to lend or copy this thesis upon request.

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SUMMARY

In this thesis, the factors shaping Irish households' meat and prepared meals expenditure decisions are analysed using the 1987/8 and 1994/5 Irish Household Budget Survey datasets.

In Chapter 1 of this thesis, the changing pattern of food consumption is outlined and the importance of two sectors of the industry, meat and prepared meals, to the Irish food sector is emphasised. A number of factors are identified as influencing the demand for these food items with the main implication being a decline in the importance of price and income factors and a simultaneous increase in the significance of socio-demographic factors, assumed to underpin consumers' tastes and preferences. Specifically, convenience and health are identified as significant attributes of food products desired by many household groups.

In Chapter 2, the econometric methodology specific to modelling household expenditure using micro survey data, in the presence of zero observations on the dependent variable, is discussed in detail. This entails a description of the three relevant models, the tobit, double-hurdle and infrequency of purchase models, the estimation procedures applied, relevant specification issues and the interpretation of parameters.

In Chapter 3, aspects of the 1987/8 and 1994/5 Irish Household Budget Survey datasets are introduced. The sample and variables used in the analyses of the thesis are described with specific attention paid to describing the chosen dependent and independent variables and how they relate to each other.

In Chapters 4, 5 and 6, Irish households' expenditure patterns on aggregate meat, disaggregated meat categories and prepared meals are analysed using the methodologies outlined in Chapter 2 and the data described in Chapter 3.

As identified in the literature, the way in which economic factors impact on food expenditure changed between 1987 and 1994. For all expenditure categories considered in this analysis the magnitude of the income elasticity estimate declined. The main implication of these findings is that in order to encourage increased participation and expenditure in aggregate and disaggregated meat markets and in the market for prepared meals, the industry needs to identify other factors influencing expenditure decisions.

In Chapters 4 and 5, convenience and perceived healthiness were the main explanations given for the observed differences in household expenditure patterns on aggregate and disaggregated meat categories. In Chapter 6, households' preferences for convenience are explored further by analysing their expenditure decisions regarding prepared meals. Younger households, all-working households, urban households, female-headed households, educated households, professional households and single adult households all

exhibit expenditure patterns suggestive of a greater desire for convenience compared with other households. For younger households, all-working households, urban households, educated households and professional households this can be attributed to time constraints imposed by the lifestyles which they lead, relative to other households. For female-headed and single adult households it can be attributed to the fact that these household groups are not typical family households, in a traditional sense, and so purchase convenient alternatives to better suit non-family oriented eating habits. Households with children and married households do not exhibit stronger preferences for convenience compared with other household groups. While these households consume convenient food products, the deduction can be made that they have a greater preference for traditional meal centres[a] compared with other households.

In Chapter 4, it is noted that explaining differences in household meat expenditure patterns with attitudes and preferences regarding health issues is difficult due to the diversity of products the aggregate meat category entails. Furthermore, in Chapter 5 it is concluded that it is difficult to deduce the different degrees of health consciousness of different household groups based on their meat expenditure patterns, without specific attitudinal data of individual households. Nevertheless certain deductions regarding the health consciousness of different household groups are made. For example, it is proposed that female-headed households exhibit meat expenditure behaviour suggestive of a greater level of health consciousness compared with other households.

The main implication of the results observed in the analyses conducted in this thesis is that economic incentives alone may not be as effective in maintaining or stimulating demand for food products as campaigns marketing the attributes of food that changing lifestyles demand. In the case of meat, examples may include identifying ways in which meat can be conveniently prepared or providing information about the nutritional value of meat. For prepared meals, focusing on quality and nutritional aspects could encourage consumption.

In the late 1990s and early 2000s, lifestyles across Europe and more specifically in Ireland have been converging. In Ireland, an increase in the proportion of the Irish population of working age, an increase in third level graduates, an explosion of population in urban areas and government incentives aimed at expanding labour supply increasing the number of all-working households in Ireland, will all shape the food market of the future. It is therefore increasingly important for the food industry to identify the attributes of food products desired by these consumers who form an increasing proportion of the Irish and European population.

[a] This refers to the main component of the meal e.g. steak or roast chicken *etc*.

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TABLE OF CONTENTS

LIST OF TABLES

PAGE

CHAPTER 4

(Tables refer to aggregate meat expenditure models of Irish households for 1987 and 1994 unless otherwise stated)

CHAPTER 5

(Tables refer to individual meat expenditure models of Irish households for 1987 and 1994 unless otherwise stated)

PAGE

CHAPTER 6

(Tables refer to prepared meals expenditure models of Irish households for 1987 and 1994 unless otherwise stated)

LIST OF APPENDICES

CHAPTER 4 PAGE

(Appendices refer to aggregate meat expenditure models of Irish households for 1987 and 1994 unless otherwise stated)

CHAPTER 5

(Appendices refer to individual meat expenditure models of Irish households for 1987 and 1994 unless otherwise stated)

CHAPTER 6 PAGE

(Appendices refer to prepared meals expenditure models of Irish households for 1987 and 1994 unless otherwise stated)

CHAPTER 1

INTRODUCTION TO THE THESIS

1.1 Setting the context

The food industry is of central importance to the Irish economy. In 1999 the gross value added of the food industry was 8.8 per cent of all industries, directly employing 41,300 people (Department of Agriculture Food and Rural Development, 2001). In addition to this, the importance of the sector to agricultural and rural communities throughout the country is well recognised (Department of Agriculture, Food and Rural Development, 2001). Trends indicate that the sector is in transition with expenditure data revealing a shift in consumer expenditure from fresh to frozen products, from basic products to more prepared products and from buying food for home consumption to eating out (Forfás, 1999). These changes have been attributed to changes in social structures resulting in consumers demanding new attributes in food products to meet the demands of their new time consuming lifestyles.

This thesis is concerned with the changing pattern of consumer expenditure on food in Ireland with specific application to Irish household expenditure on meat and on prepared meals. Using the 1987/8 and 1994/5 Irish Household Budget Survey datasets, Irish households' preferences with regard to their expenditure on meat and prepared meals are modelled by examining the influence that various socio-economic characteristics have on their expenditure patterns and how this is changing over time. The most up to date econometric techniques are applied and critiqued in order to obtain the most accurate estimates of how both economic and socio-economic factors influence Irish households' expenditure on meat and prepared meals. The study aims to provide useful recommendations to policy makers and the meat industry as to how they can better influence household expenditure patterns by understanding what determines their expenditure decisions.

Section 1.2 provides the motivation behind the research, identifying the important factors influencing the demand for food, specifically meat and prepared meals. Section 1.3 outlines other literature specifically estimating the demand for food both in Ireland and internationally. Section 1.5 summarises the chapter.

1.2 Motivation of the Research

Smallwood *et al.* (1986) recognised that the market for food exhibits characteristics of uncertainty and instability as a result of changes in both economic and demographic factors affecting the environment within which the food sector operates. Increasing consumer incomes, advertising, changing lifestyles and increased health concerns are all characteristics of modern food markets making it increasingly difficult to explain the demand for food using traditional economic factors alone. According to traditional demand analysis, the demand for food products is determined by (Bansback, 1995):

- Consumer's income
- Price of the product
- Price of substitutes
- Changing structure of the population
- Tastes and preferences of consumers

Traditionally, economic factors, namely income and price, were used to explain consumer demand taking tastes and preferences as given. In the past this approach was considered appropriate for the modelling of food expenditure since key price and income factors were known to explain most of the changes in food consumption (Bansback, 1995). In the last two decades however consumers consider other factors when deciding what food items to consume and how much.

1.2.1 Trends in Food Consumption

Food consumption in Europe has reached a saturation point in terms of volume as total calorie and animal calorie intake are reaching a maximum (Blandford, 1984, Gracia and Albisu, 1997). This combined with the fact that real incomes across Europe are increasing means that the proportion of expenditure allocated to food products is decreasing (Gracia and Albisu, 1997). Between 1987 and 1997 the proportion of total spending allocated to food, beverages and tobacco declined in all EU member states from 20 per cent to 17 per cent (European Commission, 1990, 2001). In Ireland, between these years, the proportion of total expenditure allocated to food alone decreased from 21 per cent to 15 per cent, continuing to decline to 13 per cent by 1999 (Central Statistics Office, 1991, 2000). At the same time, total household expenditure more than doubled between 1987 and 1999 (Central Statistics Office, 1991, 2000). This trend can be explained by the fact that at low-income levels food consumption, as a percentage of income, is relatively high due to the fact that a minimal level of food is required in order to survive. However as income grows, food consumption increases at a slower rate up to a threshold level which cannot physically be passed. Up to a certain point income is therefore the main determinant of food consumption (Gil *et al.*, 1995). In Europe, as countries became wealthier the consumption of cheaper foods with high calorie content declined and the consumption of meat and fish increased. However, as countries became even wealthier and approached the calorie content threshold, factors other than price and income began to determine food demand. Generally prices and income are no longer satisfactory in explaining food demand (Herrmann and Roder, 1995). The food market is facing a new type of consumer leading to an increasing level of competitiveness among food items (Gracia and Albisu, 1997, Angulo *et al.*, 1997). Competition intensifies as the standard economic factors influencing food consumption decline in importance and factors such as attitudes and preferences, resulting from socio-economic influences, increasingly determine food consumption.

1.2.2 The Demand for Meat

The meat sector is one of the main components of the Irish food industry. In 1997, the Irish primary meats industry, consisting of beef, sheep and pigs, was valued at £2.6 billion (€3.3 billion), directly employing over 7,000 people (Enterprise Ireland, 1999). This made up 28 per cent of the industry in that year. While this figure is large, it has been declining since the early 1990s when the meat sector contributed 37 per cent to total food output (Department of Agriculture Food and Rural Development, 2001).

In general there has been a shift in consumer expenditure from basic products, like meat, to more prepared products and from buying food for home consumption to eating out (Forfás, 1999). It is therefore increasingly important to understand the factors shaping consumers' demand for meat in order to provide them with the attributes in meat products that they desire.

Recent demand studies indicate that while price and income elasticities of meat demand are still of significance, socio-economic variables are increasingly of explanatory importance (Gao and Spreen, 1994, Bansback, 1995[1], Burton *et al.*, 1996, Burton *et al.*, 1998). This has been attributed to a number of factors:

- Since the 1980s there has been a general deterioration in the image attached to meat and meat products across Europe (Alvensleben and Mahlau, 1998, Burton *et al.*, 1998, Verbeke and Viaene, 1998). In particular, red meats have suffered in this way in recent decades. The result has been a general shift away from red meat consumption in favour of white meats, in particular chicken.[2] Between 1989 and 2000 per capita beef consumption in Ireland fell from 19.1kg/head to 17.1kg/head while per capita poultry consumption increased from 21.7kg/head to 33.7kg/head (GIRA, 2000)
- Bansback (1995) attributes the changing pattern of meat consumption to changes in the attitudes of the consumer. This is also cited as a contributing factor by authors such as Verbeke and Viaene (1998) and McCarthy *et al.* (1998) who

[1] Bansback (1995) concludes that standard economic factors explained 60% of the changes in meat consumption between 1975-94 compared with 90% between 1955-74.
[2] This trend was accentuated by the BSE crisis in 1996. Due to data limitations, the analysis in this thesis can only deal with pre-1996 meat demand. However, the decline in the image of meat and the consequential shift in consumption from red meats to white meats is a long term trend which has merely been accentuated by such events as the BSE crisis.

specifically identify increasing concerns about health as the main cause of shifts in meat consumption.

- Bansback *et al.* (1998) emphasise social patterns and lifestyles as the main reasons for the changes in the pattern of meat consumption in Britain. Particular reference was made to the decline in average household size and the decline in the importance of the family meal-eating occasion along with the growing importance attached to leisure time leading to the conclusion that consumers require an increased level of convenience in their cooking patterns.

The lifestyle choices which consumers make have lead to a decline in the importance of factors traditionally influencing the demand for meat, such as price, and an increase in the demand for attributes in meat such as convenience and health.

Definition and Attributes of Meat

In this thesis, Irish households' aggregate and disaggregated meat expenditure patterns are analysed in an attempt to identify the factors contributing to the formation of Irish households' meat expenditure decisions, using the 1987 and 1994 Irish Household Budget Survey datasets. However, there are three distinguishable markets for meat, which differ from each other in terms of the way each serves different needs of the consumer (Meat and Livestock Commission, 1999a). Meat can be purchased fresh or frozen from the retailer for preparation at home or as a processed product for consumption at home. Meat can also be purchased and consumed away from home. This thesis is mostly concerned with expenditure on meat for preparation in the home. The first aim is to analyse Irish households' expenditure patterns on aggregate meat expenditure. This analysis is conducted in Chapter 4. The aggregate meat expenditure category includes beef, lamb, pork, pork products, bacon & ham, chicken and minced meat. Certain processed meat products, which could be considered more convenient alternatives to these meat categories, such as hamburgers, meat pies and cooked meats (with the exception of chicken) *etc.* are not included. Furthermore, the meat components of ready or prepared meals and meat consumed away from home are excluded from the aggregate meat expenditure category.

The literature proposes that the two most important preferences of consumers with regard to meat expenditure are convenience and perceived healthiness. Defining aggregate meat expenditure in this way therefore has implications for both of these issues. Firstly, in terms of convenience, each meat category, forming the aggregate meat expenditure category, requires preparation time prior to consumption. As such, consumers have the option to choose other more convenient alternatives to this food category, such as prepared meals, other prepared meat products or eating out of home. Secondly, in terms of health issues, consumers in general perceive fresh meat products to be healthier than frozen or processed meat products (Meat and Livestock Commission, 1999b). Therefore, aggregate meat expenditure may be perceived as being 'healthier' than the other processed meat alternatives excluded from the analysis. However, it must also be noted that other 'healthier' meat alternatives exist, such as fish, which may affect the meat expenditure patterns of the more health conscious households.

In Chapter 5, meat expenditure is disaggregated into seven categories, which are individually analysed. As with aggregate meat expenditure, the socio-economic factors affecting expenditure on each meat category are interpreted through households' preferences for convenience and perceived healthiness.

In terms of convenience, while the most convenient types of meats are not included in the analysis, the seven meat categories considered are very different in terms of the amount of preparation time they require and the amount of convenience they offer the consumer. Traditional meat categories, such as beef, lamb and bacon & ham are cuts of meat appropriate for traditional family meals, such as roasting joints, steaks *etc*., which require time and care to prepare. Pork and chicken can also be in the form of traditional meat meal centres, for example pork joints for roasting, roast chicken *etc*, but both categories also include other more conveniently prepared cuts, for example pork chops, chicken pieces, cooked chicken, and as such possess more convenience attributes compared to other traditional cuts. The Meat and Livestock Commission (1995) attributed the decline in the consumption of beef and lamb relative to pork and poultry in the UK to, among other things, the lack of convenience associated with the former meat categories. Pork products traditionally form the basis of a breakfast meal and as such cannot be compared to other cuts, which form the basis of the household's main meal, in terms of the length of time they take to prepare. There are many convenient alternatives to a home-cooked breakfast available on the market, for example cereal products, and so pork products in general cannot be considered a convenient meat category. However, a component of this category, sausages, are no longer considered suitable for breakfast use only and often form the meat centre of evening meals (Meat and Livestock Commission, 1993). Used in this context, pork products could be considered a more convenient meat for home preparation than other cuts. The most conveniently prepared category is minced meat due to its versatility and widespread use in Italian and other ethnic meals. In the UK there is a trend towards the consumption of minced meat over other cuts of meat due to the decline in formal meal eating occasions and the increasing popularity of minced meat based meals (Meat and Livestock Commission, 1996).

With regard to health issues, as the literature states, there has been a general deterioration in the image attached to meat in general but in particular red meats resulting in a decline in red meat consumption and an increase in white meat consumption. In this analysis higher expenditure levels on chicken at the expense of other red meats by certain household groups could therefore be interpreted as a health-orientated preference. Kinnucan *et al.* (1997) estimated the impact of the provision of health information on meat consumption in the US. They estimated large 'health information elasticities' and concluded that health information was of great importance in explaining the increase in poultry consumption and the decline in the consumption of other red meats.

1.2.3 The Demand for Prepared Meals

The prepared consumer foods sector is very diverse including all items which have undergone secondary processing such as ready meals, processed meats, soups, yoghurts, pet food etc. (McCarthy and Pitts, 1999). In Ireland the sector is small compared to the total food sector with sales of £1.4 billion (€1.78 billion) in 1997 (McCarthy and Pitts, 1999). It is however one of the fastest growing sectors of the Irish food industry with future growth rates predicted at 8 per cent per annum (McCarthy and Pitts, 1999). In this thesis, household expenditure on prepared meals is analysed. Prepared meals (often referred to as ready meals) form a small part of the overall prepared consumer foods sector and are defined as meals which can be cooked or microwaved directly and require no further preparation. Throughout Europe, the ready meals market has shown dynamic growth since the 1980s (Meat and Livestock Commission, 1997). As with the European market, the Irish Household Budget Survey reveals an increase in expenditure on prepared meals as a proportion of total food expenditure of 1 per cent between 1987 and 1994. A number of factors have been identified in the literature as contributing to the growth of the prepared consumer food sector of the economy with overall changes in social structures seen as the driving force:

- Household members are adopting more individualistic lifestyles leading to a breakdown of formal family meal eating occasions (Meat and Livestock Commission, 1997). Children are developing more sophisticated consumer behaviour at increasingly earlier ages (Food Product Development Centre, 1997). Senauer *et al.* (1998) identify how individuals choose the food they want to eat independently of the homemaker leading to a decline in the family meal eating occasion and an increase in individual household members cooking their own meals.
- Lifestyles in general are more affluent with consumers unwilling to spend as much time preparing food (Meat and Livestock Commission, 1997). Increasing disposable incomes has led to increasing expenditure on more convenient time-saving and labour-saving foods (Food Product Development Centre, 1997). Consumers place increased value on leisure time and are unwilling to devote large amounts of time to preparing home-cooked meals (PROMAR International, 1997). Furthermore, time and mobility pressures imposed by new working and living habits lead to a decline in the amount of time spent preparing home cooked meals (PROMAR International, 1997).

- A redefinition of gender roles has led to an increase in the number of working women (from 42.6 per cent to 52.1 per cent in Ireland between 1990 and 1998 (O'Hagan, 2000)). This trend is thought to have led to a general loss in traditional cooking skills and less time available to prepare food in the home, also contributing to a breakdown in the family meal eating occasion (The Food Product Development Centre, 1997, Meat and Livestock Commission, 1997, PROMAR International, 1997).
- Declining household size and the increase in the number of 1-2 person households has had two effects on food demand. Firstly, it has led to an increase in the need for easy-to-serve, portion-controlled convenience foods (Meat and Livestock Commission, 1997). Secondly, it has led to an increase in the numbers of dual income households and increased disposable income to spend on value-added convenience foods (The Food Product Development Centre, 1997, PROMAR International, 1997).
- Increasing ownership of microwaves and freezers has meant that manufacturers are more willing to develop new ready-to-eat products (Meat and Livestock Commission, 1997).
- A rise in younger consumers with disposable incomes who are more likely to experiment with new products, have non-traditional eating habits and eat out more often is also cited as a factor contributing to the increase in demand for prepared consumer foods (McCarthy and Pitts, 1999).

McCarthy and Pitts (1999) summarise that all of these factors have resulted in a 'cash-rich, time-poor' consumer who drives the demand for prepared consumer foods. The impact of socio-economic characteristics of Irish households on their prepared meals expenditure patterns in 1987/8 and 1994/5 is analysed in this thesis. Characteristics such as marital status, the presence of children in a household, social status etc. are considered in an attempt to incorporate each of the contributing factors cited above into the analysis in order to accurately determine the factors influencing Irish consumers' decisions to purchase prepared meals.

1.2.4 Summary and Hypotheses

Sections 1.2.1 and 1.2.2 outlined how lifestyles increasingly impact on consumers' decisions to consume food items, specifically meat and prepared meals. The importance of these non-price/income factors emphasises the limitations of traditional demand analysis (Burton *et al.*, 1996). Factors other than price and income must be included when analysing food consumption. In this thesis the way in which lifestyles impact on Irish households' food expenditure decisions is quantified by identifying differences in the behaviour of different household groups with regard to their expenditure on meat and prepared meals, in 1987/8 and 1994/5.[3] Differences in the lifestyles of these household groups, leading to a demand for certain attributes of food products, will be used to explain their different expenditure patterns. In terms of meat and prepared meals the literature proposes the most important of these attributes to be convenience and perceived healthiness.[4]

[3] These years are selected because of the availability of the Irish Household Budget Survey datasets.
[4] Quality is also cited as an important attribute but, due to data limitations cannot be incorporated into the analyses considered in this thesis (see Chapter 3, Section 3.4.1).

1.3 Other Literature

The empirical literature estimating Irish consumers' demand for food is limited and has thus far been based on aggregate time series data ignoring the impact of socio-economic factors on food demand (O'Riordan, 1975, 1976, Conniffe and Hegarty, 1980). Madden (1993) estimates an Almost Ideal Demand System of Irish consumer demand and concludes by emphasising the need to incorporate micro variables into food demand studies. In the case of meat demand, the latest published study by Boyle (1996) estimates expenditure and price elasticities of demand for meat using a Modified Almost Ideal Demand System and time series data. As with other time series analyses, the effects of non-economic factors are excluded. This study does, however, provide useful estimates of expenditure elasticities for comparison purposes in later chapters.

A qualitative study by McCarthy *et al.* (1998) deals with Irish consumers' perception of meat and of beef in particular, concentrating on the effects of the BSE crisis on Irish consumers' perception of beef, an issue not directly relevant to this study. However, they do emphasise a general move away from red meat consumption in favour of white meats since the mid-eighties, a trend evident across all of Europe as discussed in Section 1.2.2. McCarthy *et al.* (1998) attribute this trend to the public's increased concern about health issues, an issue addressed in subsequent chapters of this thesis.

The shortcoming of the above literature is the failure to incorporate the effect of socio-economic variables which underpin preferences and attitudes in modelling food demand. In the last decade, there has been a great interest among economists in modelling the demand for food items using micro-data which overcomes this problem.

Gould (1992), Yen (1993), Burton *et al.* (1996), Jensen *et al.* (1996), Jensen and Yen (1996), Su and Yen (1996), Yen and Jones (1997), Jensen and Manrique (1998), are all examples of such analyses cited in this thesis. Of particular interest is the analysis of UK household meat expenditure conducted by Burton *et al.* (1996) who identify a decline in the magnitude of income elasticities since 1983 and significant relationships between household meat expenditure and various socio-economic characteristics of households.

The demand for convenience foods, and more specifically ready or prepared meals, has not been empirically explored in Ireland to date. Previous studies have focussed on the 'type' of convenience food consumer emerging in Ireland and the factors driving the demand for these products as discussed in Section 1.2.3 above. As such this thesis represents the first attempt to empirically explain Irish households' expenditure patterns on this food category in terms of how their economic and socio-economic characteristics shape their expenditure decisions. Furthermore, the author is not aware of any international literature empirically analysing the demand for prepared or ready meals.

In this thesis, the latest cross-sectional data available in Ireland, the 1987/8 and the 1994/5 Household Budget Surveys, are used to analyse the factors influencing Irish households' expenditure on meat and prepared meals using the most appropriate econometric techniques suggested by the literature. In an Irish context, this represents the first study of its kind related to consumers' food expenditure dealing with disaggregated food categories and analysed at the micro-level using household expenditure data. Furthermore, in an international context, this analysis represents the first study to analyse meat at such a disaggregated level[5] and to quantitatively analyse the demand for prepared meals.

1.4 Summary

The literature suggests a changing food market, which is increasingly dependent on consumers' tastes and preferences regarding particular food items and the attributes they possess. In this thesis, the expenditure patterns of Irish households in 1987/8 and 1994/5 are analysed in an attempt to explain the factors influencing household expenditure on meat and prepared meals. Consumer needs are becoming more sophisticated as they are better informed about health and quality. However, convenience has become an increasingly important attribute of food products to Irish consumers, as the pace of life increases and consumers devote less time to meal preparation providing more time for work, family and leisure (Forfás, 1999). As a result, the Irish food industry is now in a position to influence its markets to a greater extent than ever before through innovation and effective marketing strategies (Bansback, 1995). For these reasons it is important to model changes in the pattern of influences on the demand for food in an accurate and sophisticated manner so both industry and policy makers can be better informed about what influences their consumers.

In this chapter, the importance of the meat industry to Ireland and the changes in demand for meat evident in the literature are outlined. These factors make the category

[5] Gao and Spreen (1994), analyse beef expenditure disaggregated into three sub-expenditure categories, steak, roast and ground beef. They also include pork and poultry. In this thesis meat expenditure is disaggregated into seven sub-expenditure equations, beef, lamb, pork, pork products, bacon & ham, chicken and minced meat.

an obvious choice for this analysis. While prepared meals are a small component of the Irish food industry, prepared consumer foods is the fastest growing sector of the industry. As a result, understanding the factors shaping Irish households' decisions to purchase prepared meals is important due to the dynamic nature of the market and its future growth potential. For this reason, identifying the factors influencing household expenditure on prepared meals is also chosen for this analysis.

1.5 Structure of the Thesis

The methodology required for modelling household expenditure data is detailed in Chapter 2. Chapter 3 provides a detailed discussion of the data used throughout the thesis. In Chapter 4, Irish households' aggregate meat expenditure patterns are analysed. In Chapter 5, meat expenditure is disaggregated into seven sub expenditure equations and are analysed accordingly. Chapter 6 looks at how Irish households' expenditure decisions regarding prepared meals are formed, identifying the important explanatory influences. The thesis concludes with Chapter 7, providing an overview of the results of each analysis and highlighting similarities and differences. Recommendations, as to how the food industry can better understand and therefore influence their consumers based on the results obtained, are also made.

CHAPTER 2

ECONOMETRIC METHODOLOGY

2.1 Introduction

Using cross-section data allows an examination of the effects on consumption decisions of detailed demographic variables that are not available in aggregate time series data.[6] The problem with cross-section survey data is that it is complicated by the existence of zero observations on expenditure.[7] This raises problems when attempting to estimate models of household expenditure, as a conventional regression model cannot be used. There are three main models which have attempted to deal with these problems:

- The Tobit Model
- The Double Hurdle Model
- The Infrequency of Purchase Model

[6] In the case of Ireland, time series is the only type of data that has been used in estimating food expenditure elasticities to date.

[7] A zero observation is recorded when the survey respondent reports zero expenditure on the good in question.

The main difference between these models lies in the assumptions they make about the source of the zero observations. However, the common and desirable feature of the three models is that they recognise that, due to zero observations on the dependent variable, conventional regression analysis cannot be used to model household demand.

In Section 2.2 the theoretical model is briefly derived and the first econometric model applied in this thesis, the tobit model is described. Sections 2.3 and 2.4 describe and explain the double-hurdle and infrequency of purchase models respectively. Specification issues are addressed in Section 2.5 and the general likelihood function is described in Section 2.6. Testing procedures used to select between the different models are addressed in Section 2.7. Section 2.8 outlines the procedures required in order to meaningfully interpret parameter estimates. Section 2.9 concludes the chapter.

2.2 The Tobit Model

2.2.1 Derivation of the Model

If it is assumed that households are utility maximising units, and are faced with a usual budget constraint, a household's decision to purchase an individual food item will be based on the solution to the following utility maximization problem (Verbeek, 2000):

$$\max U(y, e, \gamma) \tag{2.1}$$

subject to:

$$y + e = Y \tag{2.2}$$

$$e > 0 \tag{2.3}$$

$$y \geq 0 \qquad \textbf{2.4}$$

where y is the household's expenditure on a specific food item, e is all other expenditure of the household[8], Y is total household expenditure and γ represents the household's tastes and preferences which is assumed to be a function of observed household characteristics g. The decision problem we are interested in solving is the household's level of expenditure on y which maximises utility. Ignoring the constraint in Equation 2.4, and under appropriate assumptions on U, the solution to this problem, denoted here by y^*, can be linear in Y and g:

$$y^* = \beta_o + \beta_1 Y + \sum_{s=1}^{S} \beta_s g_s + u \qquad \textbf{2.5}$$

where u corresponds to unobserved heterogeneity since it is not possible to observe everything that determines the utility a household will attach to an individual food item. Since this solution is obtained without placing any restrictions on y, if a household could spend any amount they wanted on y, they would spend y^*. However, since the utility maximising problem is constrained by the fact that y must be greater than or equal to zero, the solution to the problem would be such that if the household wishes to spend a negative amount on the food item in question, that is if $y^* < 0$, it would spend nothing at all on that item. That is:

$$y = y^* \quad \text{if} \quad y^* > 0$$

$$y = 0 \quad \text{if} \quad y^* \leq 0 \qquad \textbf{2.6}$$

[8] Since it is unreasonable to assume that a household would spend all of its money on one individual food item, for example beef, the corner solution $e = 0$ is excluded *a priori*.

This solution gives the standard tobit model (Tobin, 1958) which can be formalised as:

$$y_i^* = x_i'\beta + u_i \qquad u_i \sim N(0,\sigma^2) \qquad i = 1,.........,n$$

$$y_i = y_i^* \qquad \text{if } y_i^* > 0$$

$$y_i = 0 \qquad \text{otherwise} \qquad \textbf{2.7}$$

where x_i are a vector of variables corresponding to the ith household, including total household expenditure, Y, and household characteristics, g, assumed to underpin tastes and preferences.

2.2.2 Description of the Model

The tobit model is a form of limited dependent variable model. Like any limited dependent variable model, the latent variable, y_i^*, determines the value of the observed dependent variable y_i, which in a model of household expenditure is the actual expenditure of the ith household. Within the model, it is possible to observe values of the latent variable within a certain range, but not outside that range. In the case of a model of household expenditure the latent variable is only observed if it is greater than or equal to zero. This implies that negative values of the latent variable are assumed to exist but are not observable. This kind of model is a censoring model with the censoring point lying at zero.

If it is assumed that negative values of expenditure do not exist, unnecessary restrictions are imposed on the model. For this reason the latent variable is allowed to take negative values even though they cannot be observed. The intuition behind this is that in the tobit model, expenditure can be regarded as desired consumption. In this way it is possible that a household dislikes the good so much that it would actually spend a negative amount on it. For this reason a conventional regression model cannot be used to model this behaviour since negative expenditures are unobservable as they are bunched together at the zero bound. The structure of the model, therefore, complicates the estimation procedure.

2.2.3 Estimating the Tobit Model

Under appropriate assumptions maximum likelihood estimation will produce consistent estimates of the parameters of the tobit model. In estimating the model the generation of positive and negative values of the latent variable are separated.

Positive values of the latent variable can be generated from the tobit model under the assumption that $u_i \sim N(0, \sigma^2)$. The contribution to the likelihood function of a positive observation will equal:

$$f(y_i \mid y_i > 0)P(y_i > 0) \qquad \textbf{2. 8}$$

where $f(.)$ is the conditional density function. This can also be expressed as:

$$\left(2\pi\sigma^2\right)^{-1/2} \exp\left[-\frac{(y_i - x_i'\beta)^2}{2\sigma^2}\right] dy_i \qquad \textbf{2. 9}$$

$$= \sigma^{-1}\phi\left[\frac{y_i - x_i'\beta}{\sigma}\right] dy_i \qquad \textbf{2. 10}$$

where $\phi(.)$ is the standard normal probability density function.

Negative values of the latent variable are assumed to exist but are unobservable. Maximum likelihood estimation however allows information about the implied disturbance distribution to be incorporated into the estimation technique. The probability of observing a zero value of y_i is:

$$P(y_i = 0) = P(y_i^* \leq 0) = P(x_i'\beta + u_i \leq 0)$$

$$= P(u_i \leq -x_i'\beta) = P\left(\frac{u_i}{\sigma} \leq -\frac{x_i'\beta}{\sigma}\right)$$

$$= 1 - \Phi\left(\frac{x_i'\beta}{\sigma}\right) \qquad \textbf{2. 11}$$

where $\Phi(.)$ is the standard normal cumulative distribution function.

Using Equations 2.10 and 2.11, the likelihood function for the observed sample of y_i values can be written as[9]:

$$L(\beta, \sigma^2) = \prod_0 \left[1 - \Phi\left(\frac{x_i'\beta}{\sigma}\right)\right] \prod_1 \left[\sigma^{-1}\phi\left(\frac{y_i - x_i'\beta}{\sigma}\right)\right] \qquad \textbf{2. 12}$$

2.2.4 Problems with the Tobit Model

The main problem with the tobit model is the restrictive assumptions it makes about the source of the zero observations on expenditure. It is assumed in the tobit model that zero expenditure is observed because of some factor or characteristic in x_i or other

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[9] $\prod_0$ denotes the product over all zero observations and $\prod_1$ denotes the product over all positive observations.

unobserved heterogeneity captured in u_i, which in some cases makes the household want to purchase negative amounts of the good. In this way, desired consumption translates directly into actual expenditure. Since negative expenditures are unobservable, negative desire and zero desire imply zero expenditure and as such are treated in the same way. In this way the tobit model assumes that factors which determine the probability that positive or zero expenditure is observed also determine the level of expenditure, and so zero observations are treated as true non-consumption or a standard corner solution. In this way, any variable that increases the probability of observing non-zero expenditures also increases the conditional mean of the positive values (Yen, 1993). This is a very strong restriction to place on expenditure on food commodities. Cragg (1971) extended the standard tobit model by considering the possibility that the decision to purchase and how much to purchase may not be determined by the same set of variables and so accommodated zero observations due to non-participation as well as a standard corner solution. This was the first step towards the double-hurdle model, outlined in Section 2.3. The second possible source of zero observations, ignored by the tobit model, is infrequency of purchase. Deaton and Irish (1984) were the first to recognise the fact that special consideration needs to be given to situations where goods are infrequently purchased. This infrequency of purchase model is outlined in Section 2.4.

2.3 The Double-Hurdle Model

This model, originally formulated by Cragg (1971) and built on by Blundell and Meghir (1987) and Jones (1989, 1992), has become very popular in the estimation of food demand using micro-data (Yen, 1993, Burton *et al.*, 1996, Jensen *et al.*, 1996, Jensen and Yen, 1996, Yen and Jones, 1997, Jensen and Manrique, 1998).

The model assumes that zero observations are attributed to either corner solutions or non-participation i.e. households that never participate in the market. The underlying assumption of the model is that each consumer makes two choices with respect to a product to maximise his or her utility. These two choices are whether to purchase the good and conditional on purchase how much to spend. In this way, in order to observe a positive level of expenditure the household must pass two separate hurdles representing the participation and expenditure decisions of the household. The double-hurdle model allows these decisions to be determined by two separate sets of parameters by allowing each decision to be modelled using different explanatory factors.

$$y_{1i}^{*} = w_i'\alpha + v_i \quad \text{(Participation Decision)} \qquad \textbf{2. 13}$$

$$y_{2i}^{*} = x_i'\beta + u_i \quad \text{(Expenditure Decision)} \qquad \textbf{2. 14}$$

Equations 2.13 and 2.14 relate to actual expenditure in the following way:

$$y_i = x_i'\beta + u_i \quad \text{if } y_{1i}^{*} > 0 \text{ and } y_{2i}^{*} > 0$$

$$y_i = 0 \quad \text{otherwise} \qquad \textbf{2. 15}$$

y_{i1}^{*}: latent variable describing the household's decision to participate in a particular food market

y_{i2}^{*} : latent variable describing household consumption of a specific food item

y_i : observed dependent variable – household expenditure

w_i : vector of variables explaining the participation decision

x_i : vector of variables explaining the expenditure decision

v_i, u_i : respective error terms assumed to be independent and distributed as $v_i \sim N(0,1)$ [10]

and $u_i \sim N(0, \sigma^2)$ [11]

Estimating the Double-Hurdle Model

In empirical applications, the double-hurdle model is estimated using maximum likelihood estimation. As with the tobit model, the sample is divided into households with zero expenditure and households with positive expenditure. The likelihood function for the full double-hurdle model, assuming independence between the error terms is (Cragg, 1971):

$$L(\alpha, \beta, \sigma^2) = \prod_0 \left[1 - \Phi(w_i'\alpha)\Phi\left(\frac{x_i'\beta}{\sigma}\right)\right] \prod_1 \left[\Phi(w_i'\alpha)\sigma^{-1}\phi\left(\frac{y_i - x_i'\beta}{\sigma}\right)\right] \qquad \textbf{2.16}$$

The double-hurdle model reduces to the tobit model if the restriction $\Phi(w_i'\alpha) = 1$ is imposed. Recent applications of the double-hurdle model include Burton *et al.*'s (1996) application of a double-hurdle model to UK household meat expenditure, Jensen and Yen's (1996) application to US food expenditure away from home, Yen and Jones' (1997) application to US household consumption of cheese and Dong and Gould's (1999) application to Mexican food demand.

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[10] If y_{i1}^* is interpreted as the utility associated with participation in the market, the scale of this utility will not be identified since only values of 0 and 1 are observed. Therefore, a normalisation of the distribution v_i is required and so the variance is fixed at a given value, 1 (Verbeek, 2000).

[11] Independence of the error terms is a common assumption in these kinds of models (Yen and Su, 1995, Jensen and Yen, 1996, Su and Yen, 1996). Dependence of the error terms is not considered in this analysis.

2.4 The Infrequency of Purchase Model

The infrequency of purchase model takes account of the fact that most household expenditure surveys are based on a very short observation period – the Irish Household Budget Survey records average weekly expenditure on goods based on purchases recorded over a two-week period (Central Statistics Office, 1997). This raises the possibility that zero observations reflect non-purchase due to the survey period being too short as opposed to non-consumption, as assumed in the tobit model, and either non-participation or non-consumption, as assumed in the double-hurdle model. In estimating a demand model we are concerned with true rates of consumption of the commodities in question. In the household budget survey only purchases are observable. This kind of data are only relevant if observed purchases equal actual consumption. Due to the infrequency of purchase problem in a survey of such short duration as the household budget survey, consumption and purchases during the survey period can differ by large amounts. This implies we cannot fit a model of consumption to data on purchases, which implies that both the tobit and double-hurdle models may not be applicable. The first to attempt to model this type of behaviour were Deaton and Irish (1984) whose methodology was later developed by Keen (1986), Blundell and Meghir (1987) and Robin (1993). Infrequency of purchase is modelled in a two-equation model which is merely an extension of Cragg's double-hurdle model.

The infrequency of purchase model is based on a similar structure to the double-hurdle model in that there are two separate processes at work within the model. The first latent purchase equation models whether or not a purchase is observed during the survey period and is expressed as a linear function of exogenous variables r_i:

$$y_{i1}^* = r_i'\delta + \varepsilon_i \qquad \text{(Purchase decision)} \qquad \textbf{2.17}$$

where $\varepsilon_i \sim N(0,1)$.

The expenditure equation is as before:

$$y_{i2}^* = x_i'\beta + u_i \qquad \text{(Expenditure decision)} \qquad \textbf{2.18}$$

where $u_i \sim N(0,\sigma^2)$.

This model differs from the double-hurdle model in the way the decision to purchase relates to actual expenditure (Blundell and Meghir, 1987). The latent variable, y_{i1}^*, describes the decision to purchase with a probability P_i, that is the probability of purchase. Therefore:

$$E(y_i) = E(y_i \mid y_{i1}^* > 0)P_i + E(y_i \mid y_{i1}^* \leq 0)(1 - P_i) \qquad \textbf{2.19}$$

The latent variable y_{i2}^*, generated in Equation 2.18, can be interpreted as household i's consumption of the commodity in question. Assuming that consumption equals expenditure, implying $E(y_{i2}^*) = E(y_i)$, and noting that $E(y_i \mid y_{i1}^* \leq 0) = 0$, Equation 2.19 can be rewritten as:

$$E(y_i \mid y_{i1}^* > 0)P_i = E(y_{i2}^*) \qquad \textbf{2.20}$$

Since $0 \leq P_i \leq 1$, P_i can be interpreted as a depreciation rate, implying that strictly positive expenditures are upward biased and will in general exceed the true rate of consumption. This implies that the relationship between expenditure and consumption can be written as:

$$P_i y_i = y_{i2}^* + \omega_i = (x_i'\beta + u_i) + \omega_i \qquad \textbf{2. 21}$$

where u_i is distributed as before and $\omega_i \sim N(0,1)$. From Equation 2.17, the probability of purchase can be written as $P_i = \Phi(r_i'\delta)$. Furthermore defining $u_i + \omega_i = e_i$, and assuming independence between e_i and ε_i, the equation describing purchasing behaviour can be written as:

$$\Phi(r_i'\delta)y_i = x_i'\beta + e_i \qquad \text{for } y_i > 0 \qquad \textbf{2. 22}$$

The infrequency of purchase model can therefore be written as:

$$y_i = (x_i'\beta + e_i)/\Phi(r_i'\delta) \qquad \text{if } y_{i1}^* > 0 \text{ and } y_{i2}^* > 0$$

$$y_i = 0 \qquad \text{otherwise} \qquad \textbf{2. 23}$$

In this case y_{i1}^* is the latent variable describing the household's decision to purchase a specific meat item, r_i is a vector of variables explaining the purchase/non-purchase decision and y_{i2}^*, y_i, x_i, e_i and u_i are as defined previously.

Estimating the Infrequency of Purchase Model

As with the tobit and double-hurdle models, the infrequency of purchase model is estimated using maximum likelihood estimation. The likelihood equation for the infrequency of purchase model described in Equation 2.24 is (Blundell and Meghir, 1987):

$$L(\delta,\beta,\sigma^2)=\prod_0\left[1-\Phi(r_i'\delta)\Phi\left(\frac{x_i'\beta}{\sigma}\right)\right]\times$$

$$\prod_1\left[\Phi(r_i'\delta)^2\sigma^{-1}\phi\left(\frac{(\Phi(r_i'\delta)y_i-x_i'\beta)}{\sigma}\right)\right] \qquad \textbf{2. 24}$$

This model reduces to the standard Tobit model if $\Phi(r_i'\delta)=1$. If this is the case the survey period is long enough for all potential customers, other than those who choose a corner solution, to purchase the product (Blisard and Blaylock, 1993).

Pudney (1989) provides some intuition into the meaning behind the variables in this model. This 'p-tobit' structure has two components. Firstly, there is a true demand model defined in terms of unobservable consumption and, secondly, there is a purchasing model which provides the link between consumption and purchasing and allows for the possibility of temporary abstention from purchasing in the survey period. y_{i2}^* is interpreted as unobservable consumption. This depends on a vector of exogenous variables, x_i, like price, income and other socio-economic variables. In effect this represents the true demand model. The way actual expenditure, y_i, is related to this true level of consumption depends on P_i, which we interpreted above as a form of depreciation rate. P_i, the probability of purchase is based on another latent variable y_{i1}^*, the value of which is generated by the equation $y_{i1}^*=r_i'\delta+\varepsilon_i$, where r_i is a vector of exogenous variables used to explain households' frequency of purchase. It is these factors which will determine the probability of a purchase being observed in the survey period. Recent applications of this model include Gould's (1992) application to at-home consumption of cheese and Su and Yen's (1996) application to US household pork consumption.

2.5 Specification Issues

In most empirical applications, the likelihood equations for each of these models and their variants are solved based on the assumptions of homoscedasticity and normality of errors. However, in most applications, maximum likelihood estimation produces inconsistent parameter estimates when either assumption is violated.

2.5.1 Heteroscedasticity

To overcome the inconsistency of the estimates in the presence of heteroscedasticity, the standard deviation of the errors can be allowed to vary across observations by specifying it as a function of some subset of explanatory variables. In most empirical applications, the specification of the variance equation tends to be arbitrary in terms of the functional form applied and the variables included. In this thesis, the standard deviation is specified as:

$$\sigma_i = \exp(z_i' h) \qquad \textbf{2.25}$$

where z_i are some elements of x_i (Yen and Su, 1995, Su and Yen, 1996, Yen and Huang, 1996, Yen *et al.*, 1996, Jensen and Yen, 1996, Yen and Jones, 1997). This exponential specification is chosen due to the fact that it ensures the standard deviation σ_i is strictly positive (Yen and Su, 1995, Su and Yen, 1996).

2.5.2 *Non-Normality of Errors*[12]

To allow for non-normality of the errors in maximum likelihood estimation the dependent variable requires a specific type of transformation.[13] An inverse hyperbolic sine (IHS) transformation to the dependent variable will accommodate skewness in the error distribution of all three models.[14] This transformation was originally proposed by Burbidge *et al.* (1988) and has been applied by Jensen and Yen (1996), Jensen *et al.* (1996) and Yen and Jones (1997). Reynolds and Shonkwiler (1991) were the first to apply this transformation to the tobit model. For the tobit and double-hurdle model the transformation is:

$$T(\theta y_i) = \log\left[\theta\, y_i + \left(\theta^2 y_i^{\,2} + 1\right)^{1/2}\right] / \theta$$

$$= \sinh^{-1}(\theta\, y_i)/\theta \qquad \textbf{2. 26}$$

For the infrequency of purchase model, the transformation is:

$$T(\theta\,\Phi(r_i'\delta)y_i) = \log\left[\theta\,\Phi(r_i'\delta)y_i + \left(\theta^2\Phi(r_i'\delta)y_i^2 + 1\right)^{1/2}\right]\Big/\theta$$

$$= \sinh^{-1}(\theta\,\Phi(r_i\delta)y_i)/\theta \qquad \textbf{2. 27}$$

where θ is an unknown parameter that controls for kurtosis (Gao *et al.*, 1995).

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[12] Tests for non-normality in the Tobit model are common, e.g. Pagan and Vella's (1989) conditional moments based test and Bera et al.'s (1984) Lagrange multiplier test. However no such test exists for the transformed or untransformed double-hurdle and infrequency of purchase models. The extension of these tests is not considered in this thesis but is recommended for future research given the importance of the normality assumption for the consistency of the parameter estimates.

[13] An alternative approach is to assume a nonnormal distribution (Yen, 1993).

[14] Yen (1993) and Burton *et al.* (1996) used a Box Cox transformation to allow for non-normality however since this transformation cannot accommodate zero values on the dependent variable (Burbidge *et al.*, 1988) it is not considered in this thesis.

This transformation has previously been applied to both the double-hurdle model (see Jensen and Yen, 1996, Yen *et al.*, 1996, Yen and Jones, 1997) and the infrequency of purchase model (see Su and Yen, 1996). As pointed out by Burbidge *et al.* (1988), $T(.)$ is symmetric about 0 in θ, the limit of $T(.)$ as $\theta \rightarrow 0$ is y_i[15] and for large values of θ, the transformation behaves logarithmically. In addition it is scale invariant and is suited to handling extreme values of the dependent variable (Jensen and Yen, 1996).

2.6 The General Likelihood Equation

Assuming independence of the error terms, all three models can be nested within the one general likelihood equation which adjusts for possible heteroscedasticity and allows for a non-normal error structure:

$$L(\delta,\alpha,\beta,h,\theta) = \prod_0 \left[1-\Phi(r_i'\delta)\Phi(w_i'\alpha)\Phi(x_i'\beta/\sigma_i)\right]\times$$

$$\prod_1 \left[\Phi(r'\delta)^2\Phi(w_i'\alpha)\sigma_i^{-1}\phi\left(\frac{T(\theta\Phi(r_i'\delta)y_i)-x_i'\beta}{\sigma_i}\right)\left(1+\theta^2\Phi(r_i'\delta)^2 y^2\right)^{-1/2}\right] \qquad \textbf{2. 28}$$

where $\left(1+\theta^2\Phi(r_i'\delta)^2 y^2\right)^{-1/2}$ is the Jacobian of the transformation from $T(\theta\Phi(r_i'\delta)y_i)$ to y_i (Burbidge *et al.*, 1988). By imposing necessary restrictions the equation can be decomposed as follows:

- If $\Phi(r_i'\delta)=1$ and $\Phi(w_i'\alpha)=1$, the equation reduces to the IHS heteroscedastic tobit model.

[15] This can be shown using $d\sinh^{-1}(a)/da = (1+a^2)^{-1/2}$ and l'Hopital's rule.

- If $\Phi(r_i'\delta) = 1$, the equation reduces to the IHS heteroscedastic double-hurdle model.
- If $\Phi(w_i'\alpha) = 1$, the equation reduces to the IHS heteroscedastic infrequency of purchase model.
- If $h = 0$, the equation reduces to the general likelihood equation assuming homoscedastic errors.
- If $\theta = 0$, the equation reduces to the general likelihood equation which nests the standard tobit, double-hurdle and infrequency of purchase models described in sections 2.2, 2.3 and 2.4 respectively.

2.7 Model Choice

In this thesis each model is estimated individually.[16] Likelihood ratio tests are used to choose between the restricted tobit model and the unrestricted double-hurdle and infrequency of purchase alternatives. A non-nested model specification test, suggested by Vuong (1989), is used to discriminate between the double-hurdle and infrequency of purchase models. The null hypothesis, that the double-hurdle and infrequency of purchase specifications are equivalent in that both models are equally as close to the true distribution, is tested against the hypothesis that one model is 'better' than the other in that it is closer to the true distribution.

Vuong's limiting standard normal statistic is calculated as:

$$z = \iota' q / \left(q' q - (\iota' q)^2 / n\right)^{1/2} \xrightarrow{L} N(0,1) \qquad \textbf{2.29}$$

[16] Kimhi (1999) suggests an approach integrating the double-hurdle and infrequency of purchase models. This is not considered in this thesis.

where n is the sample size, ι is an $n-$vector of ones, and $q = f - g$, where f and g are $n-$vectors containing the evaluated individual log likelihoods of the double-hurdle and infrequency of purchase models respectively (Su and Yen, 1996). If z is greater than the critical value, the null hypothesis that the models are equivalent is rejected in favour of the double-hurdle model being better than the infrequency of purchase model. If z is less than the negative of the critical value then the null hypothesis is rejected in favour of the infrequency of purchase model. Finally if $|z|$ is less than or equal to the critical value, then, given the data, one cannot discriminate between the two models (Vuong, 1989).

2.8 Interpretation of Coefficient Estimates

As in all non-linear models, the estimated coefficients in the tobit, double-hurdle and infrequency of purchase models cannot be interpreted in the same way as in a linear regression model. To meaningfully analyse the magnitude of the effects of the explanatory factors on the dependent variable, it is necessary to analyse their marginal effects. To obtain these marginal effects the partial derivatives of the expected value of the dependent variable with respect to each explanatory variable must be calculated. This procedure is complicated by the specification adjustments made to account for the problems of heteroscedasticity and non-normality.

2.8.1 Marginal Effects in the Tobit Model

The expected value of the dependent variable for the tobit model with censoring point at zero is (Tobin, 1958):

$$E[y_i \mid x_i] = \Phi\left(\frac{x_i'\beta}{\sigma}\right)\left[x_i'\beta + \sigma\phi\left(\frac{x_i'\beta}{\sigma}\right) \Big/ \Phi\left(\frac{x_i'\beta}{\sigma}\right)\right] \qquad 2.30$$

Differentiating this with respect to each x_{ik} gives the marginal effects for each individual explanatory variable (McDonald and Moffitt, 1980):

$$\frac{\partial E[y_i \mid x_i]}{\partial x_{ik}} = \Phi\left(\frac{x_i'\beta}{\sigma}\right)\beta_k \qquad 2.31$$

McDonald and Moffitt (1980) decompose this marginal effect into two separate components, firstly to determine changes in the probability of being above the limit, and secondly, to determine changes in the value of the dependent variable once above the limit. The unconditional mean for the tobit model can also be written as:

$$E[y_i \mid x_i] = P(y_i > 0)E[y_i \mid y_i > 0] \qquad 2.32$$

These components are:

$$P(y_i > 0) = \Phi\left(\frac{x_i'\beta}{\sigma}\right) \qquad 2.33$$

and:

$$E[y_i \mid y_i > 0] = x_i'\beta + \sigma\phi\left(\frac{x_i'\beta}{\sigma}\right) \Big/ \Phi\left(\frac{x_i'\beta}{\sigma}\right) \qquad 2.34$$

Differentiating Equation 2.33, with respect to a particular explanatory variable, yields the marginal effect of that variable on the probability of being above the limit or in this analysis, the probability of a positive level of expenditure being recorded:

$$\frac{\partial P(y_i > 0)}{\partial x_{ik}} = \phi\left(\frac{x_i'\beta}{\sigma}\right)\frac{\beta_k}{\sigma} \qquad \textbf{2. 35}$$

Differentiating Equation 2.34, with respect to a particular explanatory variable, yields the marginal effect of that variable on the level of expenditure conditional on a purchase being made:

$$\frac{\partial E[y_i \mid y_i > 0]}{\partial x_{ik}} = \beta_k\left(1 - \phi\left(\frac{x_i'\beta}{\sigma}\right)\Big/\Phi\left(\frac{x_i'\beta}{\sigma}\right)\left(\frac{x_i'\beta}{\sigma}\right) - \phi\left(\frac{x_i'\beta}{\sigma}\right)^2\Big/\Phi\left(\frac{x_i'\beta}{\sigma}\right)^2\right)$$

2. 36

The marginal effect associated with the unconditional level of expenditure is therefore (equivalent to Equation 2.31):

$$\frac{\partial E[y_i \mid x_i]}{\partial x_{ik}} = P(y_i > 0)\frac{\partial E[y_i \mid y_i > 0]}{\partial x_{ik}} + E[y_i \mid y_i > 0]\frac{\partial P(y_i > 0)}{\partial x_{ik}} \qquad \textbf{2. 37}$$

Complications arise when the IHS transformation and the heteroscedasticity adjustment are imposed. The expected value of the dependent variable is now of the form:

$$E[y_i \mid x_i] = \int_0^{\infty}\left(\frac{y_i}{\sigma_i\sqrt{1+\theta^2 y_i^2}}\phi\left(\frac{T(\theta y_i) - x_i'\beta}{\sigma_i}\right)\right)dy_i \qquad \textbf{2. 38}$$

and McDonald and Moffitt's components are now:

$$P(y_i > 0) = \Phi\left(\frac{x_i'\beta}{\sigma_i}\right) \qquad \textbf{2. 39}$$

and

$$E[y_i \mid y_i > 0] = \left[\Phi\left(\frac{x_i'\beta}{\sigma_i}\right)\right]^{-1} \times$$

$$\int_0^{\infty}\left(\frac{y_i}{\sigma_i\sqrt{1+\theta^2 y_i^{\,2}}}\phi\left(\frac{T(\theta y)-x_i'\beta}{\sigma_i}\right)\right)dy_i \qquad \textbf{2.40}$$

As before the marginal effects of the explanatory factors are derived by differentiating these components of the dependent variable and are evaluated using numerical integration (see Appendix 2A for derivatives).

2.8.2 Marginal Effects in the Double-Hurdle and Infrequency of Purchase Models

The marginal effects of the explanatory variables on the dependent variable in the double-hurdle and infrequency of purchase models are similar to those for the tobit model and are based on McDonald and Moffitt's (1980) decomposition described in the previous section. Assuming the general form of each model, that is imposing the heteroscedasticity and non-normality adjustments, the unconditional mean for both models, as with the tobit model, can be written as:

$$E[y_i \mid x_i] = P(y_i > 0)E(y_i \mid y_i > 0) \qquad \textbf{2.41}$$

For the double-hurdle model, the probability of participation and the level of expenditure conditional on participation are (Jensen and Yen, 1996, Yen and Jones, 1997, Yen and Huang, 1996):

$$P(y_i > 0) = \Phi(w_i'\alpha)\Phi\left(\frac{x_i'\beta}{\sigma_i}\right) \qquad \textbf{2.42}$$

and

$$E(y_i \mid y_i > 0) = \Phi\left(\frac{x_i'\beta}{\sigma_i}\right)^{-1} \int_0^{\infty}\left(\frac{y_i}{\sigma_i\sqrt{1+\theta^2 y_i^{\,2}}}\ \phi\left(\frac{T(\theta y_i) - x_i'\beta}{\sigma_i}\right)\right)dy_i \qquad \textbf{2.43}$$

For the infrequency of purchase model, these components are (Su and Yen, 1996):

$$P(y_i > 0) = \Phi(r_i'\delta)\Phi\left(\frac{x_i'\beta}{\sigma_i}\right) \qquad \textbf{2.44}$$

and

$$E(y_i \mid y_i > 0) = \Phi(r_i'\delta)\Phi\left(\frac{x_i'\beta}{\sigma_i}\right)^{-1} \times$$

$$\int_0^{\infty}\left(\frac{y_i}{\sigma_i\sqrt{1+\theta^2\Phi(r_i'\delta)^2 y_i^{\,2}}}\ \phi\left(\frac{T(\theta\Phi(r_i'\delta)y_i) - x_i'\beta}{\sigma_i}\right)\right)dy_i \qquad \textbf{2.45}$$

The marginal effect of each explanatory variable on the probability of participation and the level of expenditure conditional on participation in the double-hurdle model are calculated by differentiating Equations 2.42 and 2.43 respectively (see Appendix 2B for derivatives). The marginal effect of each explanatory variable on the probability of purchase and the level of expenditure conditional on purchase in the infrequency of purchase model are calculated by differentiating Equations 2.44 and 2.45 respectively (see Appendix 2C for derivatives). As with the tobit model, the marginal effect of each explanatory variable on the unconditional level of expenditure can be calculated, using these components, from Equation 2.41.

2.8.3 Elasticities and Discrete Effects

For the continuous explanatory variables in each model, marginal effects are used to calculate elasticities at the sample means of the explanatory variables. By construction, the elasticity associated with the probability of a positive purchase being observed and the elasticity associated with the conditional level of expenditure add up to the overall unconditional elasticity of expenditure.

The effect of discrete or categorical explanatory variables cannot be quantified using elasticities. In each model, the effect of these variables on expenditure is calculated as the percentage change in the mean level of probability of participation/purchase and the conditional and unconditional levels of expenditure as a result of the variable moving from zero to one, holding all other x's constant at their mean. By construction, discrete effects on the probability of participation/purchase and the conditional level of expenditure sum to the discrete effect on the unconditional level of expenditure.

2.8.4 Standard Errors of Marginal Effects

In order to perform statistical inferences, standard errors of the estimated marginal effects are approximated using the "delta method". Defining m_j as the marginal effect of a particular variable on a particular expenditure category, the variance of m_j can be written as (Yen and Huang, 1996, Su and Yen, 1996):

$$\mathrm{var}(m_j) = \left[\frac{\partial(m_j)}{\partial(\tau)}\right] \Sigma \left[\frac{\partial(m_j)}{\partial(\tau)}\right] \qquad \textbf{2. 46}$$

where τ is a vector of maximum likelihood parameter estimates and Σ is the estimated variance covariance matrix from the maximum likelihood estimators of the relevant model. Each marginal effect, m_j, is differentiated by each individual parameter of the model (see Appendix 2D for derivatives). The variance of m_j is then approximated by pre and post multiplying the variance covariance matrix of the parameter estimates by this vector of derivatives. The resulting variance estimate is used to calculate a t-statistic for m_j to determine its significance. Finally it is assumed that if m_j is significant the elasticities and discrete effects estimated on the basis of m_j are also significant.

2.9 Summary

This chapter provided a thorough and detailed discussion of the econometric methodology to be used in this thesis. Model descriptions, estimation procedures, specification issues, parameter interpretation and inference are all discussed in an attempt to provide a clear structure and rationale to the econometric procedures to be applied in the following chapters.

In the case of aggregate meat expenditure, analysed in Chapter 4, individual meat expenditure categories, analysed in Chapter 5, and prepared meals analysed in Chapter 6, tobit, double-hurdle and infrequency of purchase models with the necessary specification adjustments are applied to the data in an attempt to estimate elasticity and discrete effect estimates within the most appropriate model specification.

2A Appendices[♦]

Appendix 2A Derivatives of McDonald and Moffitt's (1980) components for the IHS heteroscedastic tobit model

Let ξT_i be the vector of all explanatory variables in the Tobit Model, $[x_i, z_i]$.

Probability of observing positive y_i:

$$P(y_i > 0) = \Phi\left(\frac{x_i'\beta}{\sigma_i}\right)$$

Derivative with respect to the k th explanatory variable:

$$\frac{\partial(P(y_i > 0))}{\partial(\xi T_{ik})} = \phi\left(\frac{x_i'\beta}{\sigma_i}\right)\left(\frac{\beta_k - (x_i'\beta)h_k}{\sigma_i}\right)$$

Conditional mean:

$$E[y_i \mid y_i > 0] = \left[\Phi\left(\frac{x_i'\beta}{\sigma_i}\right)\right]^{-1} \int_0^\infty \left(\frac{y_i}{\sigma_i\sqrt{1+\theta^2 y_i^2}}\phi\left(\frac{T(\theta y) - x_i'\beta}{\sigma_i}\right)\right) dy_i$$

Derivative with respect to the k th explanatory variable:

$$\frac{\partial(E[y_i \mid y_i > 0])}{\partial(\xi T_{ik})} = \left[\Phi\left(\frac{x_i'\beta}{\sigma_i}\right)\right]^{-1} \times$$

$$\int_0^\infty \left(\begin{array}{l} \dfrac{y_i}{\sigma_i\sqrt{1+\theta^2 y_i^2}}\phi\left(\dfrac{T(\theta y) - x_i'\beta}{\sigma_i}\right) \times \\ \left(\left(\dfrac{T(\theta y) - x_i'\beta}{\sigma_i}\right)\dfrac{\beta_k}{\sigma_i} + \left(\dfrac{T(\theta y) - x_i'\beta}{\sigma_i}\right)^2 h_k \right. \\ \left. - h_k - \Phi\left(\dfrac{x_i'\beta}{\sigma_i}\right)^{-1}\phi\left(\dfrac{x_i'\beta}{\sigma_i}\right)\left(\dfrac{\beta_k - (x_i'\beta)h_k}{\sigma_i}\right)\right) \end{array}\right) dy_i$$

♦ All formulae presented in this appendix are derived by the author. Formulae do not apply to the income variable which is adjusted for income squared. For details of this adjustment contact the author.

Appendix 2B Derivatives of the probability of participation/purchase for the IHS heteroscedastic double-hurdle and infrequency of purchase models

The Double-Hurdle Model

Let ξD_i be the vector of all explanatory variables in the double-hurdle model, $[w_i, x_i, z_i]$.

Probability of participation:

$$P(y_i > 0) = \Phi(w_i'\alpha)\Phi\left(\frac{x_i'\beta}{\sigma_i}\right)$$

Derivative with respect to the k th explanatory variable:

$$\frac{\partial(P(y_i > 0))}{\partial(\xi D_{ik})} = \phi(w_i'\alpha)\Phi\left(\frac{x_i'\beta}{\sigma_i}\right)\alpha_k + \Phi(w_i'\alpha)\phi\left(\frac{x_i'\beta}{\sigma_i}\right)\left(\frac{\beta_k - (x_i'\beta)h_k}{\sigma_i}\right)$$

The Infrequency of Purchase Model

Let ξI_i be the vector of all explanatory variables in the infrequency of purchase model, $[r_i, x_i, z_i]$.

Probability of purchase:

$$P(y_i > 0) = \Phi(r_i'\delta)\Phi\left(\frac{x_i'\beta}{\sigma_i}\right)$$

Derivative with respect to the k th explanatory variable:

$$\frac{\partial(P(y_i > 0))}{\partial(\xi I_{ik})} = \phi(r_i'\delta)\Phi\left(\frac{x_i'\beta}{\sigma_i}\right)\delta_k + \Phi(r_i'\delta)\phi\left(\frac{x_i'\beta}{\sigma_i}\right)\left(\frac{\beta_k - (x_i'\beta)h_k}{\sigma_i}\right)$$

Appendix 2C Derivatives of the conditional mean values for the IHS heteroscedastic double-hurdle and infrequency of purchase models

The Double-Hurdle Model

Conditional mean:

$$E[y_i \mid y_i > 0] = \left[\Phi\left(\frac{x_i'\beta}{\sigma_i}\right)\right]^{-1} \int_0^\infty \left(\frac{y_i}{\sigma_i\sqrt{1+\theta^2 y_i^2}}\phi\left(\frac{T(\theta y) - x_i'\beta}{\sigma_i}\right)\right) dy_i$$

Derivative with respect to the k th explanatory variable:

$$\frac{\partial(E[y_i \mid y_i > 0])}{\partial(\xi D_{ik})} = \left[\Phi\left(\frac{x_i'\beta}{\sigma_i}\right)\right]^{-1} \times$$

$$\int_0^\infty \left(\begin{array}{l} \dfrac{y_i}{\sigma_i\sqrt{1+\theta^2 y_i^2}}\phi\left(\dfrac{T(\theta y) - x_i'\beta}{\sigma_i}\right) \times \\ \left(\left(\dfrac{T(\theta y) - x_i'\beta}{\sigma_i}\right)\dfrac{\beta_k}{\sigma_i} + \left(\dfrac{T(\theta y) - x_i'\beta}{\sigma_i}\right)^2 h_k \right. \\ \left. - h_k - \Phi\left(\dfrac{x_i'\beta}{\sigma_i}\right)^{-1}\phi\left(\dfrac{x_i'\beta}{\sigma_i}\right)\left(\dfrac{\beta_k - (x_i'\beta)h_k}{\sigma_i}\right) \right) \end{array} \right) dy_i$$

The Infrequency of Purchase Model

Conditional mean:

$$E(y_i \mid y_i > 0) = \Phi(r_i'\delta)\Phi\left(\frac{x_i'\beta}{\sigma_i}\right)^{-1} \times$$

$$\int_0^\infty \left(\frac{y_i}{\sigma_i\sqrt{1+\theta^2\Phi(r_i'\delta)^2 y_i^2}}\ \phi\left(\frac{T(\theta\Phi(r_i'\delta)y_i) - x_i'\beta}{\sigma_i}\right)\right) dy_i$$

Derivative with respect to the k th explanatory variable:

$$\frac{\partial(E[y_i \mid y_i > 0])}{\partial(\xi I_{ik})} = \Phi(r'\delta)\left[\Phi\left(\frac{x_i'\beta}{\sigma_i}\right)\right]^{-1} \times$$

$$\int_0^\infty \left(\frac{y_i}{\sigma_i\sqrt{1+\theta^2\Phi(r_i'\delta)^2 y_i^2}}\phi\left(\frac{T(\theta\Phi(r_i'\delta)y) - x_i'\beta}{\sigma_i}\right) \times \left(\begin{array}{l} \left(\frac{T(\theta y) - x_i'\beta}{\sigma_i}\right)\frac{\beta_k}{\sigma_i} + \left(\frac{T(\theta y) - x_i'\beta}{\sigma_i}\right)^2 h_k \\ - h_k - \Phi\left(\frac{x_i'\beta}{\sigma_i}\right)^{-1}\phi\left(\frac{x_i'\beta}{\sigma_i}\right)\left(\frac{\beta_k - (x_i'\beta)h_k}{\sigma_i}\right) \\ - \phi(r_i'\delta)\left(\frac{y_i}{\sigma_i\sqrt{1+\theta^2\Phi(r_i'\delta)^2 y_i^2}}\right)\left(\frac{T(\theta y) - x_i'\beta}{\sigma_i}\right)\delta_k \\ - \phi(r_i'\delta)\Phi(r_i'\delta)\left(\frac{\theta^2 y^2}{1+\theta^2\Phi(r_i'\delta)^2 y^2}\right)\delta_k \\ + \phi(r_i'\sigma)\Phi(r_i'\delta)^{-1}\delta_k \end{array} \right) \right) dy_i$$

Appendix 2D Derivatives of the marginal effects associated with the probability of participation/purchase, the conditional and unconditional levels of expenditure with respect to each parameter

The Tobit Model

Marginal effect of k th explanatory variable on the probability of observing positive y_i:

$$\frac{\partial(P(y_i > 0))}{\partial(\xi T_{ik})} = \phi\left(\frac{x_i'\beta}{\sigma_i}\right)\left(\frac{\beta_k - (x_i'\beta)h_k}{\sigma_i}\right) = MEPT_{ik}$$

Derivative with respect to $\tau = [\beta, h, \theta]$:

$$\frac{\partial(MEPT_{ik})}{\partial(\beta_q)} = \phi\left(\frac{x_i'\beta}{\sigma_i}\right) \times \left[-\left(\frac{x_i'\beta}{\sigma_i}\right)\left(\frac{x_{iq}\beta_k - (x_i'\beta)x_{iq}h_k}{\sigma_i}\right) - \left(\frac{x_{iq}h_k}{\sigma_i}\right)\right]$$

$$\frac{\partial(MEPT_{ik})}{\partial(\beta_k)} = \phi\left(\frac{x_i'\beta}{\sigma_i}\right) \times \left[-\left(\frac{x_i'\beta}{\sigma_i}\right)\left(\frac{x_{ik}\beta_k - (x_i'\beta)x_{ik}h_k}{\sigma_i}\right) - \left(\frac{1 - x_{ik}h_k}{\sigma_i}\right)\right]$$

$$\frac{\partial(MEPT_{ik})}{\partial(h_q)} = \phi\left(\frac{x_i'\beta}{\sigma_i}\right)\left(\frac{z_{iq}\beta_k - (x_i'\beta)z_{iq}h_k}{\sigma_i}\right) \times \left[\left(\frac{x_i'\beta}{\sigma_i}\right)^2 - 1\right]$$

$$\frac{\partial(MEPT_{ik})}{\partial(h_k)} = \phi\left(\frac{x_i'\beta}{\sigma_i}\right)\left(\frac{z_{ik}\beta_k - (x_i'\beta)z_{ik}h_k}{\sigma_i}\right) \times \left[\left(\frac{x_i'\beta}{\sigma_i}\right)^2 - 1\right] - \phi\left(\frac{x_i'\beta}{\sigma_i}\right)\left(\frac{x_i'\beta}{\sigma_i}\right)$$

$$\frac{\partial(MEPT_{ik})}{\partial(\theta)} = 0$$

Marginal effect of k th explanatory variable on the conditional level of expenditure:

$$\frac{\partial(E[y_i \mid y_i > 0])}{\partial(\xi T_{ik})} = \left[\Phi\left(\frac{x_i'\beta}{\sigma_i}\right)\right]^{-1} \times$$

$$\int_0^\infty \left(\begin{array}{l} \dfrac{y_i}{\sigma_i\sqrt{1+\theta^2 y_i^2}} \phi\left(\dfrac{T(\theta y) - x_i'\beta}{\sigma_i}\right) \times \\ \left(\left(\dfrac{T(\theta y) - x_i'\beta}{\sigma_i}\right)\dfrac{\beta_k}{\sigma_i} + \left(\dfrac{T(\theta y) - x_i'\beta}{\sigma_i}\right)^2 h_k \right. \\ \left. - h_k - \Phi\left(\dfrac{x_i'\beta}{\sigma_i}\right)^{-1} \phi\left(\dfrac{x_i'\beta}{\sigma_i}\right)\left(\dfrac{\beta_k - (x_i'\beta)h_k}{\sigma_i}\right) \right) \end{array} \right) dy_i = MECT_{ik}$$

$$\text{Let } CT = \left(\begin{array}{l} \left(\dfrac{T(\theta y) - x_i'\beta}{\sigma_i}\right)\dfrac{\beta_k}{\sigma_i} + \left(\dfrac{T(\theta y) - x_i'\beta}{\sigma_i}\right)^2 h_k \\ - h_k - \Phi\left(\dfrac{x_i'\beta}{\sigma_i}\right)^{-1} \phi\left(\dfrac{x_i'\beta}{\sigma_i}\right)\left(\dfrac{\beta_k - (x_i'\beta)h_k}{\sigma_i}\right) \end{array} \right)$$

Derivative with respect to $\tau = [\beta, h, \theta]$:

$$\frac{\partial(MECT_{ik})}{\partial \beta_q} = \Phi\left(\frac{x_i'\beta}{\sigma_i}\right)^{-1} \times$$

$$\frac{y_i}{\sigma_i\sqrt{1+\theta^2 y_i^2}}\phi\left(\frac{T(\theta y_i) - x_i'\beta}{\sigma_i}\right)\times$$

$$\int_0^{\infty}\left(\begin{array}{l} -\Phi\left(\frac{x_i'\beta}{\sigma_i}\right)^{-1}\phi\left(\frac{x_i'\beta}{\sigma_i}\right)\left(\frac{x_{iq}}{\sigma_i}\right)\times(CT) \\ +\left(\frac{T(\theta y_i) - x_i'\beta}{\sigma_i}\right)\left(\frac{x_{iq}}{\sigma_i}\right)\times(CT) \\ -\left(\frac{x_{iq}\beta_k}{\sigma_i^2}\right) - 2\left(\frac{T(\theta y_i) - x_i'\beta}{\sigma_i}\right)\left(\frac{x_{iq}h_k}{\sigma_i}\right) \\ +\Phi\left(\frac{x_i'\beta}{\sigma_i}\right)^{-2}\phi\left(\frac{x_i'\beta}{\sigma_i}\right)^{2}\left(\frac{x_{iq}\beta_k - (x_i'\beta)x_{iq}h_k}{\sigma_i^2}\right) \\ +\Phi\left(\frac{x_i'\beta}{\sigma_i}\right)^{-1}\phi\left(\frac{x_i'\beta}{\sigma_i}\right)\left(\frac{x_i'\beta}{\sigma_i}\right)\left(\frac{x_{iq}\beta_k - (x_i'\beta)x_{iq}h_k}{\sigma_i^2}\right) \\ +\Phi\left(\frac{x_i'\beta}{\sigma_i}\right)^{-1}\phi\left(\frac{x_i'\beta}{\sigma_i}\right)\left(\frac{x_{iq}h_k}{\sigma_i}\right) \end{array}\right) dy_i$$

$$\frac{\partial(MECT_{ik})}{\partial\beta_k} = \Phi\left(\frac{x_i'\beta}{\sigma_i}\right)^{-1} \times$$

$$\int_0^\infty \left[\begin{array}{l} \dfrac{y_i}{\sigma_i\sqrt{1+\theta^2 y_i^2}}\,\phi\left(\dfrac{T(\theta y_i)-x_i'\beta}{\sigma_i}\right)\times \\ \left(\begin{array}{l} -\Phi\left(\dfrac{x_i'\beta}{\sigma_i}\right)^{-1}\phi\left(\dfrac{x_i'\beta}{\sigma_i}\right)\left(\dfrac{x_{ik}}{\sigma_i}\right)\times(CT) \\ +\left(\dfrac{T(\theta y_i)-x_i'\beta}{\sigma_i}\right)\left(\dfrac{x_{ik}}{\sigma_i}\right)\times(CT) \\ -\left(\dfrac{x_{ik}\beta_k}{\sigma_i^2}\right)-2\left(\dfrac{T(\theta y_i)-x_i'\beta}{\sigma_i}\right)\left(\dfrac{x_{ik}h_k}{\sigma_i}\right) \\ +\Phi\left(\dfrac{x_i'\beta}{\sigma_i}\right)^{-2}\phi\left(\dfrac{x_i'\beta}{\sigma_i}\right)^2\left(\dfrac{x_{ik}\beta_k-(x_i'\beta)x_{ik}h_k}{\sigma_i^2}\right) \\ +\Phi\left(\dfrac{x_i'\beta}{\sigma_i}\right)^{-1}\phi\left(\dfrac{x_i'\beta}{\sigma_i}\right)\left(\dfrac{x_i'\beta}{\sigma_i}\right)\left(\dfrac{x_{ik}\beta_k-(x_i'\beta)x_{ik}h_k}{\sigma_i^2}\right) \\ -\Phi\left(\dfrac{x_i'\beta}{\sigma_i}\right)^{-1}\phi\left(\dfrac{x_i'\beta}{\sigma_i}\right)\left(\dfrac{1-x_{ik}h_k}{\sigma_i}\right) \\ +\left(\dfrac{T(\theta y_i)-x_i'\beta}{\sigma_i}\right)\left(\dfrac{1}{\sigma_i}\right) \end{array} \right) \end{array} \right] dy_i$$

$$\frac{\partial(MECT_{ik})}{\partial h_q} = \Phi\left(\frac{x_i'\beta}{\sigma_i}\right)^{-1} \times$$

$$\int_0^\infty \left[\frac{y_i}{\sigma_i\sqrt{1+\theta^2 y_i^2}} \phi\left(\frac{T(\theta y_i) - x_i'\beta}{\sigma_i}\right) \times \left(\begin{aligned} &\Phi\left(\frac{x_i'\beta}{\sigma_i}\right)^{-1} \phi\left(\frac{x_i'\beta}{\sigma_i}\right)\left(\frac{x_i'\beta}{\sigma_i}\right) z_{iq} \times (CT) \\ &- z_{iq} \times (CT) + \left(\frac{T(\theta y_i) - x_i'\beta}{\sigma_i}\right)^2 z_{iq} \times (CT) \\ &- \left(\frac{T(\theta y_i) - x_i'\beta}{\sigma_i}\right)\left(\frac{z_{iq}\beta_k}{\sigma_i}\right) - 2\left(\frac{T(\theta y_i) - x_i'\beta}{\sigma_i}\right)^2 (z_{iq}h_k) \\ &- \Phi\left(\frac{x_i'\beta}{\sigma_i}\right)^{-2} \phi\left(\frac{x_i'\beta}{\sigma_i}\right)^2 \left(\frac{x_i'\beta}{\sigma_i}\right)\left(\frac{z_{iq}\beta_k - (x_i'\beta)z_{iq}h_k}{\sigma_i}\right) \\ &- \Phi\left(\frac{x_i'\beta}{\sigma_i}\right)^{-1} \phi\left(\frac{x_i'\beta}{\sigma_i}\right)\left(\frac{x_i'\beta}{\sigma_i}\right)^2 \left(\frac{z_{iq}\beta_k - (x_i'\beta)z_{iq}h_k}{\sigma_i}\right) \\ &+ \Phi\left(\frac{x_i'\beta}{\sigma_i}\right)^{-1} \phi\left(\frac{x_i'\beta}{\sigma_i}\right)\left(\frac{z_{iq}\beta_k - (x_i'\beta)z_{iq}h_k}{\sigma_i}\right) \end{aligned} \right) \right] dy_i$$

$$\frac{\partial(MECT_{ik})}{\partial h_k} = \Phi\left(\frac{x_i'\beta}{\sigma_i}\right)^{-1} \times$$

$$\int_0^{\infty}\left[\begin{array}{l}\dfrac{y_i}{\sigma_i\sqrt{1+\theta^2 y_i^2}}\phi\left(\dfrac{T(\theta y_i)-x_i'\beta}{\sigma_i}\right)\times \\ \left(\begin{array}{l}\Phi\left(\dfrac{x_i'\beta}{\sigma_i}\right)^{-1}\phi\left(\dfrac{x_i'\beta}{\sigma_i}\right)\left(\dfrac{x_i'\beta}{\sigma_i}\right)z_{ik}\times(CT) \\ -z_{ik}\times(CT)+\left(\dfrac{T(\theta y_i)-x_i'\beta}{\sigma_i}\right)^2 z_{ik}\times(CT) \\ -\left(\dfrac{T(\theta y_i)-x_i'\beta}{\sigma_i}\right)\left(\dfrac{z_{ik}\beta_k}{\sigma_i}\right)-2\left(\dfrac{T(\theta y_i)-x_i'\beta}{\sigma_i}\right)^2(z_{ik}h_k) \\ -\Phi\left(\dfrac{x_i'\beta}{\sigma_i}\right)^{-2}\phi\left(\dfrac{x_i'\beta}{\sigma_i}\right)^2\left(\dfrac{x_i'\beta}{\sigma_i}\right)\left(\dfrac{z_{ik}\beta_k-(x_i'\beta)z_{ik}h_k}{\sigma_i}\right) \\ -\Phi\left(\dfrac{x_i'\beta}{\sigma_i}\right)^{-1}\phi\left(\dfrac{x_i'\beta}{\sigma_i}\right)\left(\dfrac{x_i'\beta}{\sigma_i}\right)^2\left(\dfrac{z_{ik}\beta_k-(x_i'\beta)z_{ik}h_k}{\sigma_i}\right) \\ +\Phi\left(\dfrac{x_i'\beta}{\sigma_i}\right)^{-1}\phi\left(\dfrac{x_i'\beta}{\sigma_i}\right)\left(\dfrac{z_{ik}\beta_k-(x_i'\beta)z_{ik}h_k}{\sigma_i}\right) \\ +\left(\dfrac{T(\theta y_i)-x_i'\beta}{\sigma_i}\right)^2-1+\Phi\left(\dfrac{x_i'\beta}{\sigma_i}\right)^{-1}\phi\left(\dfrac{x_i'\beta}{\sigma_i}\right)\left(\dfrac{x_i'\beta}{\sigma_i}\right)\end{array}\right)\end{array}\right]dy_i$$

$$\frac{\partial(MECT_{ik})}{\partial\theta}=\Phi\left(\frac{x_i'\beta}{\sigma_i}\right)^{-1}\times$$

$$\int_0^\infty\left[\begin{array}{l}\dfrac{y_i}{\sigma_i\sqrt{1+\theta^2 y_i{}^2}}\phi\left(\dfrac{T(\theta y_i)-x_i'\beta}{\sigma_i}\right)\times\\ \left(\begin{array}{l}-\left(\dfrac{\theta y_i^2}{1+\theta^2 y_i^2}\right)\times(CT)\\ -\left(\dfrac{T(\theta y_i)-x_i'\beta}{\sigma_i}\right)\left(\dfrac{y_i}{\theta\sigma_i\sqrt{1+\theta^2 y_i^2}}\right)\times(CT)\\ +\left(\dfrac{T(\theta y_i)-x_i'\beta}{\sigma_i}\right)\left(\dfrac{T(\theta y_i)}{\theta\sigma_i}\right)\times(CT)\\ +\left(\dfrac{y_i}{\theta\sigma_i\sqrt{1+\theta^2 y_i^2}}\right)\left(\dfrac{\beta_k}{\sigma_i}\right)-\left(\dfrac{T(\theta y_i)}{\theta\sigma_i}\right)\left(\dfrac{\beta_k}{\sigma_i}\right)\\ +2\left(\dfrac{T(\theta y_i)-x_i'\beta}{\sigma_i}\right)\left(\dfrac{y_i}{\theta\sigma_i\sqrt{1+\theta^2 y_i^2}}\right)h_k\\ -2\left(\dfrac{T(\theta y_i)-x_i'\beta}{\sigma_i}\right)\left(\dfrac{T(\theta y_i)}{\theta\sigma_i}\right)h_k\end{array}\right)\end{array}\right]dy_i$$

Marginal effect of k th explanatory variable on the unconditional level of expenditure:

$$\frac{\partial(E[y_i])}{\partial(\xi T_{ik})}=\int_0^\infty\left(\begin{array}{l}\dfrac{y_i}{\sigma_i\sqrt{1+\theta^2 y_i{}^2}}\phi\left(\dfrac{T(\theta y)-x_i'\beta}{\sigma_i}\right)\times\\ \left(\left(\dfrac{T(\theta y)-x_i'\beta}{\sigma_i}\right)\dfrac{\beta_k}{\sigma_i}+\left(\dfrac{T(\theta y)-x_i'\beta}{\sigma_i}\right)^2 h_k-h_k\right)\end{array}\right)dy_i=MEUT_{ik}$$

Let $UT=\left(\left(\dfrac{T(\theta y)-x_i'\beta}{\sigma_i}\right)\dfrac{\beta_k}{\sigma_i}+\left(\dfrac{T(\theta y)-x_i'\beta}{\sigma_i}\right)^2 h_k-h_k\right)$

Derivative with respect to $\tau = [\beta, h, \theta]$:

$$\frac{\partial(MEUT_{ik})}{\partial\beta_q} = \int_0^{\infty} \left(\begin{array}{l} \frac{y_i}{\sigma_i\sqrt{1+\theta^2 y_i^2}} \phi\left(\frac{T(\theta y) - x_i'\beta}{\sigma_i}\right) \times \\ \left(\left(\frac{T(\theta y) - x_i'\beta}{\sigma_i}\right)\left(\frac{x_{iq}}{\sigma_i}\right) \times (UT) \right. \\ \left. -\left(\frac{x_{iq}\beta_k}{\sigma_i^2}\right) - 2\left(\frac{T(\theta y) - x_i'\beta}{\sigma_i}\right)\left(\frac{x_{iq}h_k}{\sigma_i}\right) \right) \end{array} \right) dy_i$$

$$\frac{\partial(MEUT_{ik})}{\partial\beta_k} = \int_0^{\infty} \left(\begin{array}{l} \frac{y_i}{\sigma_i\sqrt{1+\theta^2 y_i^2}} \phi\left(\frac{T(\theta y) - x_i'\beta}{\sigma_i}\right) \times \\ \left(\left(\frac{T(\theta y) - x_i'\beta}{\sigma_i}\right)\left(\frac{x_{ik}}{\sigma_i}\right) \times (UT) \right. \\ -\left(\frac{x_{ik}\beta_k}{\sigma_i^2}\right) - 2\left(\frac{T(\theta y) - x_i'\beta}{\sigma_i}\right)\left(\frac{x_{ik}h_k}{\sigma_i}\right) \\ \left. +\left(\frac{T(\theta y) - x_i'\beta}{\sigma_i}\right)\left(\frac{1}{\sigma_i}\right) \right) \end{array} \right) dy_i$$

$$\frac{\partial(MEUT_{ik})}{\partial h_q} = \int_0^{\infty} \left(\begin{array}{l} \frac{y_i}{\sigma_i\sqrt{1+\theta^2 y_i^2}} \phi\left(\frac{T(\theta y) - x_i'\beta}{\sigma_i}\right) \times \\ \left(-z_{iq} \times (UT) + \left(\frac{T(\theta y) - x_i'\beta}{\sigma_i}\right)^2 z_{iq} \times (UT) \right. \\ \left. -\left(\frac{T(\theta y) - x_i'\beta}{\sigma_i}\right)\left(\frac{z_{iq}\beta_k}{\sigma_i}\right) - 2\left(\frac{T(\theta y) - x_i'\beta}{\sigma_i}\right)^2 (z_{iq}h_k) \right) \end{array} \right) dy_i$$

$$\frac{\partial(MEUT_{ik})}{\partial h_k}=\int_0^\infty \begin{pmatrix} \dfrac{y_i}{\sigma_i\sqrt{1+\theta^2 y_i^{\,2}}}\phi\left(\dfrac{T(\theta y)-x_i'\beta}{\sigma_i}\right)\times \\ \begin{pmatrix} -z_{ik}\times(UT)+\left(\dfrac{T(\theta y)-x_i'\beta}{\sigma_i}\right)^2 z_{ik}\times(UT) \\ -\left(\dfrac{T(\theta y)-x_i'\beta}{\sigma_i}\right)\left(\dfrac{z_{ik}\beta_k}{\sigma_i}\right)-2\left(\dfrac{T(\theta y)-x_i'\beta}{\sigma_i}\right)^2(z_{ik}h_k) \\ +\left(\dfrac{T(\theta y)-x_i'\beta}{\sigma_i}\right)^2-1 \end{pmatrix} \end{pmatrix} dy_i$$

$$\frac{\partial(MEUT_{ik})}{\partial \theta}=\int_0^\infty \begin{pmatrix} \dfrac{y_i}{\sigma_i\sqrt{1+\theta^2 y_i^{\,2}}}\phi\left(\dfrac{T(\theta y)-x_i'\beta}{\sigma_i}\right)\times \\ \begin{pmatrix} -\left(\dfrac{\theta y^2}{1+\theta^2 y^2}\right)\times(UT) \\ -\left(\dfrac{T(\theta y)-x_i'\beta}{\sigma_i}\right)\left(\dfrac{y}{\theta\sigma_i\sqrt{1+\theta^2 y_i^{\,2}}}\right)\times(UT) \\ +\left(\dfrac{T(\theta y)-x_i'\beta}{\sigma_i}\right)\left(\dfrac{T(\theta y)}{\theta\sigma}\right)\times(UT) \\ +\left(\dfrac{y}{\theta\sigma_i\sqrt{1+\theta^2 y_i^{\,2}}}\right)\left(\dfrac{\beta_k}{\sigma_i}\right)-\left(\dfrac{T(\theta y)}{\theta\sigma}\right)\left(\dfrac{\beta_k}{\sigma_i}\right) \\ +2\left(\dfrac{T(\theta y)-x_i'\beta}{\sigma_i}\right)\left(\dfrac{y}{\theta\sigma_i\sqrt{1+\theta^2 y_i^{\,2}}}\right)h_k \\ -2\left(\dfrac{T(\theta y)-x_i'\beta}{\sigma_i}\right)\left(\dfrac{T(\theta y)}{\theta\sigma}\right)h_k \end{pmatrix} \end{pmatrix} dy_i$$

The Double Hurdle Model

Marginal effect of k th explanatory variable on the probability of observing positive y_i:

$$\frac{\partial(P(y_i > 0))}{\partial(\xi D_{ik})} = \phi(w_i'\alpha)\Phi\left(\frac{x_i'\beta}{\sigma_i}\right)\alpha_k + \Phi(w_i'\alpha)\phi\left(\frac{x_i'\beta}{\sigma_i}\right)\left(\frac{\beta_k - (x_i'\beta)h_k}{\sigma_i}\right)$$
$$= MEPD_{ik}$$

Derivative with respect to $\tau = [\alpha, \beta, h, \theta]$:

$$\frac{\partial(MEPD_{ik})}{\partial(\alpha_q)} = -\phi(w_i'\alpha)\Phi\left(\frac{x_i'\beta}{\sigma_i}\right)(w_i'\alpha)w_{iq}\alpha_k$$
$$+\phi(w_i'\alpha)\phi\left(\frac{x_i'\beta}{\sigma_i}\right)\left(\frac{w_{iq}\beta_k - (x_i'\beta)w_{iq}\beta_k}{\sigma_i}\right)$$

$$\frac{\partial(MEPD_{ik})}{\partial(\alpha_k)} = -\phi(w_i'\alpha)\Phi\left(\frac{x_i'\beta}{\sigma_i}\right)(w_i'\alpha)w_{ik}\alpha_k$$
$$+\phi(w_i'\alpha)\phi\left(\frac{x_i'\beta}{\sigma_i}\right)\left(\frac{w_{ik}\beta_k - (x_i'\beta)w_{ik}\beta_k}{\sigma_i}\right)$$
$$+\phi(w_i'\alpha)\Phi\left(\frac{x_i'\beta}{\sigma_i}\right)$$

$$\frac{\partial(MEPD_{ik})}{\partial(\beta_q)} = \phi(w_i'\alpha)\phi\left(\frac{x_i'\beta}{\sigma_i}\right)\left(\frac{x_{iq}\alpha_k}{\sigma_i}\right)$$
$$-\Phi(w_i'\alpha)\phi\left(\frac{x_i'\beta}{\sigma_i}\right)\left(\frac{x_i'\beta}{\sigma_i}\right)\left(\frac{x_{iq}\beta_k - (x_i'\beta)x_{iq}h_k}{\sigma_i}\right)$$
$$-\Phi(w_i'\alpha)\phi\left(\frac{x_i'\beta}{\sigma_i}\right)\left(\frac{x_{iq}h_k}{\sigma_i}\right)$$

$$\frac{\partial(MEPD_{ik})}{\partial(\beta_k)} = \phi(w_i'\alpha)\phi\left(\frac{x_i'\beta}{\sigma_i}\right)\left(\frac{x_{ik}\alpha_k}{\sigma_i}\right)$$

$$-\Phi(w_i'\alpha)\phi\left(\frac{x_i'\beta}{\sigma_i}\right)\left(\frac{x_i'\beta}{\sigma_i}\right)\left(\frac{x_{ik}\beta_k-(x_i'\beta)x_{ik}h_k}{\sigma_i}\right)$$

$$+\Phi(w_i'\alpha)\phi\left(\frac{x_i'\beta}{\sigma_i}\right)\left(\frac{1-x_{ik}h_k}{\sigma_i}\right)$$

$$\frac{\partial(MEPD_{ik})}{\partial(h_q)} = -\phi(w_i'\alpha)\phi\left(\frac{x_i'\beta}{\sigma_i}\right)\left(\frac{x_i'\beta}{\sigma_i}\right)(z_{iq}\alpha_k)$$

$$+\Phi(w_i'\alpha)\phi\left(\frac{x_i'\beta}{\sigma_i}\right)\left(\frac{x_i'\beta}{\sigma_i}\right)^2\left(\frac{z_{iq}\beta_k-(x_i'\beta)z_{iq}h_k}{\sigma_i}\right)$$

$$-\Phi(w_i'\alpha)\phi\left(\frac{x_i'\beta}{\sigma_i}\right)\left(\frac{z_{iq}\beta_k-(x_i'\beta)z_{iq}h_k}{\sigma_i}\right)$$

$$\frac{\partial(MEPD_{ik})}{\partial(h_k)} = -\phi(w_i'\alpha)\phi\left(\frac{x_i'\beta}{\sigma_i}\right)\left(\frac{x_i'\beta}{\sigma_i}\right)(z_{ik}\alpha_k)$$

$$+\Phi(w_i'\alpha)\phi\left(\frac{x_i'\beta}{\sigma_i}\right)\left(\frac{x_i'\beta}{\sigma_i}\right)^2\left(\frac{z_{ik}\beta_k-(x_i'\beta)z_{ik}h_k}{\sigma_i}\right)$$

$$-\Phi(w_i'\alpha)\phi\left(\frac{x_i'\beta}{\sigma_i}\right)\left(\frac{z_{ik}\beta_k-(x_i'\beta)z_{ik}h_k}{\sigma_i}\right)$$

$$-\Phi(w_i'\alpha)\phi\left(\frac{x_i'\beta}{\sigma_i}\right)\left(\frac{x_i'\beta}{\sigma_i}\right)$$

$$\frac{\partial(MEPD_{ik})}{\partial(\theta)} = 0$$

Marginal effect of k th explanatory variable on the conditional level of expenditure:

$$\frac{\partial(E[y_i \mid y_i > 0])}{\partial(\xi D_{ik})} = \left[\Phi\left(\frac{x_i'\beta}{\sigma_i}\right)\right]^{-1} \times$$

$$\int_0^{\infty} \left(\begin{array}{l} \dfrac{y_i}{\sigma_i\sqrt{1+\theta^2 y_i^2}}\phi\left(\dfrac{T(\theta y)-x_i'\beta}{\sigma_i}\right) \times \\ \left(\left(\dfrac{T(\theta y)-x_i'\beta}{\sigma_i}\right)\dfrac{\beta_k}{\sigma_i} + \left(\dfrac{T(\theta y)-x_i'\beta}{\sigma_i}\right)^2 h_k \right. \\ \left. -h_k - \Phi\left(\dfrac{x_i'\beta}{\sigma_i}\right)^{-1}\phi\left(\dfrac{x_i'\beta}{\sigma_i}\right)\left(\dfrac{\beta_k-(x_i'\beta)h_k}{\sigma_i}\right) \right) \end{array} \right) dy_i = MECD_{ik}$$

Derivative with respect to $\tau = [\alpha, \beta, h, \theta]$:

$$\frac{\partial(MECD_{ik})}{\partial \alpha_q} = 0, \quad \frac{\partial(MECD_{ik})}{\partial \alpha_k} = 0$$

Derivatives with respect to β, h and θ are the same as for the conditional component of the tobit model.

Marginal effect of k th explanatory variable on the unconditional level of expenditure:

$$\frac{\partial(E[y_i])}{\partial(\xi D_{ik})} = \Phi(w_i'\alpha)\int_0^{\infty} \left(\begin{array}{l} \dfrac{y_i}{\sigma_i\sqrt{1+\theta^2 y_i^2}}\phi\left(\dfrac{T(\theta y)-x_i'\beta}{\sigma_i}\right) \times \\ \left(\Phi(w_i'\alpha)^{-1}\phi(w_i'\alpha)\alpha_k + \left(\dfrac{T(\theta y)-x_i'\beta}{\sigma_i}\right)\dfrac{\beta_k}{\sigma_i} \right. \\ \left. + \left(\dfrac{T(\theta y)-x_i'\beta}{\sigma_i}\right)^2 h_k - h_k \right) \end{array} \right) dy_i = MEUD_{ik}$$

Let $UD = \begin{pmatrix} \Phi(w_i'\alpha)^{-1}\phi(w_i'\alpha)\alpha_k + \left(\frac{T(\theta y) - x_i'\beta}{\sigma_i}\right)\frac{\beta_k}{\sigma_i} \\ + \left(\frac{T(\theta y) - x_i'\beta}{\sigma_i}\right)^2 h_k - h_k \end{pmatrix}$

Derivative with respect to $\tau = [\alpha, \beta, h, \theta]$:

$$\frac{\partial(MEUD_{ik})}{\partial \alpha_q} = \Phi(w_i'\alpha)\int_0^\infty \begin{pmatrix} \frac{y_i}{\sigma_i\sqrt{1+\theta^2 y_i^2}}\phi\left(\frac{T(\theta y) - x_i'\beta}{\sigma_i}\right)\times \\ \begin{pmatrix} \Phi(w_i'\alpha)^{-1}\phi(w_i'\alpha)w_{iq} \times (UD) \\ -\Phi(w_i'\alpha)^{-1}\phi(w_i'\alpha)(w_i'\alpha)w_{iq}\alpha_k \\ -\Phi(w_i'\alpha)^{-2}\phi(w_i'\alpha)^2 w_{iq}\alpha_k \end{pmatrix} \end{pmatrix} dy_i$$

$$\frac{\partial(MEUD_{ik})}{\partial \alpha_k} = \Phi(w_i'\alpha)\int_0^\infty \begin{pmatrix} \frac{y_i}{\sigma_i\sqrt{1+\theta^2 y_i^2}}\phi\left(\frac{T(\theta y) - x_i'\beta}{\sigma_i}\right)\times \\ \begin{pmatrix} \Phi(w_i'\alpha)^{-1}\phi(w_i'\alpha)w_{ik} \times (UD) \\ -\Phi(w_i'\alpha)^{-1}\phi(w_i'\alpha)(w_i'\alpha)w_{ik}\alpha_k \\ -\Phi(w_i'\alpha)^{-2}\phi(w_i'\alpha)^2 w_{ik}\alpha_k \\ +\Phi(w_i'\alpha)^{-1}\phi(w_i'\alpha) \end{pmatrix} \end{pmatrix} dy_i$$

$$\frac{\partial(MEUD_{ik})}{\partial \beta_q} = \Phi(w_i'\alpha)\int_0^\infty \begin{pmatrix} \frac{y_i}{\sigma_i\sqrt{1+\theta^2 y_i^2}}\phi\left(\frac{T(\theta y) - x_i'\beta}{\sigma_i}\right)\times \\ \begin{pmatrix} \left(\frac{T(\theta y) - x_i'\beta}{\sigma_i}\right)\left(\frac{x_{iq}}{\sigma_i}\right) \times (UD) \\ -\left(\frac{x_{iq}\beta_k}{\sigma_i^2}\right) - 2\left(\frac{T(\theta y) - x_i'\beta}{\sigma_i}\right)\left(\frac{x_{iq}h_k}{\sigma_i}\right) \end{pmatrix} \end{pmatrix} dy_i$$

$$\frac{\partial(MEUD_{ik})}{\partial\beta_k} = \Phi(w_i'\alpha)\int_0^\infty \left(\begin{array}{l} \frac{y_i}{\sigma_i\sqrt{1+\theta^2 y_i^2}}\phi\left(\frac{T(\theta y)-x_i'\beta}{\sigma_i}\right)\times \\ \left(\begin{array}{l} \left(\frac{T(\theta y)-x_i'\beta}{\sigma_i}\right)\left(\frac{x_{ik}}{\sigma_i}\right)\times(UD) \\ -\left(\frac{x_{ik}\beta_k}{\sigma_i^2}\right)-2\left(\frac{T(\theta y)-x_i'\beta}{\sigma_i}\right)\left(\frac{x_{ik}h_k}{\sigma_i}\right) \\ +\left(\frac{T(\theta y)-x_i'\beta}{\sigma_i}\right)\left(\frac{1}{\sigma_i}\right) \end{array} \right) \end{array} \right) dy_i$$

$$\frac{\partial(MEUD_{ik})}{\partial h_q} = \Phi(w_i'\alpha)\int_0^\infty \left(\begin{array}{l} \frac{y_i}{\sigma_i\sqrt{1+\theta^2 y_i^2}}\phi\left(\frac{T(\theta y)-x_i'\beta}{\sigma_i}\right)\times \\ \left(\begin{array}{l} -z_{iq}\times(.)+\left(\frac{T(\theta y)-x_i'\beta}{\sigma_i}\right)^2 z_{iq}\times(UD) \\ -\left(\frac{T(\theta y)-x_i'\beta}{\sigma_i}\right)\left(\frac{z_{iq}\beta_k}{\sigma_i}\right)-2\left(\frac{T(\theta y)-x_i'\beta}{\sigma_i}\right)^2(z_{iq}h_k) \end{array} \right) \end{array} \right) dy_i$$

$$\frac{\partial(MEUD_{ik})}{\partial h_k} = \Phi(w_i'\alpha)\int_0^\infty \left(\begin{array}{l} \frac{y_i}{\sigma_i\sqrt{1+\theta^2 y_i^2}}\phi\left(\frac{T(\theta y)-x_i'\beta}{\sigma_i}\right)\times \\ \left(\begin{array}{l} -z_{ik}\times(.)+\left(\frac{T(\theta y)-x_i'\beta}{\sigma_i}\right)^2 z_{ik}\times(UD) \\ -\left(\frac{T(\theta y)-x_i'\beta}{\sigma_i}\right)\left(\frac{z_{ik}\beta_k}{\sigma_i}\right)-2\left(\frac{T(\theta y)-x_i'\beta}{\sigma_i}\right)^2(z_{ik}h_k) \\ +\left(\frac{T(\theta y)-x_i'\beta}{\sigma_i}\right)^2-1 \end{array} \right) \end{array} \right) dy_i$$

$$\frac{\partial(MEUD_{ik})}{\partial\theta}=\Phi(w_i'\alpha)\int_0^\infty\left(\begin{array}{l}\frac{y_i}{\sigma_i\sqrt{1+\theta^2 y_i^2}}\phi\left(\frac{T(\theta y)-x_i'\beta}{\sigma_i}\right)\times\\ \left(\begin{array}{l}-\left(\frac{\theta y^2}{1+\theta^2 y^2}\right)\times(UD)\\ -\left(\frac{T(\theta y)-x_i'\beta}{\sigma_i}\right)\left(\frac{y}{\theta\sigma_i\sqrt{1+\theta^2 y_i^2}}\right)\times(UD)\\ +\left(\frac{T(\theta y)-x_i'\beta}{\sigma_i}\right)\left(\frac{T(\theta y)}{\theta\sigma}\right)\times(UD)\\ +\left(\frac{y}{\theta\sigma_i\sqrt{1+\theta^2 y_i^2}}\right)\left(\frac{\beta_k}{\sigma_i}\right)-\left(\frac{T(\theta y)}{\theta\sigma}\right)\left(\frac{\beta_k}{\sigma_i}\right)\\ +2\left(\frac{T(\theta y)-x_i'\beta}{\sigma_i}\right)\left(\frac{y}{\theta\sigma_i\sqrt{1+\theta^2 y_i^2}}\right)h_k\\ -2\left(\frac{T(\theta y)-x_i'\beta}{\sigma_i}\right)\left(\frac{T(\theta y)}{\theta\sigma}\right)h_k\end{array}\right)\end{array}\right)dy_i$$

The Infrequency of Purchase Model

Marginal effect of k th explanatory variable on the probability of observing positive y_i:

$$\frac{\partial(P(y_i>0))}{\partial(\xi I_{ik})}=\phi(r_i'\delta)\Phi\left(\frac{x_i'\beta}{\sigma_i}\right)\delta_k+\Phi(r_i'\delta)\phi\left(\frac{x_i'\beta}{\sigma_i}\right)\left(\frac{\beta_k-(x_i'\beta)h_k}{\sigma_i}\right)$$
$$=MEPI_{ik}$$

Derivative with respect to $\tau=[\delta,\beta,h,\theta]$:

$$\frac{\partial(MEPI_{ik})}{\partial(\delta_q)}=-\phi(r_i'\delta)\Phi\left(\frac{x_i'\beta}{\sigma_i}\right)(r_i'\delta)r_{iq}\delta_k$$
$$+\phi(r_i'\delta)\phi\left(\frac{x_i'\beta}{\sigma_i}\right)\left(\frac{r_{iq}\beta_k-(x_i'\beta)r_{iq}\beta_k}{\sigma_i}\right)$$

$$\frac{\partial(MEPI_{ik})}{\partial(\delta_k)} = -\phi(r_i'\delta)\Phi\left(\frac{x_i'\beta}{\sigma_i}\right)(r_i'\delta)r_{ik}\delta_k$$

$$+\phi(r_i'\delta)\phi\left(\frac{x_i'\beta}{\sigma_i}\right)\left(\frac{r_{ik}\beta_k-(x_i'\beta)r_{ik}\beta_k}{\sigma_i}\right)$$

$$+\phi(r_i'\delta)\Phi\left(\frac{x_i'\beta}{\sigma_i}\right)$$

$$\frac{\partial(MEPI_{ik})}{\partial(\beta_q)} = \phi(r_i'\delta)\phi\left(\frac{x_i'\beta}{\sigma_i}\right)\left(\frac{x_{iq}\delta_k}{\sigma_i}\right)$$

$$-\Phi(r_i'\delta)\phi\left(\frac{x_i'\beta}{\sigma_i}\right)\left(\frac{x_i'\beta}{\sigma_i}\right)\left(\frac{x_{iq}\beta_k-(x_i'\beta)x_{iq}h_k}{\sigma_i}\right)$$

$$-\Phi(r_i'\delta)\phi\left(\frac{x_i'\beta}{\sigma_i}\right)\left(\frac{x_{iq}h_k}{\sigma_i}\right)$$

$$\frac{\partial(MEPI_{ik})}{\partial(\beta_k)} = \phi(r_i'\delta)\phi\left(\frac{x_i'\beta}{\sigma_i}\right)\left(\frac{x_{ik}\delta_k}{\sigma_i}\right)$$

$$-\Phi(r_i'\delta)\phi\left(\frac{x_i'\beta}{\sigma_i}\right)\left(\frac{x_i'\beta}{\sigma_i}\right)\left(\frac{x_{ik}\beta_k-(x_i'\beta)x_{ik}h_k}{\sigma_i}\right)$$

$$+\Phi(r_i'\delta)\phi\left(\frac{x_i'\beta}{\sigma_i}\right)\left(\frac{1-x_{ik}h_k}{\sigma_i}\right)$$

$$\frac{\partial(MEPI_{ik})}{\partial(h_q)} = -\phi(r_i'\delta)\phi\left(\frac{x_i'\beta}{\sigma_i}\right)\left(\frac{x_i'\beta}{\sigma_i}\right)(z_{iq}\delta_k)$$

$$+\Phi(r_i'\delta)\phi\left(\frac{x_i'\beta}{\sigma_i}\right)\left(\frac{x_i'\beta}{\sigma_i}\right)^2\left(\frac{z_{iq}\beta_k-(x_i'\beta)z_{iq}h_k}{\sigma_i}\right)$$

$$-\Phi(r_i'\delta)\phi\left(\frac{x_i'\beta}{\sigma_i}\right)\left(\frac{z_{iq}\beta_k-(x_i'\beta)z_{iq}h_k}{\sigma_i}\right)$$

$$\frac{\partial(MEPI_{ik})}{\partial(h_k)} = -\phi(r_i'\delta)\phi\left(\frac{x_i'\beta}{\sigma_i}\right)\left(\frac{x_i'\beta}{\sigma_i}\right)(z_{ik}\delta_k)$$

$$+\Phi(r_i'\delta)\phi\left(\frac{x_i'\beta}{\sigma_i}\right)\left(\frac{x_i'\beta}{\sigma_i}\right)^2\left(\frac{z_{ik}\beta_k-(x_i'\beta)z_{ik}h_k}{\sigma_i}\right)$$

$$-\Phi(r_i'\delta)\phi\left(\frac{x_i'\beta}{\sigma_i}\right)\left(\frac{z_{ik}\beta_k-(x_i'\beta)z_{ik}h_k}{\sigma_i}\right)$$

$$-\Phi(r_i'\delta)\phi\left(\frac{x_i'\beta}{\sigma_i}\right)\left(\frac{x_i'\beta}{\sigma_i}\right)$$

$$\frac{\partial(MEPI_{ik})}{\partial(\theta)} = 0$$

Marginal effect of k th explanatory variable on the conditional level of expenditure:

$$\frac{\partial(E[y_i \mid y_i > 0])}{\partial(\xi I_{ik})} = \Phi(r'\delta)\left[\Phi\left(\frac{x_i'\beta}{\sigma_i}\right)\right]^{-1} \times$$

$$\int_0^{\infty} \left(\begin{array}{l} \dfrac{y_i}{\sigma_i\sqrt{1+\theta^2\Phi(r_i'\delta)^2 y_i^2}}\,\phi\left(\dfrac{T(\theta\Phi(r_i'\delta)y)-x_i'\beta}{\sigma_i}\right) \times \\ \left(\begin{array}{l} \phi(r_i'\sigma)\Phi(r_i'\delta)^{-1}\delta_k + \left(\dfrac{T(\theta y)-x_i'\beta}{\sigma_i}\right)\dfrac{\beta_k}{\sigma_i} \\ + \left(\dfrac{T(\theta y)-x_i'\beta}{\sigma_i}\right)^2 h_k - h_k \\ - \Phi\left(\dfrac{x_i'\beta}{\sigma_i}\right)^{-1} \phi\left(\dfrac{x_i'\beta}{\sigma_i}\right)\left(\dfrac{\beta_k - (x_i'\beta)h_k}{\sigma_i}\right) \\ - \left(\dfrac{T(\theta y)-x_i'\beta}{\sigma_i}\right)\left(\dfrac{\phi(r_i'\delta)y_i}{\sigma_i\sqrt{1+\theta^2\Phi(r_i'\delta)^2 y_i^2}}\right)\delta_k \\ - \left(\dfrac{\phi(r_i'\delta)\Phi(r_i'\delta)\theta^2 y^2}{1+\theta^2\Phi(r_i'\delta)^2 y^2}\right)\delta_{kk} \end{array} \right) \end{array} \right) dy_i = MECI_{ik}$$

$$\text{Let } CI = \left(\begin{array}{l} \phi(r_i'\sigma)\Phi(r_i'\delta)^{-1}\delta_k + \left(\dfrac{T(\theta y)-x_i'\beta}{\sigma_i}\right)\dfrac{\beta_k}{\sigma_i} \\ + \left(\dfrac{T(\theta y)-x_i'\beta}{\sigma_i}\right)^2 h_k - h_k \\ - \Phi\left(\dfrac{x_i'\beta}{\sigma_i}\right)^{-1} \phi\left(\dfrac{x_i'\beta}{\sigma_i}\right)\left(\dfrac{\beta_k - (x_i'\beta)h_k}{\sigma_i}\right) \\ - \left(\dfrac{T(\theta y)-x_i'\beta}{\sigma_i}\right)\left(\dfrac{\phi(r_i'\delta)y_i}{\sigma_i\sqrt{1+\theta^2\Phi(r_i'\delta)^2 y_i^2}}\right)\delta_k \\ - \left(\dfrac{\phi(r_i'\delta)\Phi(r_i'\delta)\theta^2 y^2}{1+\theta^2\Phi(r_i'\delta)^2 y^2}\right)\delta_{kk} \end{array} \right)$$

Derivative with respect to $\tau = [\delta, \beta, h, \theta]$:

$$\frac{\partial(MECI_{ik})}{\partial\delta_q} = \Phi(r_i'\delta)\Phi\left(\frac{x_i'\beta}{\sigma_i}\right)^{-1} \times$$

$$\int_0^\infty \left[\begin{array}{l} \dfrac{y_i}{\sigma_i\sqrt{1+\theta^2\Phi(r_i'\delta)^2 y_i^2}}\phi\left(\dfrac{T(\theta\Phi(r_i'\delta)y_i)-x_i'\beta}{\sigma_i}\right)\times \\ \left(\begin{array}{l} \Phi(r_i'\delta)^{-1}\phi(r_i'\delta)r_{iq}\times(CI)-\left(\dfrac{\phi(r_i'\sigma)\Phi(r_i'\delta)\theta^2 y_i^2}{1+\theta^2\Phi(r_i'\delta)^2 y_i^2}\right)r_{iq}\times(CI) \\ -\left(\dfrac{T(\theta\Phi(r_i'\delta)y_i)-x_i'\beta}{\sigma_i}\right)\left(\dfrac{\phi(r_i'\delta)y_i}{\sigma_i\sqrt{1+\theta^2\Phi(r_i'\delta)^2 y_i^2}}\right)r_{iq}\times(CI) \\ -\Phi(r_i'\delta)^{-1}\phi(r_i'\delta)(r_i'\delta)r_{iq}\delta_k-\Phi(r_i'\delta)^{-2}\phi(r_i'\delta)^2 r_{iq}\delta_k \\ +\left(\dfrac{\phi(r_i'\delta)y_i}{\sigma_i\sqrt{1+\theta^2\Phi(r_i'\delta)^2 y_i^2}}\right)\left(\dfrac{r_{iq}\beta_k}{\sigma_i}\right) \\ +2\left(\dfrac{T(\theta\Phi(r_i'\delta)y_i)-x_i'\beta}{\sigma_i}\right)\left(\dfrac{\phi(r_i'\delta)y_i}{\sigma_i\sqrt{1+\theta^2\Phi(r_i'\delta)^2 y_i^2}}\right)r_{iq}h_k \\ -\left(\dfrac{\phi(r_i'\delta)y_i}{\sigma_i\sqrt{1+\theta^2\Phi(r_i'\delta)^2 y_i^2}}\right)^2 r_{iq}\delta_k \\ +\left(\dfrac{T(\theta\Phi(r_i'\delta)y_i)-x_i'\beta}{\sigma_i}\right)\left(\dfrac{\phi(r_i'\delta)y_i}{\sigma_i\sqrt{1+\theta^2\Phi(r_i'\delta)^2 y_i^2}}\right)(r_i'\delta)r_{iq}\delta_k \\ +\left(\dfrac{T(\theta\Phi(r_i'\delta)y_i)-x_i'\beta}{\sigma_i}\right)\left(\dfrac{\phi(r_i'\delta)y_i}{\sigma_i\sqrt{1+\theta^2\Phi(r_i'\delta)^2 y_i^2}}\right)\left(\dfrac{\phi(r_i'\sigma)\Phi(r_i'\delta)\theta^2 y_i^2}{1+\theta^2\Phi(r_i'\delta)^2 y_i^2}\right)r_{iq}\delta_k \\ +\left(\dfrac{\phi(r_i'\sigma)\Phi(r_i'\delta)\theta^2 y_i^2}{1+\theta^2\Phi(r_i'\delta)^2 y_i^2}\right)(r_i'\delta)r_{iq}\delta_k-\left(\dfrac{\phi(r_i'\sigma)^2\theta^2 y_i^2}{1+\theta^2\Phi(r_i'\delta)^2 y_i^2}\right)r_{iq}\delta_k \\ +2\left(\dfrac{\phi(r_i'\sigma)\Phi(r_i'\delta)\theta^2 y_i^2}{1+\theta^2\Phi(r_i'\delta)^2 y_i^2}\right)^2 r_{iq}\delta_k \end{array} \right) \end{array} \right] dy_i$$

$$\frac{\partial(MECI_{ik})}{\partial\delta_k} = \Phi(r_i'\delta)\Phi\left(\frac{x_i'\beta}{\sigma_i}\right)^{-1} \times$$

$$\int_0^\infty \left[\begin{array}{l} \dfrac{y_i}{\sigma_i\sqrt{1+\theta^2\Phi(r_i'\delta)^2 y_i^2}}\phi\left(\dfrac{T(\theta\Phi(r_i'\delta)y_i)-x_i'\beta}{\sigma_i}\right)\times \\ \left(\begin{array}{l} \Phi(r_i'\delta)^{-1}\phi(r_i'\delta)r_{ik}\times(CI)-\left(\dfrac{\phi(r_i'\sigma)\Phi(r_i'\delta)\theta^2 y_i^2}{1+\theta^2\Phi(r_i'\delta)^2 y_i^2}\right)r_{ik}\times(CI) \\ -\left(\dfrac{T(\theta\Phi(r_i'\delta)y_i)-x_i'\beta}{\sigma_i}\right)\left(\dfrac{\phi(r_i'\delta)y_i}{\sigma_i\sqrt{1+\theta^2\Phi(r_i'\delta)^2 y_i^2}}\right)r_{ik}\times(CI) \\ -\Phi(r_i'\delta)^{-1}\phi(r_i'\delta)(r_i'\delta)r_{ik}\delta_k-\Phi(r_i'\delta)^{-2}\phi(r_i'\delta)^2 r_{ik}\delta_k \\ +\left(\dfrac{\phi(r_i'\delta)y_i}{\sigma_i\sqrt{1+\theta^2\Phi(r_i'\delta)^2 y_i^2}}\right)\left(\dfrac{r_{ik}\beta_k}{\sigma_i}\right) \\ +2\left(\dfrac{T(\theta\Phi(r_i'\delta)y_i)-x_i'\beta}{\sigma_i}\right)\left(\dfrac{\phi(r_i'\delta)y_i}{\sigma_i\sqrt{1+\theta^2\Phi(r_i'\delta)^2 y_i^2}}\right)r_{ik}h_k \\ -\left(\dfrac{\phi(r_i'\delta)y_i}{\sigma_i\sqrt{1+\theta^2\Phi(r_i'\delta)^2 y_i^2}}\right)^2 r_{ik}\delta_k \\ +\left(\dfrac{T(\theta\Phi(r_i'\delta)y_i)-x_i'\beta}{\sigma_i}\right)\left(\dfrac{\phi(r_i'\delta)y_i}{\sigma_i\sqrt{1+\theta^2\Phi(r_i'\delta)^2 y_i^2}}\right)(r_i'\delta)r_{ik}\delta_k \\ +\left(\dfrac{T(\theta\Phi(r_i'\delta)y_i)-x_i'\beta}{\sigma_i}\right)\left(\dfrac{\phi(r_i'\delta)y_i}{\sigma_i\sqrt{1+\theta^2\Phi(r_i'\delta)^2 y_i^2}}\right)\left(\dfrac{\phi(r_i'\sigma)\Phi(r_i'\delta)\theta^2 y_i^2}{1+\theta^2\Phi(r_i'\delta)^2 y_i^2}\right)r_{ik}\delta_k \\ +\left(\dfrac{\phi(r_i'\sigma)\Phi(r_i'\delta)\theta^2 y_i^2}{1+\theta^2\Phi(r_i'\delta)^2 y_i^2}\right)(r_i'\delta)r_{ik}\delta_k-\left(\dfrac{\phi(r_i'\sigma)^2\theta^2 y_i^2}{1+\theta^2\Phi(r_i'\delta)^2 y_i^2}\right)r_{ik}\delta_k \\ +2\left(\dfrac{\phi(r_i'\sigma)\Phi(r_i'\delta)\theta^2 y_i^2}{1+\theta^2\Phi(r_i'\delta)^2 y_i^2}\right)^2 r_{ik}\delta_k \\ +\Phi(r_i'\delta)^{-1}\phi(r_i'\delta)-\left(\dfrac{\phi(r_i'\sigma)\Phi(r_i'\delta)\theta^2 y_i^2}{1+\theta^2\Phi(r_i'\delta)^2 y_i^2}\right) \\ -\left(\dfrac{T(\theta\Phi(r_i'\delta)y_i)-x_i'\beta}{\sigma_i}\right)\left(\dfrac{\phi(r_i'\delta)y_i}{\sigma_i\sqrt{1+\theta^2\Phi(r_i'\delta)^2 y_i^2}}\right) \end{array} \right) \end{array} \right] dy_i$$

$$
\frac{\partial(MECI_{ik})}{\partial\beta_q} = \Phi(r_i'\delta)\Phi\left(\frac{x_i'\beta}{\sigma_i}\right)^{-1} \times
$$

$$
\int_0^\infty \left[\begin{array}{l}
\dfrac{y_i}{\sigma_i\sqrt{1+\theta^2\Phi(r_i'\delta)^2 y_i^2}}\phi\left(\dfrac{T(\theta\Phi(r_i'\delta)y_i) - x_i'\beta}{\sigma_i}\right) \times \\
\left(\begin{array}{l}
-\Phi\left(\dfrac{x_i'\beta}{\sigma_i}\right)^{-1}\phi\left(\dfrac{x_i'\beta}{\sigma_i}\right)\left(\dfrac{x_{iq}}{\sigma_i}\right) \times (CI) \\
+\left(\dfrac{T(\theta\Phi(r_i'\delta)y_i) - x_i'\beta}{\sigma_i}\right)\left(\dfrac{x_{iq}}{\sigma_i}\right) \times (CI) \\
-\left(\dfrac{x_{iq}\beta_k}{\sigma_i^2}\right) - 2\left(\dfrac{T(\theta\Phi(r_i'\delta)y_i) - x_i'\beta}{\sigma_i}\right)\left(\dfrac{x_{iq}h_k}{\sigma_i}\right) \\
+\Phi\left(\dfrac{x_i'\beta}{\sigma_i}\right)^{-2}\phi\left(\dfrac{x_i'\beta}{\sigma_i}\right)^{2}\left(\dfrac{x_{iq}\beta_k - (x_i'\beta)x_{iq}h_k}{\sigma_i^2}\right) \\
+\Phi\left(\dfrac{x_i'\beta}{\sigma_i}\right)^{-1}\phi\left(\dfrac{x_i'\beta}{\sigma_i}\right)\left(\dfrac{x_i'\beta}{\sigma_i}\right)\left(\dfrac{x_{iq}\beta_k - (x_i'\beta)x_{iq}h_k}{\sigma_i^2}\right) \\
+\Phi\left(\dfrac{x_i'\beta}{\sigma_i}\right)^{-1}\phi\left(\dfrac{x_i'\beta}{\sigma_i}\right)\left(\dfrac{x_{iq}h_k}{\sigma_i}\right) \\
+\left(\dfrac{\phi(r_i'\delta)y_i}{\sigma_i\sqrt{1+\theta^2\Phi(r_i'\delta)^2 y_i^2}}\right)\left(\dfrac{x_{iq}\delta_k}{\sigma_i}\right)
\end{array} \right)
\end{array} \right] dy_i
$$

$$\frac{\partial(MECI_{ik})}{\partial\beta_q} = \Phi(r_i'\delta)\Phi\left(\frac{x_i'\beta}{\sigma_i}\right)^{-1} \times$$

$$\int_0^\infty \left[\begin{array}{l} \dfrac{y_i}{\sigma_i\sqrt{1+\theta^2\Phi(r_i'\delta)^2 y_i^2}}\phi\left(\dfrac{T(\theta\Phi(r_i'\delta)y_i)-x_i'\beta}{\sigma_i}\right)\times \\ \left(\begin{array}{l} -\Phi\left(\dfrac{x_i'\beta}{\sigma_i}\right)^{-1}\phi\left(\dfrac{x_i'\beta}{\sigma_i}\right)\left(\dfrac{x_{iq}}{\sigma_i}\right)\times(CI) \\ +\left(\dfrac{T(\theta\Phi(r_i'\delta)y_i)-x_i'\beta}{\sigma_i}\right)\left(\dfrac{x_{iq}}{\sigma_i}\right)\times(CI) \\ -\left(\dfrac{x_{iq}\beta_k}{\sigma_i^2}\right)-2\left(\dfrac{T(\theta\Phi(r_i'\delta)y_i)-x_i'\beta}{\sigma_i}\right)\left(\dfrac{x_{iq}h_k}{\sigma_i}\right) \\ +\Phi\left(\dfrac{x_i'\beta}{\sigma_i}\right)^{-2}\phi\left(\dfrac{x_i'\beta}{\sigma_i}\right)^2\left(\dfrac{x_{iq}\beta_k-(x_i'\beta)x_{iq}h_k}{\sigma_i^2}\right) \\ +\Phi\left(\dfrac{x_i'\beta}{\sigma_i}\right)^{-1}\phi\left(\dfrac{x_i'\beta}{\sigma_i}\right)\left(\dfrac{x_i'\beta}{\sigma_i}\right)\left(\dfrac{x_{iq}\beta_k-(x_i'\beta)x_{iq}h_k}{\sigma_i^2}\right) \\ +\Phi\left(\dfrac{x_i'\beta}{\sigma_i}\right)^{-1}\phi\left(\dfrac{x_i'\beta}{\sigma_i}\right)\left(\dfrac{1-x_{iq}h_k}{\sigma_i}\right) \\ +\left(\dfrac{\phi(r_i'\delta)y_i}{\sigma_i\sqrt{1+\theta^2\Phi(r_i'\delta)^2 y_i^2}}\right)\left(\dfrac{x_{iq}\delta_k}{\sigma_i}\right) \\ +\left(\dfrac{T(\theta\Phi(r_i'\delta)y_i)-x_i'\beta}{\sigma_i}\right)\left(\dfrac{1}{\sigma_i}\right) \end{array} \right) \end{array} \right] dy_i$$

$$\frac{\partial(MECI_{ik})}{\partial h_q} = \Phi(r_i'\delta)\Phi\left(\frac{x_i'\beta}{\sigma_i}\right)^{-1} \times$$

$$\int_0^\infty \left[\begin{array}{l} \dfrac{y_i}{\sigma_i\sqrt{1+\theta^2\Phi(r_i'\delta)^2 y_i^2}}\phi\left(\dfrac{T(\theta\Phi(r_i'\delta)y_i)-x_i'\beta}{\sigma_i}\right)\times \\ \left(\begin{array}{l} \Phi\left(\dfrac{x_i'\beta}{\sigma_i}\right)^{-1}\phi\left(\dfrac{x_i'\beta}{\sigma_i}\right)\left(\dfrac{x_i'\beta}{\sigma_i}\right)z_{iq}\times(CI) \\ -z_{iq}\times(CI)+\left(\dfrac{T(\theta\Phi(r_i'\delta)y_i)-x_i'\beta}{\sigma_i}\right)^2 z_{iq}\times(CI) \\ -2\left(\dfrac{T(\theta\Phi(r_i'\delta)y_i)-x_i'\beta}{\sigma_i}\right)\left(\dfrac{z_{iq}\beta_k}{\sigma_i}\right)-2\left(\dfrac{T(\theta\Phi(r_i'\delta)y_i)-x_i'\beta}{\sigma_i}\right)^2(z_{iq}h_k) \\ -\Phi\left(\dfrac{x_i'\beta}{\sigma_i}\right)^{-2}\phi\left(\dfrac{x_i'\beta}{\sigma_i}\right)^2\left(\dfrac{x_i'\beta}{\sigma_i}\right)\left(\dfrac{z_{iq}\beta_k-(x_i'\beta)z_{iq}h_k}{\sigma_i}\right) \\ -\Phi\left(\dfrac{x_i'\beta}{\sigma_i}\right)^{-1}\phi\left(\dfrac{x_i'\beta}{\sigma_i}\right)\left(\dfrac{x_i'\beta}{\sigma_i}\right)^2\left(\dfrac{z_{iq}\beta_k-(x_i'\beta)z_{iq}h_k}{\sigma_i}\right) \\ +\Phi\left(\dfrac{x_i'\beta}{\sigma_i}\right)^{-1}\phi\left(\dfrac{x_i'\beta}{\sigma_i}\right)\left(\dfrac{z_{iq}\beta_k-(x_i'\beta)z_{iq}h_k}{\sigma_i}\right) \\ +2\left(\dfrac{T(\theta\Phi(r_i'\delta)y_i)-x_i'\beta}{\sigma_i}\right)\left(\dfrac{\phi(r_i'\delta)y_i}{\sigma_i\sqrt{1+\theta^2\Phi(r_i'\delta)^2 y_i^2}}\right)(z_{iq}\delta_k) \end{array} \right) \end{array} \right] dy_i$$

$$\frac{\partial(MECI_{ik})}{\partial h_k} = \Phi(r_i'\delta)\Phi\left(\frac{x_i'\beta}{\sigma_i}\right)^{-1} \times$$

$$\int_0^\infty \left[\begin{array}{l} \dfrac{y_i}{\sigma_i\sqrt{1+\theta^2\Phi(r_i'\delta)^2 y_i^2}}\phi\left(\dfrac{T(\theta\Phi(r_i'\delta)y_i)-x_i'\beta}{\sigma_i}\right)\times \\ \left(\begin{array}{l} \Phi\left(\dfrac{x_i'\beta}{\sigma_i}\right)^{-1}\phi\left(\dfrac{x_i'\beta}{\sigma_i}\right)\left(\dfrac{x_i'\beta}{\sigma_i}\right)z_{ik}\times(CI) \\ -z_{ik}\times(CI)+\left(\dfrac{T(\theta\Phi(r_i'\delta)y_i)-x_i'\beta}{\sigma_i}\right)^2 z_{ik}\times(CI) \\ -2\left(\dfrac{T(\theta\Phi(r_i'\delta)y_i)-x_i'\beta}{\sigma_i}\right)\left(\dfrac{z_{ik}\beta_k}{\sigma_i}\right)-2\left(\dfrac{T(\theta\Phi(r_i'\delta)y_i)-x_i'\beta}{\sigma_i}\right)^2(z_{ik}h_k) \\ -\Phi\left(\dfrac{x_i'\beta}{\sigma_i}\right)^{-2}\phi\left(\dfrac{x_i'\beta}{\sigma_i}\right)^2\left(\dfrac{x_i'\beta}{\sigma_i}\right)\left(\dfrac{z_{ik}\beta_k-(x_i'\beta)z_{ik}h_k}{\sigma_i}\right) \\ -\Phi\left(\dfrac{x_i'\beta}{\sigma_i}\right)^{-1}\phi\left(\dfrac{x_i'\beta}{\sigma_i}\right)\left(\dfrac{x_i'\beta}{\sigma_i}\right)^2\left(\dfrac{z_{ik}\beta_k-(x_i'\beta)z_{ik}h_k}{\sigma_i}\right) \\ +\Phi\left(\dfrac{x_i'\beta}{\sigma_i}\right)^{-1}\phi\left(\dfrac{x_i'\beta}{\sigma_i}\right)\left(\dfrac{z_{ik}\beta_k-(x_i'\beta)z_{ik}h_k}{\sigma_i}\right) \\ +2\left(\dfrac{T(\theta\Phi(r_i'\delta)y_i)-x_i'\beta}{\sigma_i}\right)\left(\dfrac{\phi(r_i'\delta)y_i}{\sigma_i\sqrt{1+\theta^2\Phi(r_i'\delta)^2 y_i^2}}\right)(z_{ik}\delta_k) \\ +\Phi\left(\dfrac{x_i'\beta}{\sigma_i}\right)^{-1}\phi\left(\dfrac{x_i'\beta}{\sigma_i}\right)\left(\dfrac{x_i'\beta}{\sigma_i}\right)-1+\left(\dfrac{\phi(r_i'\delta)y_i}{\sigma_i\sqrt{1+\theta^2\Phi(r_i'\delta)^2 y_i^2}}\right)^2 \end{array} \right) \end{array} \right] dy_i$$

$$\frac{\partial(MECI_{ik})}{\partial\theta}=\Phi(r_i'\delta)\Phi\left(\frac{x_i'\beta}{\sigma_i}\right)^{-1}\times$$

$$\int_0^\infty\left[\begin{array}{l}\dfrac{y_i}{\sigma_i\sqrt{1+\theta^2\Phi(r_i'\delta)^2 y_i^2}}\phi\left(\dfrac{T(\theta\Phi(r_i'\delta)y_i)-x_i'\beta}{\sigma_i}\right)\times\\
\left(\begin{array}{l}-\left(\dfrac{\theta\Phi(r_i'\delta)^2 y_i^2}{1+\theta^2\Phi(r_i'\delta)^2 y_i^2}\right)\times(CI)\\
-\left(\dfrac{T(\theta\Phi(r_i'\delta)y_i)-x_i'\beta}{\sigma_i}\right)\left(\dfrac{\Phi(r_i'\delta)y_i}{\theta\sigma_i\sqrt{1+\theta^2\Phi(r_i'\delta)^2 y_i^2}}\right)\times(CI)\\
+\left(\dfrac{T(\theta\Phi(r_i'\delta)y_i)-x_i'\beta}{\sigma_i}\right)\left(\dfrac{T(\theta\Phi(r_i'\delta)y_i)}{\theta\sigma_i}\right)\times(CI)\\
+\left(\dfrac{\Phi(r_i'\delta)y_i}{\theta\sigma_i\sqrt{1+\theta^2\Phi(r_i'\delta)^2 y_i^2}}\right)\left(\dfrac{\beta_k}{\sigma_i}\right)-\left(\dfrac{T(\theta\Phi(r_i'\delta)y_i)}{\theta\sigma_i}\right)\left(\dfrac{\beta_k}{\sigma_i}\right)\\
+2\left(\dfrac{T(\theta\Phi(r_i'\delta)y_i)-x_i'\beta}{\sigma_i}\right)\left(\dfrac{\Phi(r_i'\delta)y_i}{\theta\sigma_i\sqrt{1+\theta^2\Phi(r_i'\delta)^2 y_i^2}}\right)h_k\\
-2\left(\dfrac{T(\theta\Phi(r_i'\delta)y_i)-x_i'\beta}{\sigma_i}\right)\left(\dfrac{T(\theta\Phi(r_i'\delta)y_i)}{\theta\sigma_i}\right)h_k\\
-2\left(\dfrac{\phi(r_i'\delta)\Phi(r_i'\delta)\theta y_i^2}{1+\theta^2\Phi(r_i'\delta)^2 y_i^2}\right)\delta_k+2\left(\dfrac{\phi(r_i'\delta)\Phi(r_i'\delta)^3\theta^3 y_i^4}{\left(1+\theta^2\Phi(r_i'\delta)^2 y_i^2\right)^2}\right)\delta_k\\
-\left(\dfrac{\Phi(r_i'\delta)y_i}{\theta\sigma_i\sqrt{1+\theta^2\Phi(r_i'\delta)^2 y_i^2}}\right)\left(\dfrac{\phi(r_i'\delta)y_i}{\sigma_i\sqrt{1+\theta^2\Phi(r_i'\delta)^2 y_i^2}}\right)\delta_k\\
+\left(\dfrac{T(\theta\Phi(r_i'\delta)y_i)}{\theta\sigma_i}\right)\left(\dfrac{\phi(r_i'\delta)y_i}{\sigma_i\sqrt{1+\theta^2\Phi(r_i'\delta)^2 y_i^2}}\right)\delta_k\\
+\left(\dfrac{T(\theta\Phi(r_i'\delta)y_i)-x_i'\beta}{\sigma_i}\right)\left(\dfrac{\phi(r_i'\delta)y_i}{\sigma_i\sqrt{1+\theta^2\Phi(r_i'\delta)^2 y_i^2}}\right)\left(\dfrac{\theta\Phi(r_i'\delta)^2 y_i^2}{1+\theta^2\Phi(r_i'\delta)^2 y_i^2}\right)\delta_k\end{array}\right)\end{array}\right]dy_i$$

Marginal effect of k th explanatory variable on the unconditional level of expenditure:

$$\frac{\partial(E[y_i])}{\partial(\xi I_{ik})} = \Phi(r'\delta)^2 \times$$

$$\int_0^\infty \left(\begin{array}{l} \dfrac{y_i}{\sigma_i\sqrt{1+\theta^2\Phi(r_i'\delta)^2 y_i^2}}\phi\left(\dfrac{T(\theta\Phi(r_i'\delta)y)-x_i'\beta}{\sigma_i}\right)\times \\ \left(\begin{array}{l} 2\Phi(r_i'\delta)^{-1}\phi(r_i'\delta)\delta_{k+}\left(\dfrac{T(\theta y)-x_i'\beta}{\sigma_i}\right)\dfrac{\beta_k}{\sigma_i} \\ +\left(\dfrac{T(\theta y)-x_i'\beta}{\sigma_i}\right)^2 h_k - h_k \\ -\left(\dfrac{T(\theta y)-x_i'\beta}{\sigma_i}\right)\left(\dfrac{\phi(r_i'\delta)y_i}{\sigma_i\sqrt{1+\theta^2\Phi(r_i'\delta)^2 y_i^2}}\right)\delta_k \\ -\left(\dfrac{\phi(r_i'\delta)\Phi(r_i'\delta)\theta^2 y^2}{1+\theta^2\Phi(r_i'\delta)^2 y^2}\right)\delta_k \end{array} \right) \end{array} \right) dy_i = MEUI_{ik}$$

$$\text{Let } UI = \left(\begin{array}{l} 2\Phi(r_i'\delta)^{-1}\phi(r_i'\delta)\delta_{k+}\left(\dfrac{T(\theta y)-x_i'\beta}{\sigma_i}\right)\dfrac{\beta_k}{\sigma_i} \\ +\left(\dfrac{T(\theta y)-x_i'\beta}{\sigma_i}\right)^2 h_k - h_k \\ -\left(\dfrac{T(\theta y)-x_i'\beta}{\sigma_i}\right)\left(\dfrac{\phi(r_i'\delta)y_i}{\sigma_i\sqrt{1+\theta^2\Phi(r_i'\delta)^2 y_i^2}}\right)\delta_k \\ -\left(\dfrac{\phi(r_i'\delta)\Phi(r_i'\delta)\theta^2 y^2}{1+\theta^2\Phi(r_i'\delta)^2 y^2}\right)\delta_k \end{array} \right)$$

Derivative with respect to $\tau = [\alpha, \beta, h, \theta]$:

$$
\begin{aligned}
\frac{\partial(MEUI_{ik})}{\partial\delta_q} &= \Phi(r_i'\delta)^2 \times \\
\int_0^\infty \Bigg[& \frac{y_i}{\sigma_i\sqrt{1+\theta^2\Phi(r_i'\delta)^2 y_i^2}}\,\phi\left(\frac{T(\theta\Phi(r_i'\delta)y_i)-x_i'\beta}{\sigma_i}\right)\times \\
& \Bigg(2\Phi(r_i'\delta)^{-1}\phi(r_i'\delta)r_{iq}\times(UI) - \left(\frac{\phi(r_i'\sigma)\Phi(r_i'\delta)\theta^2 y_i^2}{1+\theta^2\Phi(r_i'\delta)^2 y_i^2}\right) r_{iq}\times(UI) \\
& - \left(\frac{T(\theta\Phi(r_i'\delta)y_i)-x_i'\beta}{\sigma_i}\right)\left(\frac{\phi(r_i'\delta)y_i}{\sigma_i\sqrt{1+\theta^2\Phi(r_i'\delta)^2 y_i^2}}\right) r_{iq}\times(UI) \\
& - 2\Phi(r_i'\delta)^{-1}\phi(r_i'\delta)(r_i'\delta)r_{iq}\delta_k - 2\Phi(r_i'\delta)^{-2}\phi(r_i'\delta)^2 r_{iq}\delta_k \\
& + \left(\frac{\phi(r_i'\delta)y_i}{\sigma_i\sqrt{1+\theta^2\Phi(r_i'\delta)^2 y_i^2}}\right)\left(\frac{r_{iq}\beta_k}{\sigma_i}\right) \\
& + 2\left(\frac{T(\theta\Phi(r_i'\delta)y_i)-x_i'\beta}{\sigma_i}\right)\left(\frac{\phi(r_i'\delta)y_i}{\sigma_i\sqrt{1+\theta^2\Phi(r_i'\delta)^2 y_i^2}}\right) r_{iq}h_k \\
& - \left(\frac{\phi(r_i'\delta)y_i}{\sigma_i\sqrt{1+\theta^2\Phi(r_i'\delta)^2 y_i^2}}\right)^2 r_{iq}\delta_k \\
& + \left(\frac{T(\theta\Phi(r_i'\delta)y_i)-x_i'\beta}{\sigma_i}\right)\left(\frac{\phi(r_i'\delta)y_i}{\sigma_i\sqrt{1+\theta^2\Phi(r_i'\delta)^2 y_i^2}}\right)(r_i'\delta)r_{iq}\delta_k \\
& + \left(\frac{T(\theta\Phi(r_i'\delta)y_i)-x_i'\beta}{\sigma_i}\right)\left(\frac{\phi(r_i'\delta)y_i}{\sigma_i\sqrt{1+\theta^2\Phi(r_i'\delta)^2 y_i^2}}\right)\left(\frac{\phi(r_i'\sigma)\Phi(r_i'\delta)\theta^2 y_i^2}{1+\theta^2\Phi(r_i'\delta)^2 y_i^2}\right) r_{iq}\delta_k \\
& + \left(\frac{\phi(r_i'\sigma)\Phi(r_i'\delta)\theta^2 y_i^2}{1+\theta^2\Phi(r_i'\delta)^2 y_i^2}\right)(r_i'\delta)r_{iq}\delta_k - \left(\frac{\phi(r_i'\sigma)^2\theta^2 y_i^2}{1+\theta^2\Phi(r_i'\delta)^2 y_i^2}\right) r_{iq}\delta_k \\
& + 2\left(\frac{\phi(r_i'\sigma)\Phi(r_i'\delta)\theta^2 y_i^2}{1+\theta^2\Phi(r_i'\delta)^2 y_i^2}\right)^2 r_{iq}\delta_k \Bigg) \Bigg] dy_i
\end{aligned}
$$

$$\frac{\partial(MEUI_{ik})}{\partial\delta_k} = \Phi(r_i'\delta)^2 \times$$

$$\int_0^\infty \left[\begin{array}{l} \frac{y_i}{\sigma_i\sqrt{1+\theta^2\Phi(r_i'\delta)^2 y_i^2}}\phi\left(\frac{T(\theta\Phi(r_i'\delta)y_i)-x_i'\beta}{\sigma_i}\right)\times \\ \left(\begin{array}{l} 2\Phi(r_i'\delta)^{-1}\phi(r_i'\delta)r_{ik}\times(UI)-\left(\frac{\phi(r_i'\sigma)\Phi(r_i'\delta)\theta^2 y_i^2}{1+\theta^2\Phi(r_i'\delta)^2 y_i^2}\right)r_{ik}\times(UI) \\ -\left(\frac{T(\theta\Phi(r_i'\delta)y_i)-x_i'\beta}{\sigma_i}\right)\left(\frac{\phi(r_i'\delta)y_i}{\sigma_i\sqrt{1+\theta^2\Phi(r_i'\delta)^2 y_i^2}}\right)r_{ik}\times(UI) \\ -2\Phi(r_i'\delta)^{-1}\phi(r_i'\delta)(r_i'\delta)r_{ik}\delta_k-2\Phi(r_i'\delta)^{-2}\phi(r_i'\delta)^2 r_{ik}\delta_k \\ +\left(\frac{\phi(r_i'\delta)y_i}{\sigma_i\sqrt{1+\theta^2\Phi(r_i'\delta)^2 y_i^2}}\right)\left(\frac{r_{ik}\beta_k}{\sigma_i}\right) \\ +2\left(\frac{T(\theta\Phi(r_i'\delta)y_i)-x_i'\beta}{\sigma_i}\right)\left(\frac{\phi(r_i'\delta)y_i}{\sigma_i\sqrt{1+\theta^2\Phi(r_i'\delta)^2 y_i^2}}\right)r_{ik}h_k \\ -\left(\frac{\phi(r_i'\delta)y_i}{\sigma_i\sqrt{1+\theta^2\Phi(r_i'\delta)^2 y_i^2}}\right)^2 r_{ik}\delta_k \\ +\left(\frac{T(\theta\Phi(r_i'\delta)y_i)-x_i'\beta}{\sigma_i}\right)\left(\frac{\phi(r_i'\delta)y_i}{\sigma_i\sqrt{1+\theta^2\Phi(r_i'\delta)^2 y_i^2}}\right)(r_i'\delta)r_{ik}\delta_k \\ +\left(\frac{T(\theta\Phi(r_i'\delta)y_i)-x_i'\beta}{\sigma_i}\right)\left(\frac{\phi(r_i'\delta)y_i}{\sigma_i\sqrt{1+\theta^2\Phi(r_i'\delta)^2 y_i^2}}\right)\left(\frac{\phi(r_i'\sigma)\Phi(r_i'\delta)\theta^2 y_i^2}{1+\theta^2\Phi(r_i'\delta)^2 y_i^2}\right)r_{ik}\delta_k \\ +\left(\frac{\phi(r_i'\sigma)\Phi(r_i'\delta)\theta^2 y_i^2}{1+\theta^2\Phi(r_i'\delta)^2 y_i^2}\right)(r_i'\delta)r_{ik}\delta_k-\left(\frac{\phi(r_i'\sigma)^2\theta^2 y_i^2}{1+\theta^2\Phi(r_i'\delta)^2 y_i^2}\right)r_{ik}\delta_k \\ +2\left(\frac{\phi(r_i'\sigma)\Phi(r_i'\delta)\theta^2 y_i^2}{1+\theta^2\Phi(r_i'\delta)^2 y_i^2}\right)^2 r_{ik}\delta_k \\ +2\Phi(r_i'\sigma)^{-1}\phi(r_i'\delta)-\left(\frac{\phi(r_i'\sigma)\Phi(r_i'\delta)\theta^2 y_i^2}{1+\theta^2\Phi(r_i'\delta)^2 y_i^2}\right) \\ -\left(\frac{T(\theta\Phi(r_i'\delta)y_i)-x_i'\beta}{\sigma_i}\right)\left(\frac{\phi(r_i'\delta)y_i}{\sigma_i\sqrt{1+\theta^2\Phi(r_i'\delta)^2 y_i^2}}\right) \end{array} \right) \end{array} \right] dy_i$$

$$\frac{\partial(MEUI_{ik})}{\partial\beta_q} = \Phi(r_i'\delta)^2 \times$$

$$\int_0^\infty \left[\frac{y_i}{\sigma_i\sqrt{1+\theta^2\Phi(r_i'\delta)^2 y_i^2}} \phi\left(\frac{T(\theta\Phi(r_i'\delta)y_i)-x_i'\beta}{\sigma_i}\right) \times \left(\begin{array}{l} \left(\frac{T(\theta\Phi(r_i'\delta)y_i)-x_i'\beta}{\sigma_i}\right)\left(\frac{x_{iq}}{\sigma_i}\right) \times (UI) \\ -\left(\frac{x_{iq}\beta_k}{\sigma_i^2}\right) - 2\left(\frac{T(\theta\Phi(r_i'\delta)y_i)-x_i'\beta}{\sigma_i}\right)\left(\frac{x_{iq}h_k}{\sigma_i}\right) \\ +\left(\frac{\phi(r_i'\delta)y_i}{\sigma_i\sqrt{1+\theta^2\Phi(r_i'\delta)^2 y_i^2}}\right)\left(\frac{x_{iq}\delta_k}{\sigma_i}\right) \end{array} \right) \right] dy_i$$

$$\frac{\partial(MEUI_{ik})}{\partial\beta_k} = \Phi(r_i'\delta)^2 \times$$

$$\int_0^\infty \left[\frac{y_i}{\sigma_i\sqrt{1+\theta^2\Phi(r_i'\delta)^2 y_i^2}} \phi\left(\frac{T(\theta\Phi(r_i'\delta)y_i)-x_i'\beta}{\sigma_i}\right) \times \left(\begin{array}{l} \left(\frac{T(\theta\Phi(r_i'\delta)y_i)-x_i'\beta}{\sigma_i}\right)\left(\frac{x_{ik}}{\sigma_i}\right) \times (UI) \\ -\left(\frac{x_{ik}\beta_k}{\sigma_i^2}\right) - 2\left(\frac{T(\theta\Phi(r_i'\delta)y_i)-x_i'\beta}{\sigma_i}\right)\left(\frac{x_{ik}h_k}{\sigma_i}\right) \\ +\left(\frac{\phi(r_i'\delta)y_i}{\sigma_i\sqrt{1+\theta^2\Phi(r_i'\delta)^2 y_i^2}}\right)\left(\frac{x_{ik}\delta_k}{\sigma_i}\right) \\ +\left(\frac{T(\theta\Phi(r_i'\delta)y_i)-x_i'\beta}{\sigma_i}\right)\left(\frac{1}{\sigma_i}\right) \end{array} \right) \right] dy_i$$

$$\frac{\partial(MEUI_{ik})}{\partial h_q} = \Phi(r_i'\delta)^2 \times$$

$$\int_0^\infty \left[\begin{array}{l} \dfrac{y_i}{\sigma_i\sqrt{1+\theta^2\Phi(r_i'\delta)^2 y_i^2}}\phi\left(\dfrac{T(\theta\Phi(r_i'\delta)y_i)-x_i'\beta}{\sigma_i}\right)\times \\ \left(\begin{array}{l} -z_{iq}\times(UI)+\left(\dfrac{T(\theta\Phi(r_i'\delta)y_i)-x_i'\beta}{\sigma_i}\right)^2 z_{iq}\times(UI) \\ -2\left(\dfrac{T(\theta\Phi(r_i'\delta)y_i)-x_i'\beta}{\sigma_i}\right)\left(\dfrac{z_{iq}\beta_k}{\sigma_i}\right)-2\left(\dfrac{T(\theta\Phi(r_i'\delta)y_i)-x_i'\beta}{\sigma_i}\right)^2(z_{iq}h_k) \\ +2\left(\dfrac{T(\theta\Phi(r_i'\delta)y_i)-x_i'\beta}{\sigma_i}\right)\left(\dfrac{\phi(r_i'\delta)y_i}{\sigma_i\sqrt{1+\theta^2\Phi(r_i'\delta)^2 y_i^2}}\right)(z_{iq}\delta_k) \end{array} \right) \end{array} \right] dy_i$$

$$\frac{\partial(MEUI_{ik})}{\partial h_k} = \Phi(r_i'\delta)^2 \times$$

$$\int_0^\infty \left[\begin{array}{l} \dfrac{y_i}{\sigma_i\sqrt{1+\theta^2\Phi(r_i'\delta)^2 y_i^2}}\phi\left(\dfrac{T(\theta\Phi(r_i'\delta)y_i)-x_i'\beta}{\sigma_i}\right)\times \\ \left(\begin{array}{l} -z_{ik}\times(UI)+\left(\dfrac{T(\theta\Phi(r_i'\delta)y_i)-x_i'\beta}{\sigma_i}\right)^2 z_{ik}\times(UI) \\ -2\left(\dfrac{T(\theta\Phi(r_i'\delta)y_i)-x_i'\beta}{\sigma_i}\right)\left(\dfrac{z_{ik}\beta_k}{\sigma_i}\right)-2\left(\dfrac{T(\theta\Phi(r_i'\delta)y_i)-x_i'\beta}{\sigma_i}\right)^2(z_{ik}h_k) \\ +2\left(\dfrac{T(\theta\Phi(r_i'\delta)y_i)-x_i'\beta}{\sigma_i}\right)\left(\dfrac{\phi(r_i'\delta)y_i}{\sigma_i\sqrt{1+\theta^2\Phi(r_i'\delta)^2 y_i^2}}\right)(z_{ik}\delta_k) \\ +\left(\dfrac{T(\theta\Phi(r_i'\delta)y_i)-x_i'\beta}{\sigma_i}\right)^2-1 \end{array} \right) \end{array} \right] dy_i$$

$$\frac{\partial\left(MEUI_{ik}\right)}{\partial\theta} = \Phi\left(r_i'\delta\right)^2 \times$$

$$\int_0^\infty \left[\begin{array}{l}
\dfrac{y_i}{\sigma_i\sqrt{1+\theta^2\Phi\left(r_i'\delta\right)^2 y_i^2}}\,\phi\left(\dfrac{T\left(\theta\Phi\left(r_i'\delta\right)y_i\right)-x_i'\beta}{\sigma_i}\right)\times \\
\left(\begin{array}{l}
-\left(\dfrac{\theta\Phi\left(r_i'\delta\right)^2 y_i^2}{1+\theta^2\Phi\left(r_i'\delta\right)^2 y_i^2}\right)\times\left(UI\right) \\
-\left(\dfrac{T\left(\theta\Phi\left(r_i'\delta\right)y_i\right)-x_i'\beta}{\sigma_i}\right)\left(\dfrac{\Phi\left(r_i'\delta\right)y_i}{\theta\sigma_i\sqrt{1+\theta^2\Phi\left(r_i'\delta\right)^2 y_i^2}}\right)\times\left(UI\right) \\
+\left(\dfrac{T\left(\theta\Phi\left(r_i'\delta\right)y_i\right)-x_i'\beta}{\sigma_i}\right)\left(\dfrac{T\left(\theta\Phi\left(r_i'\delta\right)y_i\right)}{\theta\sigma_i}\right)\times\left(UI\right) \\
+\left(\dfrac{\Phi\left(r_i'\delta\right)y_i}{\theta\sigma_i\sqrt{1+\theta^2\Phi\left(r_i'\delta\right)^2 y_i^2}}\right)\left(\dfrac{\beta_k}{\sigma_i}\right)-\left(\dfrac{T\left(\theta\Phi\left(r_i'\delta\right)y_i\right)}{\theta\sigma_i}\right)\left(\dfrac{\beta_k}{\sigma_i}\right) \\
+2\left(\dfrac{T\left(\theta\Phi\left(r_i'\delta\right)y_i\right)-x_i'\beta}{\sigma_i}\right)\left(\dfrac{\Phi\left(r_i'\delta\right)y_i}{\theta\sigma_i\sqrt{1+\theta^2\Phi\left(r_i'\delta\right)^2 y_i^2}}\right)h_k \\
-2\left(\dfrac{T\left(\theta\Phi\left(r_i'\delta\right)y_i\right)-x_i'\beta}{\sigma_i}\right)\left(\dfrac{T\left(\theta\Phi\left(r_i'\delta\right)y_i\right)}{\theta\sigma_i}\right)h_k \\
-2\left(\dfrac{\phi\left(r_i'\delta\right)\Phi\left(r_i'\delta\right)\theta y_i^2}{1+\theta^2\Phi\left(r_i'\delta\right)^2 y_i^2}\right)\delta_k+2\left(\dfrac{\phi\left(r_i'\delta\right)\Phi\left(r_i'\delta\right)^3\theta^3 y_i^4}{\left(1+\theta^2\Phi\left(r_i'\delta\right)^2 y_i^2\right)^2}\right)\delta_k \\
-\left(\dfrac{\Phi\left(r_i'\delta\right)y_i}{\theta\sigma_i\sqrt{1+\theta^2\Phi\left(r_i'\delta\right)^2 y_i^2}}\right)\left(\dfrac{\phi\left(r_i'\delta\right)y_i}{\sigma_i\sqrt{1+\theta^2\Phi\left(r_i'\delta\right)^2 y_i^2}}\right)\delta_k \\
+\left(\dfrac{T\left(\theta\Phi\left(r_i'\delta\right)y_i\right)}{\theta\sigma_i}\right)\left(\dfrac{\phi\left(r_i'\delta\right)y_i}{\sigma_i\sqrt{1+\theta^2\Phi\left(r_i'\delta\right)^2 y_i^2}}\right)\delta_k \\
+\left(\dfrac{T\left(\theta\Phi\left(r_i'\delta\right)y_i\right)-x_i'\beta}{\sigma_i}\right)\left(\dfrac{\phi\left(r_i'\delta\right)y_i}{\sigma_i\sqrt{1+\theta^2\Phi\left(r_i'\delta\right)^2 y_i^2}}\right)\left(\dfrac{\theta\Phi\left(r_i'\delta\right)^2 y_i^2}{1+\theta^2\Phi\left(r_i'\delta\right)^2 y_i^2}\right)\delta_k
\end{array}\right)
\end{array}\right] dy_i$$

Chapter 3

The Irish Household Budget Survey Dataset

3.1 Introduction

In this chapter, the datasets used in the subsequent analyses of aggregate meat expenditure, disaggregated meat expenditure categories and prepared meals, detailed in Chapters 4, 5 and 6 respectively, are introduced and described. Section 3.2 introduces the Irish Household Budget Survey datasets while in Section 3.3 the sample used in the expenditure analyses in this thesis is described. In Section 3.4, each of the dependent and explanatory variables modelled in the proceeding chapters are discussed in detail. Section 3.5 concludes the chapter.

3.2 The Household Budget Survey

The data used in this thesis are variables extracted from the 1987/8 and 1994/5 Irish Household Budget Surveys collected by the Central Statistics Office of Ireland.[17] The survey covered a random sample of 7,705, and 7,877 urban and rural households throughout the country in 1987/8 and 1994/5 respectively.[18] Different households were included in the sample for each of the surveys. A household is defined as a single person or a group of people who regularly reside together in the same accommodation and who share the same catering arrangements (Central Statistics Office, 1997). Data were collected on households' socio-economic characteristics and an extensive expenditure diary was reported for each household. Each household recorded their expenditure levels over a two week period which was then averaged to obtain a weekly expenditure figure for each item reported.

3.3 Sample Selection

The samples used in the expenditure analyses throughout this thesis consist of single adult households up to households with four adults, with and without children. A problem with the Irish Household Budget Survey is that the size of certain households is not identifiable from the survey and so the exact size of households larger than four adults cannot be ascertained. Furthermore, households with missing observations on the

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[17] The Irish Household Budget Survey is conducted every 7 years. The 2000 Irish Household Budget Survey will become available at the end of 2001.

[18] The sample is designed so that co-operating households would be proportionally distributed on a regional basis and to ensure the correct proportion of urban and rural households were represented (Central Statistics Office, 1997).

level of total expenditure are also excluded. The sample size is therefore 7,112 in 1987 and 7,332 in 1994.

3.4 Variable Selection

As outlined in Chapter 1, the main aim of this thesis is to determine the factors affecting Irish households' expenditure on meat and prepared meals. Specifically, this involves examining household expenditure on meat, a number of disaggregated meat categories and prepared meals. Theory, however, provides little guidance as to what variables should be used to explain expenditure on these food items. The choice of variables attempts to incorporate into the analysis factors cited in the literature as determining food demand (see Chapter 1, Section 1.2).

3.4.1 Dependent Variables

The dependent variables used in this analysis are listed and described in Table 3.1. Each dependent variable is adjusted for household size using EU adult equivalence scales as reported in the Household Budget Survey to obtain per capita household expenditure levels. Since the surveys are conducted over a fifteen month period, each expenditure variable is seasonally adjusted using auxiliary regressions of each variable on monthly dummy variables. The estimated coefficients are used to form an index, which is used to seasonally adjust each expenditure category (see Appendix 3A).[19] Sample statistics for the dependent variables of the model are presented in Table 3.2.

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[19] A possible implication of this type of adjustment is that since socio-economic variables may influence certain seasonal consumption patterns, important information may have been filtered out of the data. As such, the magnitude of socio-economic influences may be underestimated.

Mean weekly per capita household expenditure on meat is £3.84 and £4.47 in 1987 and 1994 respectively. This represents 17 per cent of total per capita food expenditure in 1987 and 16 per cent in 1994. The percentage of households reporting zero expenditure on meat has increased between the two years from 3 per cent to 4 per cent. In Chapter 2, three possible sources of zero observations on expenditure are identified: standard corner solutions, non-participation and infrequency of purchase. The increase in the proportion of zero observations on household meat expenditure could therefore be attributed to economic factors like a general increase in the price of meat, an increase in non-participation for non-economic reasons such as health or vegetarianism or an increase in the number of households whose meat purchasing cycle is longer than two weeks, the time frame in which the survey is conducted. These issues are explored in Chapter 4.

Table 3.3 illustrates the share of total meat expenditure apportioned to each meat category. Relative to other meat categories, the share of total household meat expenditure spent on pork, pork products, bacon & ham and minced meat has declined while the share spent on beef increased by 1 per cent and the share spent on chicken increased by 6 per cent. Furthermore, the percentage of zero observations has increased for the former meat categories but decreased for beef, lamb and chicken. Once again this could be attributed to a change in one of the three sources of zero observations identified above. These statistics indicate that not only are households spending less on pigmeat and minced meat, fewer households are purchasing these meat products in 1994 compared with 1987. On the other hand, households are spending more on beef and chicken and more households are purchasing these meat products.

Table 3.2 also presents sample statistics for the final dependent variable, prepared meals. In 1987 per capita mean household expenditure on prepared meals is substantially lower than expenditure on any of the meat categories at £0.13. In 1994 however, per capita mean household expenditure on prepared meals is £0.46, a value nearly double the mean expenditure level on minced meat and just below mean expenditure on pork. In 1987 expenditure on prepared meals forms 0.6 per cent of the total food budget compared with 1994 where its food budget share has increased to 1.5 per cent. While households spend more on prepared meals in 1994 compared with 1987 the number of households participating in the market has declined from 49 per cent in 1987 to 43 per cent in 1994.

The Household Budget Survey dataset does not report price or quantity data and as such only information on the value of household expenditure can be included in each analysis. In the presence of quantity data the division of observed expenditures by quantity can be used as an estimate of a commodity's price. Furthermore, calculating price in this way also captures differences in quality among different commodities, for which households may have considerable choice (Nelson, 1991). The literature on the estimation of cross-sectional demand functions accounting for quality effects is plentiful (see Cox and Wohlgenant, 1986, Nelson, 1991 and Dong and Gould, 1999). In the absence of quantity data, price is assumed to be constant across each cross-section. This restriction may introduce a bias on the results of the empirical analysis due to the fact that quality differences are not controlled for. For example, if one household pays less money for the same item as another household, the effects of the explanatory variables on demand will be understated for the former household. Differences in the quality of food products can only be deduced from the empirical results of each model.

3.4.2 Independent Variables

The independent variables used to explain Irish households' expenditure patterns are listed and described in Table 3.4.

A large proportion of independent variables used in these analyses refer to characteristics of the head of household. The Household Budget Survey does not provide specific instructions to survey respondents as to which member of the household should be taken as the reference person or head of household. In normal family situations, it is considered appropriate to leave this decision to each individual household, however, in other cases the reference person is generally taken as the person who owns the accommodation or in whose name it is being rented. In cases where household members are unrelated and share expenses equally, the oldest member of the household is taken to be the head in the absence of any other influencing factor (Central Statistics Office, 1997).[20]

Sample statistics for the independent variables are presented in Table 3.5. For sample statistics sub-grouped by participating and non-participating households for each expenditure category, see Appendix 3B.

[20] The socio-economic characteristics of the household meal planner would provide a more accurate indication of how these factors influence food expenditure, however, this information is not collected in the Household Budget Survey and therefore cannot be considered in the analysis (see Gao *et al.* (1995) and Gould (1996) for examples).

Income

The first continuous independent variable is Income. This variable is proxied by total household expenditure, due to the difficulty in collecting consistent income data directly from private individuals in a household survey (Central Statistics Office, 1997). The variable is seasonally adjusted (see Appendix 3C) and adjusted for household size in the same manner as the dependent variables. The mean weekly level of per capita household income has increased between 1987 and 1994 from £94 to £118 (£95 in 1987 market prices). Income squared is included to capture the possibility of a non-linear relationship between income and the relevant food expenditure category.

Age

The age variable is ordinal in nature and is coded from 1 to 8 capturing the chronological ordering of the age group of the head of household. The variable is however treated as a continuous variable in analysing its effect on households' food expenditure patterns. The main implication of this is that the estimated age elasticities require some adjustment in order to measure the full effect of a change in the age group of the head of household on expenditure (this is considered in more detail in the empirical results section of each individual analysis). The age of the head of household has been found to be significant in a number of analyses of food demand (Burton *et al.*, 1996, Jensen and Yen, 1996, Yen *et al.*, 1996). The mean age of the household head has increased from 49 to 51 between the two years.

Table 3.6 illustrates the difference in average expenditure levels of heads of household of different age groups. In both years the mean level of per capita household expenditure on meat increases with the age of the head of household, with a slight decline at the older end of the spectrum. A similar pattern is evident for each individual meat expenditure category, with the exception of minced meat, where the mean value of expenditure increases with age up to heads of household in their forties, but beyond this declines with age. The mean level of per capita household expenditure on prepared meals follows a different pattern with high values among younger headed households.

All Working

The first discrete variable, 'all-working', is a dummy variable capturing the difference between households where all adult members work and households where at least one adult member does not work. This variable is included in an attempt to capture the difference between households where at least one adult member is either officially engaged in home duties or does not work and therefore has more time to prepare home-cooked meals, and households where time constraints are imposed by all adult members working, therefore leaving less time to prepare meals in the home.

The number of all working households increased from 22 per cent in 1987 to 24 per cent in 1994. Table 3.7 illustrates the difference in average expenditure levels of all working households compared with other households. In both years all-working households have a lower mean level of expenditure on meat than other households. The same pattern is evident for each individual meat expenditure category with the exception of beef and minced meat in 1987 and beef alone in 1994 where all-working households have a higher mean level of expenditure. A dramatic change occurred in relation to prepared meals between the two years where in 1987 all-working households have a slightly lower mean level of expenditure than other households but in 1994 show a mean level of expenditure on prepared meals of twice that of other households.

Urban

The urban variable captures the difference in expenditure patterns of households living in urban areas and households living in rural areas. This variable has been found to be significant in a number of cross-sectional analyses of food demand (Burton *et al.*, 1996 Yen *et al.*, 1996, Yen and Huang, 1996, Yen and Jones, 1997). Significant differences found between these types of households can be attributed to the fact that there are differences in the type of lifestyles led by urban and rural dwellers. For example, urban dwellers face a faster pace of life and as such may encounter greater time constraints. This impacts on their decisions to prepare home-cooked meals, in terms of the types of meat they buy or whether they choose prepared meals over home cooked meat meal centres. It could also be suggested that urban dwellers have greater choice available to them in terms of the range of products they can buy and the variety of restaurants and takeaways they have to choose from.

Sixty-three per cent and 65 per cent of the sample are urban households in 1987 and 1994 respectively. Table 3.8 illustrates the differences in average expenditure levels of urban households compared with rural households. The mean level of expenditure of urban households is lower than rural households for the overall meat expenditure category, beef, lamb, pork products, and bacon & ham in both years and for chicken in

1987 and pork in 1994. For all other meat categories, urban households have a higher mean level of expenditure than rural households. In both years, urban households' mean level of expenditure on prepared meals is nearly double that of rural households.

Children

This variable captures the effect on expenditure patterns of the presence of children in a household. This variable has been included in a number of analyses of food demand (Burton *et al.*, 1996, Yen *et al.*, 1996, Yen and Huang, 1996). It is expected that households with children are more likely to enjoy family meal eating occasions than households without children. Senauer *et al.* (1998), however, suggest that the role of the family meal-eating occasion is declining as individual household members increasingly satisfy their own preferences and prepare and consume their own meals. Specifically, they reveal that two-thirds of children in the U.S. prepared at least one meal a week without supervision in 1990. On the other hand, they also found that 70 per cent of households ate dinner together at least three times a week. This analysis will attempt to capture the degree to which food expenditure patterns of households with and without children differ, allowing inferences to be made about how the presence of children influences households' decisions regarding home-cooking.

The number of households with children in the sample declined from 59 per cent to 54 per cent between 1987 and 1994. Table 3.9 illustrates the differences in average expenditure levels of households with children and households with no children. In both 1987 and 1994 households with children have a lower mean level of expenditure on the overall meat category, beef, lamb, pork products, bacon & ham and chicken and a higher mean level of expenditure on pork, minced meat and prepared meals.

Gender

The gender variable captures the difference in expenditure patterns of female and male-headed households. This variable is included in a number of cross-sectional analyses of food demand (Burton *et al.*, 1996, Yen *et al.*, 1996) but in many cases refers to the gender of the meal planner (see Gao *et al.* (1995), Gould (1996) and Yen and Jones (1997) for examples). In this analysis female-headed households differ from male-headed households in a number of interesting ways. In 1994, for example, 58 per cent of female-headed households are single adult households and only 11 per cent are married, compared with 16 per cent and 61 per cent of male-headed households respectively. Furthermore, in the same year, 39 per cent of female-headed households have children compared with 60 per cent of male-headed households. This suggests that female-headed households are less likely to be family-type households compared with male-headed households, a factor which may shape and influence differences in these households' food expenditure patterns.

In 1987 23 per cent of the sample were female-headed households while 28 per cent were female in 1994. Table 3.10 illustrates the differences in average expenditure levels of female-headed households and male-headed households. The differences in the mean levels of expenditure of male and female-headed households on different food items, in some cases have changed between 1987 and 1994. The mean meat expenditure level of female-headed households is slightly higher than that of male-headed households in 1987 but slightly lower in 1994. A higher mean level of expenditure on lamb and pork products is also observed for female-headed households compared with male-headed households in 1987, with the opposite being the case in 1994. In both years, lower mean expenditure levels are observed for women compared with men for beef, pork and bacon & ham with higher levels observed for chicken and minced meat. In 1987, female-headed households have a lower mean level of expenditure on prepared meals while in 1994 the value is slightly higher than that of their male counterparts.

Education

The education level of the head of household has been included as an explanatory factor in a number of empirical analyses of food demand.[21] In some analyses the variable is specified as a continuous variable representing the number of years of education of the household head (Blisard and Blaylock, 1993, Yen and Su, 1995, Yen *et al.*, 1996). Other analyses specify the variable as one or two dummy variables representing the type of educational qualification achieved by the head of household (Yen, 1993, Gao *et al.*, 1995, Jensen and Yen, 1996).

Data on the education level of the head of household were collected in different ways in 1987 and 1994. In 1987 the variable was collected as the year the head of household left formal education while in 1994 the variable was collected as the level of state exams reached by the household head. In an attempt to capture the same effect in both years the 1987 variable is defined as 1, for a head of household who remained in school

[21] Gould (1996) uses the education level of the meal planner in the household.

to the age of 17 or more and as 0, for a head of household who left school before this age. In 1994 the variable is defined as 1, for a head of household who obtained Leaving Certificate education or higher and as 0, for a head of household who left school before obtaining the Leaving Certificate. In both years, the aim of including the variable is to capture the effect a certain level of educational advancement has on a households' food expenditure decisions, but because data were not collected in the same manner care is required in comparing results between the two periods. In each year 33 per cent of the sample are 'educated' households, providing some justification for the chosen definitions. Table 3.11 illustrates the differences in average expenditure levels of households based on the level of education of the head of household.

In 1987, the mean level of expenditure on overall meat is slightly less for educated-headed households compared with uneducated-headed households. This, however, is only true for two individual meat expenditure categories, pork products and bacon & ham. Mean values are greater for all other expenditure categories. In 1994, the mean level of expenditure on meat is also less for educated-headed households, along with the mean levels of expenditure on lamb, pork, pork products and bacon & ham. As with the 1987 dataset, mean levels of expenditure on beef, chicken, minced meat and prepared meals are higher for educated-headed households compared with uneducated-headed households.

Social Status

The social status of the head of household has been included in some empirical analyses of food demand in the past (see Burton *et al.*, 1996, Yen and Huang, 1996). In this analysis, households are separated into three different groups based on their social status.[22] The first category is referred to in the text as households of a professional social status. In this household group, the head of household is categorised as higher professional, lower professional, an employer or a manager. In 1987 this category represents 29 per cent of the sample increasing to 31 per cent in 1994. The second category is referred to in the text as households of an intermediate social status. In this household group, the head of household is categorised as a salaried employee, an intermediate non-manual worker or other non-manual workers. In 1987, this category represents 31 per cent of the sample, declining to 27 per cent in 1994. The final category, the base category in the analysis, is composed of households whose head is categorised as a manual worker, a farmer, other agricultural workers or fishermen. In 1987, this represents 40 per cent of the sample and in 1994, 42 per cent.

Table 3.12 illustrates the differences in average expenditure levels of households of different social status. In 1987, the professional household group have the highest mean level of expenditure on beef, lamb, chicken and minced meat. The intermediate group have the highest mean level of expenditure on pork and prepared meals, while the base category has the highest mean level of expenditure on overall meat, pork products and bacon & ham. A similar pattern is evident in 1994, with the exception of lamb, where the base category has the highest mean level of expenditure, minced meat, where the intermediate category has the highest mean level of expenditure and prepared meals, where professional households spend the most on average.

[22] Yen and Huang (1996) also use a three-category variable to describe the social status of the head of household.

Marital Status

The marital status variable is composed of three different categories, single adult households, households containing a married couple and households containing two or more unmarried adults. In 1987, 22 per cent of the sample are single adult households. This figure increases to 28 per cent in 1994. The percentage of married couples on the other hand declines from 54 per cent in 1987 to 47 per cent in 1994.

Yen and Huang (1996) include a series of variables capturing the lifecycle of the head of household incorporating other factors like the presence or otherwise of children into the definition of the variables. In this analysis single-adult and married households are considered in their aggregate form, however, the way in which they interact with other variables in the model is considered in the interpretation of the results.[23]

Table 3.13 illustrates the differences in average expenditure levels of households of different marital status. In both 1987 and 1994 single-adult and married households have lower mean levels of expenditure on meat than other household groups. The same is true for lamb, pork and bacon & ham in both years. In 1987, single adult households on average spend the most on beef while in 1994 they spend the least, with married households having the highest mean level of expenditure in this meat category. The mean level of expenditure on pork products is highest for the base category followed by single-adult households in 1987, but the reverse is the case in 1994. Single adult households spend the most on chicken in 1987, but the least in 1994, with the reverse

[23] Interaction terms between categorical variables were originally included in the models. In the majority of cases they were insignificant and so were not explicitly modelled. However, in the interpretation of the results of the various models, deductions about possible interactions are made on the basis of the observed similarities in the effects of different categorical variables.

being the case for married households. Married households have the highest mean level of expenditure on minced meat and prepared meals in both years with single-adult households spending the least.

Meat Dummy

Table 3.14 illustrates average expenditure levels of households on each meat category divided into participating and non-participating household groups for each individual meat expenditure category in turn. In most cases the average level of expenditure on other meat items of a household participating in a particular meat market is greater than that of a non-participating household. This indicates that if a household buys one meat item, they spend more on other meat items than households not purchasing that meat item. In some cases, participating households spend less on other meat items than non-participating households. For example, minced meat participators in both years spend less on beef, lamb, pork products and bacon & ham than non-participators. The existence of these trends suggests that expenditure on different individual meat items may not be independent of each other.

In this thesis disaggregated meat expenditures are not modelled using a demand system approach. The econometric techniques necessary to accommodate zero observations on the dependent variable have only recently been extended to incorporate a systems approach (Moro and Sckokai, 2000) but still fail to incorporate some of the flexible features of the methodology considered in this thesis. In an attempt to assess the extent to which disaggregated meat expenditures could be related to each other, a dummy variable, capturing whether or not the household also purchased other meat items, is included as an explanatory variable in each individual meat expenditure equation considered in Chapter 5.[24]

Household Appliances

In Chapter 1, Section 1.2.3, increases in microwave and freezer ownership are cited as factors contributing to the growth of the ready meals market in Ireland (Meat and Livestock Commission, 1997). In this thesis, ownership of a microwave and ownership of a freezer are included in the analysis of prepared meals detailed in Chapter 6. While these appliances are often not necessary for the consumption of prepared meals, they can add to the convenience attribute of these products in terms of cooking and storage. Burton *et al.* (1996) found ownership of a freezer to be a significant explanatory factor in their analysis of UK household expenditure on meat. In 1987, 6 per cent of surveyed households own a microwave while 15 per cent owned a freezer. By 1994 these figures had increased to 46 per cent and 22 per cent respectively.

3.5 Summary

In this chapter, aspects of the 1987/8 and 1994/5 Irish Household Budget Survey datasets, relating to this thesis, have been introduced. The food expenditure categories forming the dependent variables in the following analyses are defined and their sample statistics are described. The variables used to explain food expenditure patterns are also defined and explained.

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[24] The inclusion of this variable, however, introduces endogeneity problems since participation in other meat markets will be related to the other economic and socio-economic explanatory variables in the model. The extent to which this endogeneity affects the results of the individual meat models is addressed in Chapter 5.

For socio-economic variables, these explanations involve grouping households according to their socio-economic characteristics and examining how their mean expenditure levels, on the food categories relevant to this thesis, differ. Some of the key differences in the expenditure patterns of different social groups identified are as follows:

- Older headed households spend more on meat than younger headed households but less on prepared meals.
- All-working households, in general, spend less on meat than other households with the exception of beef and minced meat. Furthermore in 1994, all-working households spend almost double the amount of other households on prepared meals.
- In general, urban households spend less on meat than rural households with the exception of minced meat. They also spend more on prepared meals than rural households.
- The meat expenditure levels of households with children are less than those of households without children with the exceptions of pork and minced meat. Households with children also spend more on prepared meals than households without.
- The differences in the average expenditure of male and female-headed households vary between years and across meat categories. In general, female-headed households spend less on beef, pork and bacon & ham but more on chicken and minced meat. In 1987 they spend less on prepared meals than male-headed households but in 1994 they spend more.

- Educated households spend more on beef, chicken, minced meat and prepared meals than uneducated households but less on other food categories.
- Similarly, households of higher social status spend more on beef, lamb, chicken, minced meat and prepared meals than lower social groupings.
- Finally single-adult and married households spend less on meat in general than other households. This is mainly due to lower expenditure levels by both groups on lamb, pork and bacon & ham. Married households spend the most on minced meat and prepared meals while single-adult households spend the least on these food categories.

In Chapters 4, 5 and 6, meat expenditure, disaggregated meat expenditure categories and expenditure on prepared meals are analysed using the data presented in this chapter.

3A Tables

TABLE 3.1 DEPENDENT VARIABLES*

Variable	Description
Meat	Seasonally adjusted average per capita household weekly expenditure on meat (£IRL), calculated as the sum of beef, lamb, pork, pork products, bacon & ham, chicken and minced meat described below.
Beef	Seasonally adjusted average per capita household weekly expenditure on beef (£IRL)
Lamb	Seasonally adjusted average per capita household weekly expenditure on lamb (£IRL)
Pork	Seasonally adjusted average per capita household weekly expenditure on pork (£IRL)
Pork Products	Seasonally adjusted average per capita household weekly expenditure on rashers, sausages and black and white pudding (£IRL)
Bacon & Ham	Seasonally adjusted average per capita household weekly expenditure on uncooked bacon and uncooked hams (£IRL)
Chicken	Seasonally adjusted average per capita household weekly expenditure on chicken (£IRL)
Minced Meat	Seasonally adjusted average per capita household weekly expenditure on minced meat (£IRL)
Prepared Meals	Seasonally adjusted average per capita household weekly expenditure on prepared meals (£IRL)

*All weekly expenditures are the average of expenditures recorded for a two-week period.

TABLE 3.2 SAMPLE STATISTICS OF DEPENDENT VARIABLES

	Mean (IRL£)		Std. Deviation (IRL£)		% Zeros		Maximum (IRL£)	
Dependent Vars.	**1987**	**1994**	**1987**	**1994**	**1987**	**1994**	**1987**	**1994**
Meat	3.844	4.470	3.667	3.251	3%	4%	26.33	43.73
Beef	0.425	0.538	0.911	1.076	68%	65%	12.54	16.16
Lamb	0.477	0.524	1.070	1.117	65%	61%	18.20	30.20
Pork	0.481	0.490	0.796	0.940	54%	58%	11.58	32.17
Pork Products	0.824	0.884	0.766	0.895	15%	21%	9.88	9.25
Bacon & Ham	0.576	0.577	0.912	1.006	49%	58%	13.55	11.36
Poultry	0.821	1.216	1.002	1.313	38%	30%	11.91	14.11
Minced Meat	0.240	0.241	0.389	0.468	57%	66%	3.76	8.66
Prepared Meals	0.128	0.457	0.210	0.826	51%	57%	3.56	23.21

TABLE 3.3 PERCENTAGE SHARE OF TOTAL MEAT EXPENDITURE

	1987	1994
Beef	11%	12%
Lamb	12%	12%
Pork	13%	11%
Pork Products	22%	20%
Bacon & Ham	15%	13%
Chicken	21%	27%
Minced Meat	6%	5%

TABLE 3.4 INDEPENDENT VARIABLES

Variable	Description
Continuous	
Income*	Proxied by seasonally adjusted average per capita total weekly household expenditure and scaled by 100 (£IRL)
$Income^2$	Income squared (£IRL)
Age	Age group of head of household (1-8)
Discrete	
All-working	1=Household in which all adults work 0=At least one adult does not work
Urban	1=Urban household 0=Rural household
Children	1=Children present 0=No children present
Gender	1=Female head of household 0=Male head of household
Education[a]	1=Head of household left school at age 17 or over 0=Head of household left school under the age of 17
Education[b]	1=Head of household has Leaving Certificate or a higher level of education 0=Head of household has less than Leaving Certificate education
Social1, Social2	Social1 =1 for head of household categorised as higher professional, lower professional, employer or manager, 0 otherwise Social2 =1 for head of household categorised as salaried employee, intermediate non-manual, other non-manual, 0 otherwise Base category = head of household categorised as manual workers, farmers and other agricultural workers or fishermen
Single, Married	Single =1 for single adult household with or without children, 0 otherwise Married =1 for married couple with no other adults with or without children, 0 otherwise Base category = households with 2 or more adults with or without children
Meat Dummy[c]	Dummy variable capturing whether household purchased any other meat items, other than the dependent variable, in the week surveyed
Microwave[d]	1=Household is in possession of a microwave 0=Otherwise
Freezer[d]	1=Household is in possession of a freezer 0=Otherwise

*Total weekly expenditure is the average of total expenditure recorded for a two-week period.
[a] 1987 dataset, [b] 1994 dataset, [c] Included in disaggregated meat expenditure equations only, [d] Included in prepared meals expenditure equations only

TABLE 3.5 SAMPLE STATISTICS OF INDEPENDENT VARIABLES

	Mean (IRL£)		**Std. Deviation (IRL£)**		**Maximum (IRL£)**	
Independent Vars.	**1987**	**1994**	**1987**	**1994**	**1987**	**1994**
Continuous						
Income	0.936	1.182	0.604	0.806	7.16	8.59
$Income^2$	1.241	2.047	2.045	3.498	51.34	73.77
Age	4.938	5.082	1.707	1.701	1	8
Discrete						
All-working	0.224	0.267				
Urban	0.628	0.646				
Children	0.587	0.539				
Gender	0.227	0.279				
Education	0.332	0.335				
Social1	0.294	0.311				
Social2	0.306	0.277				
Single	0.224	0.280				
Married	0.539	0.471				
Meat Dummy (Beef)	0.968	0.951				
Meat Dummy (Lamb)	0.966	0.952				
Meat Dummy (Pork)	0.968	0.951				
Meat Dummy (Pork Prod.)	0.936	0.920				
Meat Dummy (Bac. & Ham)	0.962	0.948				
Meat Dummy (Chicken)	0.961	0.933				
Meat Dummy (Minced Meat)	0.967	0.951				
Microwave	0.059	0.457				
Freezer	0.155	0.216				

TABLE 3.6 MEAN EXPENDITURE LEVELS BY AGE OF HEAD OF HOUSEHOLD

	1987						
	1-2	3	4	5	6	7	8
Meat	2.146	3.145	3.332	3.970	4.712	4.925	4.091
Beef	0.220	0.345	0.390	0.437	0.526	0.518	0.451
Lamb	0.148	0.367	0.373	0.435	0.601	0.715	0.598
Pork	0.379	0.435	0.443	0.526	0.580	0.547	0.356
Pork Products	0.477	0.652	0.707	0.852	1.054	1.051	0.879
Bacon & Ham	0.162	0.338	0.439	0.599	0.794	0.898	0.733
Chicken	0.502	0.720	0.720	0.860	0.923	1.016	0.894
Minced Meat	0.258	0.288	0.260	0.260	0.233	0.179	0.150
Prepared Meals	0.250	0.167	0.183	0.146	0.073	0.051	0.028
Sample size	255	1484	1718	942	986	1141	581
	1994						
	1-2	3	4	5	6	7	8
Meat	1.982	3.292	4.037	4.754	5.285	5.502	5.126
Beef	0.160	0.382	0.471	0.593	0.645	0.703	0.592
Lamb	0.123	0.262	0.435	0.579	0.641	0.724	0.739
Pork	0.178	0.406	0.462	0.566	0.617	0.535	0.442
Pork Products	0.486	0.652	0.755	0.914	1.051	1.144	1.028
Bacon & Ham	0.103	0.244	0.428	0.588	0.745	0.894	0.896
Chicken	0.716	1.073	1.194	1.264	1.359	1.320	1.249
Minced Meat	0.216	0.274	0.291	0.251	0.226	0.180	0.181
Prepared Meals	0.700	0.668	0.576	0.512	0.365	0.220	0.145
Sample size	263	1173	1799	1232	948	1163	754

TABLE 3.7 MEAN EXPENDITURE LEVELS OF ALL –WORKING AND OTHER HOUSEHOLDS

	1987		1994	
	All Working	Other	All Working	Other
Meat	3.664	3.897	4.051	4.623
Beef	0.505	0.402	0.552	0.533
Lamb	0.469	0.479	0.456	0.549
Pork	0.445	0.491	0.469	0.498
Pork Products	0.752	0.845	0.794	0.916
Bacon & Ham	0.454	0.612	0.388	0.646
Chicken	0.786	0.831	1.155	1.239
Minced Meat	0.252	0.237	0.236	0.243
Prepared Meals	0.121	0.130	0.641	0.389
Sample size	1594	5513	1958	5374

TABLE 3.8 MEAN EXPENDITURE LEVELS OF URBAN AND RURAL HOUSEHOLDS

	1987		1994	
	Urban	**Rural**	**Urban**	**Rural**
Meat	3.622	4.220	4.137	5.080
Beef	0.410	0.452	0.497	0.612
Lamb	0.418	0.576	0.437	0.683
Pork	0.522	0.412	0.477	0.513
Pork Products	0.770	0.915	0.811	1.016
Bacon & Ham	0.413	0.852	0.435	0.836
Chicken	0.806	0.845	1.219	1.212
Minced Meat	0.282	0.168	0.260	0.207
Prepared Meals	0.145	0.099	0.537	0.310
Sample size	4466	2641	4738	2594

TABLE 3.9 MEAN EXPENDITURE LEVELS OF HOUSEHOLDS WITH CHILDREN AND HOUSEHOLDS WITH NO CHILDREN

	1987		1994	
	Children	**No Children**	**Children**	**No Children**
Meat	3.506	4.327	4.217	4.767
Beef	0.364	0.512	0.499	0.583
Lamb	0.387	0.604	0.444	0.618
Pork	0.482	0.480	0.503	0.474
Pork Products	0.760	0.915	0.803	0.978
Bacon & Ham	0.483	0.709	0.484	0.686
Chicken	0.754	0.915	1.197	1.239
Minced Meat	0.275	0.190	0.287	0.188
Prepared Meals	0.180	0.055	0.521	0.381
Sample size	4175	2932	3952	3380

TABLE 3.10 MEAN EXPENDITURE LEVELS OF MALE AND FEMALE-HEADED HOUSEHOLDS

	1987		1994	
	Female	**Male**	**Female**	**Male**
Meat	3.890	3.831	4.314	4.531
Beef	0.424	0.425	0.467	0.565
Lamb	0.495	0.472	0.510	0.530
Pork	0.444	0.492	0.430	0.513
Pork Products	0.838	0.820	0.843	0.899
Bacon & Ham	0.524	0.592	0.527	0.596
Chicken	0.916	0.793	1.281	1.191
Minced Meat	0.249	0.237	0.256	0.236
Prepared Meals	0.097	0.137	0.475	0.449
Sample size	1612	5495	2048	5284

TABLE 3.11 MEAN EXPENDITURE LEVELS OF EDUCATED AND UNEDUCATED HEADS OF HOUSEHOLD

	1987		1994	
	Education	**Base**	**Education**	**Base**
Meat	3.795	3.869	4.199	4.607
Beef	0.464	0.406	0.569	0.522
Lamb	0.550	0.440	0.515	0.529
Pork	0.501	0.471	0.489	0.490
Pork Products	0.720	0.876	0.718	0.967
Bacon & Ham	0.432	0.648	0.379	0.677
Chicken	0.858	0.802	1.268	1.190
Minced Meat	0.269	0.226	0.261	0.232
Prepared Meals	0.143	0.121	0.688	0.340
Sample size	2361	4746	2453	4879

TABLE 3.12 MEAN EXPENDITURE LEVELS BY SOCIAL STATUS

	1987			1994		
	Social1	**Social2**	**Base**	**Social1**	**Social2**	**Base**
Meat	3.802	3.650	4.025	4.223	4.404	4.702
Beef	0.513	0.385	0.391	0.603	0.532	0.493
Lamb	0.524	0.435	0.475	0.488	0.481	0.580
Pork	0.519	0.523	0.420	0.498	0.532	0.455
Pork Products	0.702	0.808	0.926	0.724	0.914	0.983
Bacon & Ham	0.407	0.489	0.768	0.375	0.515	0.772
Chicken	0.854	0.764	0.840	1.281	1.169	1.199
Minced Meat	0.282	0.246	0.205	0.253	0.261	0.219
Prepared Meals	0.144	0.157	0.095	0.662	0.451	0.305
Sample size	2093	2176	2838	2277	2035	3020

TABLE 3.13 MEAN EXPENDITURE LEVELS BY MARITAL STATUS

	1987			1994		
	Single	**Married**	**Base**	**Single**	**Married**	**Base**
Meat	3.850	3.700	4.166	4.341	4.446	4.663
Beef	0.454	0.405	0.444	0.525	0.546	0.536
Lamb	0.493	0.460	0.500	0.518	0.524	0.532
Pork	0.376	0.501	0.535	0.391	0.519	0.547
Pork Products	0.871	0.771	0.901	0.957	0.824	0.914
Bacon & Ham	0.610	0.506	0.704	0.598	0.523	0.657
Chicken	0.864	0.792	0.845	1.160	1.248	1.220
Minced Meat	0.181	0.266	0.237	0.192	0.262	0.257
Prepared Meals	0.052	0.160	0.128	0.339	0.509	0.490
Sample size	1690	1589	3828	2054	3456	1822

TABLE 3.14 MEAN EXPENDITURE LEVELS OF HOUSEHOLDS BY PARTICIPATING AND NON-PARTICIPATING HOUSEHOLD GROUPS IN EACH EXPENDITURE CATEGORY

	1987		1994	
Expenditure Category	**Beef Participating**	**Beef Non-Participating**	**Beef Participating**	**Beef Non-Participating**
Lamb	0.573	0.431	0.637	0.462
Pork	0.559	0.444	0.590	0.435
Pork Products	0.933	0.772	0.971	0.836
Bacon & Ham	0.552	0.588	0.600	0.564
Chicken	0.889	0.788	1.372	1.131
Minced Meat	0.257	0.232	0.263	0.230

	1987		1994	
Expenditure Category	**Lamb Participating**	**Lamb Non-Participating**	**Lamb Participating**	**Lamb Non-Participating**
Beef	0.520	0.375	0.649	0.467
Pork	0.518	0.462	0.547	0.454
Pork Products	0.919	0.774	0.999	0.810
Bacon & Ham	0.592	0.568	0.673	0.516
Chicken	0.890	0.784	1.329	1.144
Minced Meat	0.249	0.235	0.255	0.233

	1987		1994	
Expenditure Category	**Pork Participating**	**Pork Non-Participating**	**Pork Participating**	**Pork Non-Participating**
Beef	0.422	0.428	0.591	0.499
Lamb	0.445	0.504	0.541	0.512
Pork Products	0.857	0.796	0.957	0.830
Bacon & Ham	0.537	0.610	0.573	0.580
Chicken	0.865	0.783	1.338	1.128
Minced Meat	0.281	0.205	0.274	0.218

	1987		1994	
Expenditure Category	**Pork Products Participating**	**Pork Products Non-Participating**	**Pork Products Participating**	**Pork Products Non-Participating**
Beef	0.444	0.317	0.563	0.441
Lamb	0.495	0.373	0.551	0.419
Pork	0.510	0.309	0.537	0.309
Bacon & Ham	0.590	0.493	0.624	0.396
Chicken	0.845	0.678	1.280	0.969
Minced Meat	0.248	0.191	0.257	0.180

	1987		1994	
Expenditure Category	**Bacon & Ham Participating**	**Bacon & Ham Non-Participating**	**Bacon & Ham Participating**	**Bacon & Ham Non-Participating**
Beef	0.417	0.434	0.590	0.500
Lamb	0.483	0.470	0.625	0.451
Pork	0.513	0.447	0.541	0.453
Pork Products	0.904	0.740	1.006	0.794
Chicken	0.851	0.789	1.309	1.148
Minced Meat	0.223	0.258	0.245	0.239

TABLE 3.14 (CONTINUED) **MEAN EXPENDITURE LEVELS OF HOUSEHOLDS BY PARTICIPATING AND NON-PARTICIPATING HOUSEHOLD GROUPS IN EACH EXPENDITURE CATEGORY**

	1987		1994	
Expenditure Category	**Chicken Participating**	**Chicken Non-Participating**	**Chicken Participating**	**Chicken Non-Participating**
Beef	0.419	0.435	0.555	0.499
Lamb	0.478	0.474	0.531	0.508
Pork	0.530	0.401	0.537	0.383
Pork Products	0.851	0.779	0.909	0.826
Bacon & Ham	0.558	0.607	0.568	0.598
Minced Meat	0.260	0.206	0.260	0.199

	1987		1994	
Expenditure Category	**Minced Meat Participating**	**Minced Meat Non-Participating**	**Minced Meat Participating**	**Minced Meat Non-Participating**
Beef	0.361	0.474	0.497	0.559
Lamb	0.393	0.540	0.466	0.554
Pork	0.522	0.451	0.547	0.460
Pork Products	0.776	0.860	0.881	0.885
Bacon & Ham	0.426	0.689	0.481	0.627
Chicken	0.810	0.829	1.257	1.195

3B Appendices

Appendix 3A **SEASONALITY INDEX FOR DEPENDENT VARIABLES**

1987

Month	Beef	Lamb	Pork	Pork Prod.	Bac. & Ham	Chick.	Mince.	Prep. Meals
January	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
February	1.104	0.886	0.989	0.961	0.965	0.989	0.994	0.991
March	1.084	0.929	0.935	1.012	1.006	0.939	0.974	1.006
April	1.047	0.955	0.914	1.029	1.030	0.874	0.960	0.992
May	0.992	0.919	0.963	1.014	1.088	1.000	0.961	0.981
June	1.037	0.931	0.877	0.998	1.036	0.885	0.960	0.988
July	1.049	0.996	0.898	0.983	1.144	0.913	0.952	0.986
August	0.973	1.013	0.983	1.059	1.187	0.894	0.988	0.965
September	1.012	1.085	0.973	0.984	1.140	0.909	0.949	0.982
October	1.003	1.023	0.975	1.004	1.124	0.903	1.001	0.995
November	0.982	1.059	0.983	1.011	1.065	0.967	1.002	1.003
December	1.042	1.092	0.890	1.076	1.549	0.874	0.964	1.010

1994

Month	Beef	Lamb	Pork	Pork Prod.	Bac. & Ham	Chick.	Mince.	Prep. Meals
January	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
February	0.998	1.062	1.007	1.031	1.014	0.877	1.002	1.003
March	1.074	1.064	1.010	1.028	1.025	0.956	0.984	1.059
April	0.984	1.207	0.873	1.031	0.939	0.903	0.954	1.072
May	0.929	1.042	0.963	1.020	0.953	0.934	1.008	1.082
June	0.937	1.291	0.867	0.951	1.021	0.819	0.979	0.995
July	0.100	1.152	0.895	1.021	1.060	0.918	0.955	1.003
August	0.970	1.209	0.910	1.073	1.057	0.810	0.919	1.007
September	1.095	1.120	0.944	0.951	0.943	0.891	1.005	1.054
October	0.967	1.190	0.968	1.033	0.941	0.892	0.970	1.054
November	1.017	1.103	0.983	0.995	0.986	0.973	1.009	1.071
December	1.043	1.085	0.959	0.970	1.246	0.790	0.987	1.022

Appendix 3B **SAMPLE STATISTICS SUB-GROUPED BY PARTICIPATING AND NON-PARTICIPATING HOUSEHOLDS FOR EACH EXPENDITURE CATEGORY**

MEAT EXPENDITURE				
	1987		1994	
Variable	**Participating**	**Non-Participating**	**Participating**	**Non-Participating**
Age	4.937	4.966	5.087	4.972
All Working	0.218	0.442	0.261	0.410
Urban	0.627	0.665	0.640	0.773
Children	0.600	0.165	0.555	0.173
Gender	0.225	0.301	0.275	0.378
Education	0.330	0.398	0.332	0.391
Social1	0.292	0.369	0.308	0.375
Social2	0.309	0.218	0.281	0.202
Single	0.209	0.694	0.261	0.703
Married	0.549	0.194	0.486	0.155

BEEF EXPENDITURE				
	1987		1994	
	Participating	**Non-Participating**	**Participating**	**Non-Participating**
Age	4.855	4.977	5.042	5.104
All Working	0.242	0.216	0.274	0.263
Urban	0.665	0.611	0.649	0.645
Children	0.629	0.567	0.625	0.492
Gender	0.191	0.244	0.229	0.307
Education	0.386	0.307	0.383	0.308
Social1	0.356	0.265	0.361	0.283
Social2	0.331	0.294	0.307	0.262
Single	0.152	0.257	0.188	0.330
Married	0.598	0.511	0.550	0.428

LAMB EXPENDITURE				
	1987		1994	
	Participating	**Non-Participating**	**Participating**	**Non-Participating**
Age	5.064	4.871	5.257	4.970
All Working	0.215	0.229	0.235	0.288
Urban	0.610	0.638	0.617	0.665
Children	0.591	0.585	0.577	0.515
Gender	0.213	0.234	0.251	0.298
Education	0.376	0.309	0.335	0.334
Social1	0.329	0.276	0.307	0.313
Social2	0.311	0.303	0.296	0.266
Single	0.175	0.249	0.210	0.325
Married	0.576	0.519	0.524	0.437

Appendix 3B (contd.) **SAMPLE STATISTICS SUB-GROUPED BY PARTICIPATING AND NON-PARTICIPATING HOUSEHOLDS FOR EACH EXPENDITURE CATEGORY**

PORK EXPENDITURE

	1987		1994	
	Participating	**Non-Participating**	**Participating**	**Non-Participating**
Age	4.742	5.105	4.989	5.149
All Working	0.203	0.242	0.238	0.288
Urban	0.699	0.568	0.680	0.622
Children	0.680	0.508	0.638	0.325
Gender	0.195	0.254	0.231	0.467
Education	0.355	0.313	0.348	0.314
Social1	0.318	0.274	0.326	0.299
Social2	0.349	0.269	0.320	0.247
Single	0.140	0.295	0.177	0.355
Married	0.600	0.486	0.539	0.422

PORK PRODUCTS EXPENDITURE

	1987		1994	
	Participating	**Non-Participating**	**Participating**	**Non-Participating**
Age	4.908	5.115	5.048	5.212
All Working	0.202	0.356	0.243	0.359
Urban	0.627	0.637	0.633	0.698
Children	0.634	0.313	0.600	0.303
Gender	0.211	0.321	0.250	0.392
Education	0.323	0.385	0.321	0.388
Social1	0.284	0.355	0.297	0.363
Social2	0.320	0.223	0.297	0.204
Single	0.182	0.466	0.225	0.491
Married	0.571	0.348	0.509	0.327

BACON & HAM EXPENDITURE

	1987		1994	
	Participating	**Non-Participating**	**Participating**	**Non-Participating**
Age	5.087	4.782	5.325	4.905
All Working	0.168	0.282	0.188	0.324
Urban	0.539	0.722	0.550	0.716
Children	0.642	0.531	0.598	0.496
Gender	0.178	0.278	0.224	0.320
Education	0.288	0.378	0.274	0.379
Social1	0.252	0.338	0.250	0.355
Social2	0.312	0.300	0.293	0.267
Single	0.154	0.296	0.194	0.343
Married	0.577	0.499	0.514	0.440

Appendix 3B (contd.) **SAMPLE STATISTICS SUB-GROUPED BY PARTICIPATING AND NON-PARTICIPATING HOUSEHOLDS FOR EACH EXPENDITURE CATEGORY**

CHICKEN EXPENDITURE

	1987		1994	
	Participating	**Non-Participating**	**Participating**	**Non-Participating**
Age	4.835	5.107	4.952	5.378
All Working	0.203	0.260	0.252	0.300
Urban	0.652	0.589	0.657	0.621
Children	0.660	0.468	0.621	0.351
Gender	0.205	0.262	0.262	0.319
Education	0.348	0.306	0.355	0.288
Social1	0.313	0.264	0.330	0.266
Social2	0.326	0.274	0.293	0.241
Single	0.156	0.336	0.198	0.468
Married	0.592	0.451	0.533	0.331

MINCED MEAT EXPENDITURE

	1987		1994	
	Participating	**Non-Participating**	**Participating**	**Non-Participating**
Age	4.488	5.275	4.648	5.309
All Working	0.202	0.241	0.244	0.279
Urban	0.722	0.558	0.692	0.622
Children	0.752	0.464	0.716	0.446
Gender	0.195	0.250	0.257	0.291
Education	0.357	0.314	0.353	0.325
Social1	0.327	0.270	0.319	0.306
Social2	0.347	0.275	0.321	0.255
Single	0.118	0.303	0.157	0.344
Married	0.638	0.464	0.562	0.424

PREPARED MEALS EXPENDITURE

	1987		1994	
	Participating	**Non-Participating**	**Participating**	**Non-Participating**
Age	4.218	5.624	4.517	5.714
All Working	0.208	0.240	0.294	0.237
Urban	0.673	0.586	0.691	0.596
Children	0.842	0.345	0.713	0.344
Gender	0.153	0.297	0.246	0.316
Education	0.368	0.298	0.427	0.231
Social1	0.330	0.260	0.385	0.228
Social2	0.364	0.251	0.307	0.245
Single	0.070	0.370	0.145	0.432
Married	0.672	0.411	0.576	0.354
Microwave	0.076	0.043	0.590	0.307
Freezer	0.182	0.130	0.264	0.162

Appendix 3C **SEASONALITY INDEX FOR TOTAL HOUSEHOLD EXPENDITURE**

Month	1987	1994
January	1.000	1.000
February	1.029	1.050
March	1.022	1.182
April	0.960	1.151
May	0.939	1.048
June	0.912	1.027
July	0.971	0.944
August	0.977	0.951
September	0.926	1.128
October	0.927	1.110
November	1.015	1.138
December	1.105	1.448

CHAPTER 4

AN ECONOMETRIC ANALYSIS OF IRISH HOUSEHOLDS' AGGREGATE MEAT EXPENDITURE PATTERNS

4.1 Introduction

In this chapter, the factors influencing Irish households' expenditure on meat are analysed using the 1987/8 and 1994/5 Irish Household Budget Survey datasets. Tobit, double-hurdle and infrequency of purchase methodologies, developed in Chapter 2, are applied to the data and the most appropriate modelling technique is chosen using likelihood ratio and non-nested testing procedures.

Meat expenditure is chosen for this analysis because of evidence that lifestyles increasingly impact on consumers' decisions to consume meat (Bansback, 1995, Bansback *et al.*, 1998, McCarthy *et al.*, 1998). This chapter aims to examine this trend by firstly identifying differences in meat expenditure patterns of different household groups and secondly ascertaining the degree to which the quantitative importance of these variables changed between 1987 and 1994. The main hypothesis, as discussed in Chapter 1, Section 1.2.4, is that, aside from price and income considerations, the lifestyle choices of households will determine their decision to purchase meat and how much to spend. It is proposed that the lifestyle choices of certain household groups, for example, younger households, all-working households, urban households, households of a professional social status *etc.* will lead to a greater demand for convenience in home cooking activities due to the time-constraints imposed by the lifestyle choices these household groups make. This will impact on the meat expenditure decisions of different household groups as the aggregate meat expenditure category excludes many time-saving processed meat alternatives, the meat components of ready or prepared meals and meat consumed away from home (see Chapter 1, Section 1.2.2). It is also proposed in Chapter 1, Section 1.2.2, that consumers are increasingly concerned about health particularly regarding red meats, which are often perceived as being unhealthy compared with white meats. While this issue cannot be addressed directly in this chapter due to the aggregate nature of the dependent variable, health concerns are also considered as an explanation for some of the patterns of expenditure observed in the results of this analysis.

The specification of the model used in this analysis is discussed in Section 4.2. Section 4.3 deals with the estimation procedures used and Section 4.4 discuses issues surrounding the choice of the most appropriate econometric model. In Section 4.5, the marginal effects associated with each model are compared and contrasted. Section 4.6 analyses the estimated elasticities and discrete effects of the most appropriate model, the infrequency of purchase model, and attempts to explain the reasons for the observed results. Section 4.7 summarises the chapter.

4.2 Specification

The dependent variable in this analysis is average weekly per capita household aggregate meat expenditure (see Chapter 3, Section 3.4.1, for a detailed description of this variable). As discussed in Chapter 3, information on the value of household expenditure only is collected and so quantity and quality effects cannot be separately identified. Furthermore, information on meat consumption out of the home cannot be ascertained from the survey. Meat expenditure is assumed to be expressible as a linear function of income, income squared and a vector of socio-economic variables, assumed to underpin tastes and preferences, listed in Table 4.1 (see Chapter 3, Section 3.4.2, for a detailed description of these variables).

4.2.1 The Tobit Model

The tobit model is described in Chapter 2, Section 2.2. All variables listed in Table 4.1 are included in the expenditure equation of the tobit model. The likelihood equation for the tobit model is given in 2.12. As detailed in Chapter 2, Section 2.5, corrections for heteroscedasticity and non-normality of the error terms must be considered. The heteroscedasticity adjustment is given in Equation 2.25, while non-normality of the error terms is allowed for by imposing an Inverse Hyperbolic Sine (IHS) transformation to the dependent variable (see Equation 2.26). The likelihood equation for the tobit model incorporating these specification adjustments is detailed in Chapter 2, Section 2.6.

4.2.2 The Double-Hurdle and Infrequency of Purchase Models

The double-hurdle and infrequency of purchase models are described in Chapter 2, Sections 2.3 and 2.4 respectively. The specification of the double-hurdle and infrequency of purchase models is not as straightforward as for the tobit model. Theory provides no guidance as to which explanatory variables to include in the first and second equations of these models. If the same set of regressors is included in each hurdle, the model may not identify the parameters of the model correctly. If more than one theory is consistent with the same data, the theories will be observationally equivalent with no way of distinguishing them (Greene, 2000). Therefore, using the same data to describe both decisions in the double-hurdle and infrequency of purchase models would introduce this identification problem. As a result, certain exclusion restrictions must be imposed (Jones, 1992, Yen *et al.*, 1996). It is assumed in this thesis that economic factors should only be included in the second hurdle of both the double-hurdle and infrequency of purchase models. As such, both income and income squared are excluded from the first equation of both models. As a guide to model specification, a probit model of the decision to participate/purchase is also estimated for meat expenditure in each year using the socio-economic variables listed in Table 4.1 (see Appendix 4A). Parameters found to be statistically insignificant in explaining the decision to participate/purchase meat in both years are excluded from the first equation of both the double-hurdle and infrequency of purchase models (Su and Yen, 1996). The variables included in the first equation of the double-hurdle and the infrequency of purchase models of meat expenditure are listed in Table 4.2.

The likelihood equations for the double-hurdle and infrequency of purchase models are detailed in Equations 2.16 and 2.24 respectively. As with the tobit model, adjustments for heteroscedasticity and non-normality are also imposed for each model. Likelihood equations incorporating these specification adjustments are detailed in Chapter 2, Section 2.6.

4.3 Estimation

The models are estimated by maximising the log of the relevant likelihood function using the Maxlik procedure in Gauss version 3.5 (for examples of the procedures used see Appendix 4B).[25] Maximum likelihood estimates for each model, with the necessary specification adjustments, are presented in Tables 4.3, 4.4 and 4.5. Likelihood ratio tests reject the restricted model of homoscedasticity in favour of the alternative variance specification (see Equation 2.25 in Chapter 2) for all models in both years (see Appendix 4C). The significance of the heteroscedasticity parameters also justifies the use of the variance equation (see Tables 4.3, 4.4 and 4.5). The IHS specification is preferred to the standard specification of all models based on both improved likelihood ratios (see Appendix 4D) and the significance of the θ parameter (see Tables 4.3, 4.4 and 4.5).

4.4 Model Choice

As discussed in Chapter 2, zero observations on expenditure can be attributed to three possible sources; a standard corner solution, non-participation or infrequency of

[25] The advanced features of the Maxlik procedures used in this thesis were coded by the author.

purchase, modelled by the tobit, double-hurdle and infrequency of purchase models respectively. In the case of aggregate meat expenditure, only 3 per cent and 4 per cent of households report zero expenditures in 1987 and 1994 respectively, implying that the sample of non-purchasing households will vary by a much smaller amount than the sample of purchasing households. Likelihood ratio tests are used to distinguish between the tobit model and either double-hurdle or infrequency of purchase specifications. The tobit model is rejected in favour of the other two model specifications in both years (see Appendix 4E). This implies that even though a small percentage of households report zero expenditure on meat, these observations cannot be attributed solely to standard corner solutions meaning they cannot be explained based on economic reasoning alone. However, maximum likelihood estimates for the double-hurdle and infrequency of purchase models, presented in Tables 4.4 and 4.5, reveal high standard errors on the first hurdle regressors compared with the second hurdle regressors. This implies that the difference in the socio-economic characteristics of non-purchasing households is difficult to estimate accurately. This could be due to a poor fit for the model, too little variation in the sample of non-purchasing households or unobserved heterogeneity not captured by the variables included in the first hurdle equation. Nevertheless, likelihood ratio tests reject the tobit model in favour of the other two specifications.[26]

Vuong's (1989) non-nested test of model specification, detailed in Chapter 2, Section 2.7, is used to select, the most appropriate specification of the meat expenditure model, between the double-hurdle and infrequency of purchase models. The results of this test are presented in Appendix 4F. In 1994 the null hypothesis that both models are the

[26] Eventhough the tobit model is rejected in favour of the double-hurdle and infrequency of purchase alternatives, the parameter estimates for the tobit model are very similar to those obtained for the expenditure equations of the other models (see Tables 4.3 – 4.5).

same is not rejected in favour of any one particular model. In 1987, however, the null hypothesis is rejected in favour of the infrequency of purchase model. This implies that of the 3 per cent of households reporting zero expenditures on meat in 1987, a proportion of these zeros are attributable to standard economic factors and a proportion are attributable to infrequency of purchase due to a purchasing cycle of longer duration than the span of the survey. In 1994 a distinction between zeros attributable to infrequency of purchase and zeros attributable to non-participation cannot be made using Vuong's (1989) test. However, considering the log likelihood value for the infrequency of purchase model (-6120.40) is slightly higher than that of the double-hurdle model (-6124.38), and for ease of comparison with the 1987 model, the infrequency of purchase model is used to explain meat expenditure patterns in 1994.

4.5 Model Comparison

The small proportion of zero observations on the dependent variable in both 1987 and 1994 implies that there is very little difference in the results of the tobit, double-hurdle and infrequency of purchase models, since these models only differ in the assumptions they make about the source of the zero observations. While in 1987, the infrequency of purchase model is statistically the most appropriate model of meat expenditure, in 1994 the choice of model is arbitrary. In this section the results of the three models are compared in order to establish the importance of model choice in the face of so few zero expenditures.

As discussed in Chapter 2, Section 2.8, the parameter estimates of models cannot be interpreted as the direct effects of the explanatory factors on the dependent variable.

Marginal effects of the explanatory variables are found by decomposing the unconditional mean of the dependent variable into the probability of participation/purchase and the conditional mean level of expenditure, and then differentiating these components with respect to each explanatory factor in turn. Marginal effects are calculated for the tobit, double-hurdle and infrequency of purchase models of meat expenditure and their standard errors are approximated using the delta method as detailed in Chapter 2, Section 2.8.

Marginal effects and associated standard errors for the tobit, double-hurdle and infrequency of purchase models are presented in Tables 4.6, 4.7 and 4.8 respectively. As with the estimated parameters, the marginal effects vary little across the three models. The first point to note is that the magnitude of the effects of the explanatory variables on the probability of purchase in all cases is small in comparison with the other two components. This can be attributed to the fact that the percentages of zero observations on expenditure in both years are small, leading to little variation in the socio-economic characteristics of non-purchasers.

The sign of each marginal effect is the same for each specification without exception. The statistical significance of the parameters, however, varies slightly, particularly between the tobit and double-hurdle specifications. While age is found to have a significant positive effect on the probability of purchase in the tobit model, it is found to be insignificant in the double-hurdle model in both 1987 and 1994. In 1987, the gender variable is found to have an insignificant effect on the unconditional level of expenditure and its two components in the tobit specification but is found to have a negative and significant effect on all components in the double-hurdle model in 1987.

Similarly in 1994, the tobit model finds the all-working variable to be insignificant while in the double-hurdle model the marginal effects associated with this variable are all significant. The marginal effects for the tobit model are closer in resemblance to the infrequency of purchase model with the only difference in the statistical significance of the parameter associated with the all-working variable which is significant in the infrequency of purchase model, as with the double-hurdle model.

Overall, the magnitudes of the unconditional marginal effects are similar across all three models. Comparison between the double-hurdle model and the other two models in 1987 is difficult due to the fact that the variable representing married households had to be excluded from the first hurdle in order for the estimation process to converge. In this year, the double-hurdle model appears to overstate the marginal effects on the probability of participation leading to larger overall unconditional marginal effects than the other two models. In 1994, the differences in the magnitude of the marginal effects vary little across the three models.

The similarities across the three models suggest that in the presence of very few zero observations on the dependent variable, assumptions made regarding the source of zero observations have little impact on the quantitative relationships between the explanatory variables and expenditure.

4.6 Empirical Results

In this section the empirical results of the infrequency of purchase model are analysed as it is found to be the most appropriate choice for modelling aggregate meat expenditure (see Section 4.4). Using the estimated marginal effects, presented in Table 4.8, elasticities and discrete effects are calculated for the continuous and discrete variables of the model respectively as discussed in Chapter 2, Section 2.8.3. The statistical significance of these elasticities and discrete effects are assumed to be the same as for their underlying marginal effect. Elasticity estimates and discrete effects are presented in Table 4.9.

4.6.1 Income

Parameter Values

Table 4.5 presents the maximum likelihood estimates for the infrequency of purchase model of meat expenditure in each year. Income has a positive and significant effect on meat expenditure in 1987 and 1994. Income squared is included in the analysis to capture the possibility of a non-linear relationship between income and meat expenditure. The results confirm a significant non-linear relationship with a significant negative coefficient for income squared in each year. This implies, that as income increases so too does household expenditure on meat, however, this occurs at a decreasing rate.

Elasticity Estimates

The income elasticities, presented in Table 4.9, are calculated at the sample means in both years and incorporate the non-linear effect of income squared discussed above. Income elasticities are positive and significant in both years. The unconditional elasticities have values of 0.397 and 0.303 in 1987 and 1994 respectively. This implies that in 1987, a 1 per cent increase in the mean level of income would lead to a 0.397 per cent increase in the mean level of household meat expenditure. Similarly for 1994 a 1 per cent increase in the mean level of income would lead to a 0.303 per cent increase in the mean level of household meat expenditure. Income elasticities associated with the probability of observing a zero expenditure[27] and the conditional level of expenditure are also positive and significant. However the majority of the effect is attributable to the effect on the conditional level of expenditure in both years.

In order to compare the elasticities over time, 1994 income elasticities are evaluated at the 1987 sample mean, adjusted for changes in the money value of income over time. The results are presented in Table 4.10. The magnitude of the elasticity has declined by 0.098. This decline is significant at the 1 per cent level. This implies that the level of meat expenditure of Irish households in 1994 is less responsive to changes in household income levels than in 1987. The decline in the income elasticity is consistent with the literature on meat demand discussed in Chapter 1, Section 1.2.3. Even at constant income levels, income has declined in importance as an explanatory factor in households' meat expenditure decisions.

4.6.2 Age

As discussed in Chapter 3, Section 3.4.2, the age variable is ordinal in nature. As a result, elasticity estimates cannot be interpreted in the same way as for other continuous

[27] Since income is excluded from the equation determining the probability of purchase the probability component of the income elasticity relates to the probability of observing a standard corner solution.

variables. The age elasticities associated with the probability of purchase, conditional and unconditional levels of expenditure are positive and significant in both years.

Burton *et al.* (1996), in their analysis of aggregate meat expenditure in the UK in 1988, also found a positive relationship between age and meat expenditure. In 1987, the unconditional age elasticity takes a value of 0.440. This implies that older heads of household spend more on meat. Specifically, a 1 per cent increase in the value of the age variable will lead to a 0.44 per cent increase in meat expenditure. Since the age variable consists of eight categories, a 12.5 per cent increase in the age variable represents the move from one age group to another. Such a move would therefore lead to a 5.5 per cent increase in meat expenditure. For example, heads of household in their 30s spend 5.5 per cent more on meat than heads of household in their 20s. The unconditional elasticity is higher in 1994 compared with 1987. This is partly attributable to the fact that the mean age of heads of household is higher in the 1994 sample compared with the 1987 sample. However, evaluating the 1994 age effect using the 1987 sample mean gives an elasticity of 0.479, a value equivalent to a 6 per cent increase in expenditure as the head of household moves from one age category to the next, which is still of greater magnitude than the 1987 elasticity. This indicates that the gap in meat expenditure levels of heads of household of different age groups is widening. The majority of the unconditional effect is attributable to the effect on the conditional level of expenditure with the elasticity associated with the probability of purchase being very small at 0.016 and 0.039 in 1987 and 1994 respectively.

As proposed in Section 4.1, a possible explanation for this result is that younger headed households are less willing to devote as much time to meal preparation compared with older headed households and chose more convenient alternatives to meat, like prepared meals or eating out of home. Alternatively, this result could indicate a greater health consciousness among younger age groups, who may perceive meat to be less healthy than other foods. It is difficult to decipher the reason for the observed result due to the aggregate nature of the meat expenditure category and the diversity of products it includes. This issue is explored in more detail in Chapter 5, with a disaggregated meat expenditure analysis.

4.6.3 All-Working

The first discrete variable captures the difference between the meat expenditure decisions of households where all adults work and households where at least one adult does not work. In both years the effect is negative and significant on the probability of purchase, the conditional and unconditional levels of expenditure. The overall, unconditional, effect in 1987 is –0.041. This implies that all-working households spent 4 per cent less on meat than households where at least one adult does not work. They were 1 per cent less likely to purchase the product, and of all households that did purchase the good, all-working households spent 3 per cent less than other households. The magnitude of the effect in 1994 has declined in all cases.

The negative result observed for this variable in both years could be explained by the fact that all-working households face greater time constraints compared with other households where at least one adult does not work and would therefore have less time for meal preparation in the home. All-working households could substitute other types of more conveniently prepared foods, or eating out of home, for preparing home cooked meat centred dinners. In 1994, for example, all-working households spent on average £0.64 per week on prepared meals; almost double the expenditure of other households at £0.39. In the same year all-working households spent on average £10.29 per week on food consumed away from home compared with £4.49 spent by other households. From these results it could be concluded that the time constraints imposed by all adult members working lead to all-working households having a stronger preference for convenience in the preparation of food than other households. These possibilities are explored in more detail in Chapters 5 and 6. However, the decline in the magnitude of the effect of this variable on meat expenditure between 1987 and 1994 suggests that households where at least one adult does not work are behaving in a more similar way to all-working households with regard to their meat expenditure decisions. This could imply a growing preference for more convenient alternatives to meat among all households, since, in real terms, expenditure of both household groups has declined between the two years.

4.6.4 Urban

The effect of living in urban areas on the unconditional level of expenditure is negative and significant in both years. In 1987 urban households were 1 per cent less likely to purchase meat than rural households. Of all households that purchase meat, urban households spent 5 per cent less than rural households. Overall, urban households spent 6 per cent less than rural households. In 1994, the difference between urban and rural households is slightly greater with urban households 2 per cent less likely to purchase meat, conditional on purchase urban households spent 6 per cent less than rural households and overall spent 8 per cent less than rural households.

The difference between the expenditure patterns of urban and rural households could be attributed to the differences in the lifestyles associated with living in these areas. It could be said that urban households face greater time constraints than rural households due to the faster pace of life associated with living in urban areas. As a result, they may require more convenience when cooking than rural households and therefore spend less on meat and more on other food items which can be more conveniently prepared, for example, urban households spent 40 per cent more than rural households on prepared meals in 1994. Due to the fact that urban households have more options available to them in terms of consuming food away from home it is also likely that they are substituting the more convenient alternative of eating out of home for preparing home cooked meat centred meals. For example, in 1994 urban households spent £6.11 per week on food consumed away from home compared with £3.65 spent by rural households. Similar conclusions can be drawn for urban households as for all-working households. In this case, city life imposes a greater amount of time constraints than living in rural areas. This combined with the options available in city areas for eating out of home leads to urban households spending less on meat than rural households. The difference between the expenditure patterns of urban and rural dwellers is increasing over time.

4.6.5 Children

In 1987 the presence of children in a household has a negative effect on household expenditure on meat. Households with children were 1 per cent less likely to purchase meat and conditional on purchase spent 4 per cent less on meat than households without children. Burton *et al.* (1996) also found a negative relationship between the presence of children and meat expenditure. The negative effect on the probability of purchase implies that either households with children eat meat less regularly than households without, or simply shop less frequently. The negative effect on the conditional level of expenditure implies that either households with children purchase less physical quantity of meat than households without, despite the imposition of adult equivalence adjustments, or they buy cheaper cuts. The lack of price and quantity data makes it impossible to distinguish between the two effects. In 1994 the effect of children is positive but insignificant in all cases.

The interesting feature about this result is the change in the meat expenditure patterns of this household group over time. In 1987, households with children appear to have a negative attitude toward meat compared with other households, while in 1994 no such distinction can be made. The most likely explanation for this negative effect observed in 1987 is that cuts of meat suitable for children can be cheaper than other types of meat and so households with children would have lower meat expenditure levels than households without as observed in this analysis. The Meat and Livestock Commission (1988) revealed sausages and beef-burgers to be the most suitable cuts of meat for children, both of which are cheap relative to other meat categories. In 1994, households with children did not spend a significantly different amount than other households suggesting that cheaper products are no-longer a distinct preference for this household group, perhaps due to health issues surrounding cheap meat products. This issue is explored in more detail in the disaggregated meat expenditure analysis presented in Chapter 5.

4.6.6 Gender

In Chapter 3, Table 3.10 small differences in the mean aggregate meat expenditure levels of male and female-headed households are identified. In this analysis, however, controlling for other factors, gender is shown to have an insignificant effect on households' aggregate meat expenditure levels. Contrary to this result, Burton *et al.* (1996) found a significantly negative relationship between female-headed households and household aggregate meat expenditure in the UK.

4.6.7 Education

The education level of the head of household has a significant and negative effect on aggregate meat expenditure in both 1987 and 1994. In 1987, educated households spent on average 7.2 per cent less per week on meat than uneducated households, were 1.5 per cent less likely to purchase meat and conditional on purchase spent 5.7 per cent less. The magnitude of the effect increased between 1987 and 1994 where the education level of the head of household has an overall effect of –0.119.

Burton *et al.* (1996) found a negative relationship between the head of household's education level and household meat expenditure in the UK. An explanation for this result could be that more educated households are more health conscious than other uneducated households and so perceive certain meats as having certain health implications. Su and Yen (1996) also found a negative relationship between education and US pork consumption and attributed this to the negative perception of meat of more educated households. However, due to the aggregate nature of the meat expenditure category and the diversity of products it entails, this relationship is difficult to ascertain. In Chapter 5 meat expenditure is disaggregated into seven sub-categories allowing more concrete deductions to be made regarding households' perceptions of meat products with regard to health issues.

4.6.8 Social Status

The social status of the head of household has a significant negative effect on household aggregate meat expenditure. The discrete effects of heads of household of a professional social status are identical to the results for the education variable in 1987 and follow a similar pattern in 1994. In 1994 households of a professional social status were 2.2 per cent less likely to purchase meat and conditional on purchase spent 6.6 per cent less than the base category. Overall professional households spent 8.8 per cent less on meat than the base category. Households of an intermediate social status also reveal a negative relationship with the components of meat expenditure when compared with the base category, albeit of a much lower magnitude.

The negative effect of social status on household meat expenditure could be attributed to time-saving convenience issues. It is possible that households of a professional social status, and to a lesser extent an intermediate social status, are less likely to purchase meat and spend less on it due to the time-constraints imposed by leading a professional/semi-professional career. As a result they purchase less meat and substitute other more convenient alternatives for preparing home-cooked meals. For example, the 1994 dataset shows that professional households spent on average £9.48 weekly on food consumed away from home and £0.66 on prepared meals, compared with intermediate households who spent on average £4.76 and £0.45 respectively and the base category who spent £2.37 and £0.30 on these food items. As before, the effect of these variables on individual meat categories, which display different attributes in terms of convenience and health, explored in Chapter 5, will reveal more on these issues.

4.6.9 Marital Status

Single adult

Single adult households have a negative effect on household aggregate meat expenditure. Furthermore, the difference between single adult households and the base category, households with two or more unmarried adults with and without children, changed very little between 1987 and 1994. In 1987, single adult households spent 5.7 per cent less on meat than other households while in 1994 they spent 5.2 per cent less. In both years they were 1.3 per cent less likely to purchase meat and conditional on purchase spent 4.4 per cent less in 1987 and 3.9 per cent less in 1994 than the base category of households.

This negative effect could be attributed to the fact that single adult households have less of an incentive to cook meat centred home cooked meals for one compared with other households who have more than one adult to cook for.

Married couples

Married couples on the other hand have a positive effect on meat expenditure with the magnitude of the effect being greater in 1994 than 1987. In 1987 married couples spent 3.9 per cent more on meat, and in 1994 5.4 per cent more on meat, than other households with two or more adults. This positive effect could indicate a greater preference for cooking traditional meat meal centres among married households compared with other adult households. Perhaps they place more value on the family eating occasion, and hence cook a greater amount of home-cooked meals than other households, leading to higher levels of meat expenditure.

4.7 Summary and Conclusions

In this chapter, Irish households' meat expenditure patterns are analysed using tobit, double-hurdle and infrequency of purchase models adjusted for heteroscedasticity and non-normality. Due to the existence of very few zero observations on the dependent variable, marginal effects and their associated standard errors for each model are compared and contrasted in order to establish the importance of model choice in a sample where most observations are positive. The analysis is based on the elasticities and discrete effects calculated using the marginal effects of the infrequency of purchase model, as it is found to be the most appropriate model for analysing Irish households' meat expenditure decisions, based on likelihood ratio and non-nested testing procedures.

Consistent with the literature outlined in Chapter 1, Section 1.2.2, the effect of income on meat expenditure decisions has declined over time. Furthermore, a non-linear relationship is identified between income and meat expenditure, indicating that as income increases, the income effect declines in magnitude, providing further evidence of the declining importance of income as an explanatory factor in meat expenditure decisions at higher income levels.

In Section 4.1, it is hypothesised that the lifestyle choices of households impact on their expenditure decisions. It is proposed that the lifestyles of certain household groups lead to an increased demand for convenience. The effects of many of the socio-economic characteristics in this analysis allow deductions to be made about this convenience preference. Younger headed households, households where all adult members work, urban households, households with children, educated households of an intermediate or professional social status and single adult households all spend less on meat than other household groups. In most cases, this behaviour can be attributed to a greater preference for convenience in meal preparation due to either time constraints imposed by the lifestyles these household groups lead or a greater preference for leisure time resulting in an unwillingness to devote as much time as other household groups to meal preparation. As a result, it is proposed that these households choose more convenient alternatives to meat centred meals like prepared meals or eating out of home. Understanding the effect of households with children on meat expenditure patterns emphasises the limitations of the data. It is difficult to ascertain whether the observed negative relationship is due to a preference of households with children for convenient alternatives to meat in general or a preference for cheaper alternatives within the meat category, due to the lack of price and quantity data collected in the survey. The positive effect of married households on meat expenditure is attributed to the possibility that this household group places more emphasis on the family meal-eating occasion than a household shared by a number of unmarried adults.

The negative effects observed for socio-economic variables could also be attributed to health issues in terms of a negative perception of meat of these groups compared with their base categories. However, it is difficult to comment on this issue due to the aggregate nature of the dependent variable and the differences in the types and quality of meat products the category contains.

The results of this analysis provide an overview of the factors influencing the demand for meat and focus on household demand for convenience, but also refer to health issues as explanations for the results observed. In Chapter 5, meat expenditure is disaggregated in seven sub-expenditure equations for each year. The issues of convenience and health can be explored in greater detail, as different meat products possess different degrees of these two attributes.

4A Tables

TABLE 4.1 **EXPLANATORY VARIABLES IN EXPENDITURE EQUATIONS**

Income
$Income^2$
Age
All-working
Urban
Children
Gender
Education
Social Status
Marital Status

TABLE 4.2 **EXPLANATORY VARIABLES IN PROBIT PARTICIPATION/PURCHASE EQUATIONS**

Age
All-working
Urban
Children
Gender
Social Status (Social 1 only)
Marital Status

TABLE 4.3 MAXIMUM LIKELIHOOD ESTIMATES OF IHS HETEROSCEDASTIC TOBIT MODEL

	1987		1994	
	Exp.	**Hetero.**	**Exp.**	**Hetero.**
Constant	0.371***	-0.682***	0.400***	-0.4010***
	(0.052)	(0.032)	(0.062)	(0.033)
Income	0.857***	0.232***	0.596***	0.128***
	(0.049)	(0.016)	(0.045)	(0.012)
$Income^2$	-0.190***		-0.103***	
	(0.017)		(0.012)	
Age	0.103***	0.065***	0.152***	0.069***
	(0.006)	(0.005)	(0.008)	(0.005)
All Working	-0.055***		-0.028	
	(0.020)		(0.022)	
Urban	-0.087***		-0.133***	
	(0.015)		(0.019)	
Children	-0.057***		0.029	
	(0.020)		(0.023)	
Gender	-0.016		-0.019	
	(0.021)		(0.024)	
Education	-0.029*		-0.056***	
	(0.017)		(0.022)	
Social1	-0.117***		-0.161***	
	(0.021)		(0.025)	
Social2	-0.038**		-0.040*	
	(0.017)		(0.021)	
Single	-0.070***		-0.075***	
	(0.027)		(0.030)	
Married	0.043**		0.080***	
	(0.018)		(0.022)	
IHS	0.322***		0.263***	
	(0.013)		(0.010)	
Log Likelihood	-5306.60		-6138.78	

*** significant at 1% level, ** significant at 5% level, * significant at 10% level
Standard errors are given in parentheses.

TABLE 4.4 MAXIMUM LIKELIHOOD ESTIMATES OF IHS HETEROSCEDASTIC DOUBLE-HURDLE MODEL

	1987			1994		
	Part.	**Exp.**	**Hetero.**	**Part.**	**Exp.**	**Hetero.**
Constant	3.441***	0.403***	-0.705***	1.282	0.423***	-0.433***
	(0.892)	(0.051)	(0.034)	(2.907)	(0.062)	(0.033)
Income		0.821***	0.223***		0.600***	0.124***
		(0.048)	(0.016)		(0.044)	(0.012)
$Income^2$		-0.180***			-0.100***	
		(0.016)			(0.012)	
Age	0.252	0.098***	0.063***	0.636***	0.145***	0.072***
	(0.160)	(0.006)	(0.006)	(0.230)	(0.008)	(0.005)
All Working	0.655**	-0.056***		0.507	-0.034	
	(0.293)	(0.019)		(0.786)	(0.022)	
Urban	0.043	-0.085***		0.372	-0.130***	
	(0.267)	(0.014)		(0.719)	(0.019)	
Children	2.775***	-0.060***		2.764***	0.018	
	(0.776)	(0.020)		(0.351)	(0.023)	
Gender	1.144	-0.037*		0.072	-0.026	
	(0.883)	(0.022)		(0.369)	(0.024)	
Education		-0.028*			-0.184***	
		(0.016)			(0.027)	
Social1	-0.062	-0.112***		-0.692	-0.136***	
	(0.372)	(0.020)		(0.796)	(0.024)	
Social2		-0.035**			-0.043**	
		(0.016)			(0.021)	
Single	-3.696***	-0.041		-2.328	-0.053*	
	(0.418)	(0.026)		(3.228)	(0.030)	
Married		0.033*		1.364	0.076***	
		(0.018)		(2.983)	(0.021)	
IHS		0.342***			0.270***	
		(0.015)			(0.011)	
Log Likelihood		-5298.09			-6124.38	

*** significant at 1% level, ** significant at 5% level, * significant at 10% level
Standard errors are given in parentheses.

TABLE 4.5 MAXIMUM LIKELIHOOD ESTIMATES OF IHS HETEROSCEDASTIC INFREQUENCY OF PURCHASE MODEL

	1987			1994		
	Part.	**Exp.**	**Hetero.**	**Part.**	**Exp.**	**Hetero.**
Constant	0.681	0.345***	-0.719***	1.748	0.383***	-0.440***
	(0.538)	(0.051)	(0.032)	(10.727)	(0.075)	(0.040)
Income		0.847***	0.227***		0.590***	0.124***
		(0.048)	(0.015)		(0.043)	(0.013)
Income^2		-0.185***			-0.098***	
		(0.016)			(0.011)	
Age	0.300***	0.102***	0.064***	0.205***	0.149***	0.068***
	(0.062)	(0.006)	(0.006)	(0.081)	(0.008)	(0.006)
All Working	0.501**	-0.053***		0.156	-0.037*	
	(0.257)	(0.019)		(0.479)	(0.023)	
Urban	0.737***	-0.078***		0.289	-0.123***	
	(0.240)	(0.014)		(0.375)	(0.020)	
Children	2.821***	-0.048***		2.746***	0.031	
	(0.367)	(0.019)		(0.311)	(0.026)	
Gender	0.648**	-0.006		0.706	-0.013	
	(0.271)	(0.020)		(0.568)	(0.023)	
Education		-0.093***			-0.184***	
		(0.019)			(0.027)	
Social1	0.124	-0.092***		0.004	-0.135***	
	(0.272)	(0.020)		(0.244)	(0.024)	
Social2		-0.035**			-0.041**	
		(0.016)			(0.021)	
Single	-1.525***	-0.074***		-1.702	-0.079***	
	(0.388)	(0.026)		(10.114)	(0.030)	
Married	0.127	0.051***		1.356	0.083***	
	(0.538)	(0.018)		(9.962)	(0.024)	
IHS		0.337***			0.277***	
		(0.015)			(0.011)	
Log Likelihood		-5286.38			-6120.40	

*** significant at 1% level, ** significant at 5% level, * significant at 10% level
Standard errors are given in parentheses.

TABLE 4.6 MARGINAL EFFECTS FOR IHS HETEROSCEDASTIC TOBIT MODEL

	1987			1994		
	Prob.	**Cond.**	**Uncond.**	**Prob.**	**Cond.**	**Uncond.**
Continuous						
Income$^{\theta}$	0.030***	0.577***	0.030***	0.022***	0.403***	0.409***
	(0.004)	(0.031)	(0.004)	(0.003)	(0.025)	(0.027)
Age	0.003***	0.128***	0.003***	0.006***	0.184***	0.180***
	(0.001)	(0.031)	(0.001)	(0.001)	(0.023)	(0.011)
Discrete						
All Working	-0.008***	-0.050***	-0.059***	-0.004	-0.024	-0.029
	(0.003)	(0.018)	(0.021)	(0.003)	(0.019)	(0.023)
Urban	-0.013***	-0.078***	-0.093***	-0.019***	-0.114***	-0.138***
	(0.000)	(0.013)	(0.015)	(0.000)	(0.016)	(0.020)
Children	-0.009***	-0.051***	-0.061***	0.004	0.025	0.031
	(0.003)	(0.018)	(0.021)	(0003)	(0.020)	(0.024)
Gender	-0.002	-0.014	-0.017	-0.003	-0.016	-0.019
	(0.003)	(0.019)	(0.023)	(0.003)	(0.020)	(0.025)
Education	-0.004*	-0.026**	-0.031**	-0.008***	-0.048***	-0.058***
	(0.003)	(0.015)	(0.018)	(0.003)	(0.019)	(0.023)
Social1	-0.018***	-0.105***	-0.125***	-0.022***	-0.138***	-0.168***
	(0.003)	(0.018)	(0.022)	(0.004)	(0.022)	(0.026)
Social2	-0.006**	-0.034**	-0.040**	-0.006**	-0.034**	-0.041**
	(0.002)	(0.015)	(0.018)	(0.003)	(0.018)	(0.022)
Single	-0.011***	-0.063***	-0.075***	-0.010***	-0.065***	-0.078***
	(0.004)	(0.024)	(0.029)	(0.004)	(0.026)	(0.031)
Married	0.006***	0.038***	0.054***	0.011***	0.068***	0.083***
	(0.003)	(0.016)	(0.019)	(0.003)	(0.019)	(0.023)

*** significant at 1% level, ** significant at 5% level, * significant at 10% level
Standard errors are given in parentheses.
$^{\theta}$The marginal effect of income is calculated including income^2.

TABLE 4.7 MARGINAL EFFECTS FOR IHS HETEROSCEDASTIC DOUBLE-HURDLE MODEL

	1987			1994		
	Prob.	**Cond.**	**Uncond.**	**Prob.**	**Cond.**	**Uncond.**
Continuous						
Income$^{\theta}$	0.042***	0.562***	0.571***	0.026***	0.406***	0.418***
	(0.005)	(0.033)	(0.147)	(0.003)	(0.025)	(0.018)
Age	0.004	0.126***	0.119***	0.006	0.179***	0.173**
	(0.017)	(0.047)	(0.041)	(0.004)	(0.022)	(0.100)
Discrete						
All Working	-0.012***	-0.047***	-0.061***	-0.005*	-0.029*	-0.036*
	(0.004)	(0.016)	(0.021)	(0.003)	(0.019)	(0.023)
Urban	-0.018***	-0.071***	-0.092***	-0.019***	-0.112***	-0.136***
	(0.003)	(0.012)	(0.015)	(0.003)	(0.016)	(0.019)
Children	-0.013***	-0.050***	-0.065***	0.003	0.015	0.019
	(0.004)	(0.016)	(0.021)	(0.003)	(0.020)	(0.024)
Gender	-0.008**	-0.030**	-0.039**	-0.004	-0.022	-0.027
	(0.004)	(0.018)	(0.023)	(0.003)	(0.020)	(0.025)
Education	-0.006**	-0.023*	-0.030**	-0.027***	-0.157***	-0.191***
	(0.003)	(0.014)	(0.018)	(0.004)	(0.023)	(0.028)
Social1	-0.024***	-0.094***	-0.121***	-0.020***	-0.116***	-0.141***
	(0.004)	(0.017)	(0.022)	(0.003)	(0.021)	(0.025)
Social2	-0.007**	-0.029**	-0.038**	-0.006**	-0.037**	-0.045**
	(0.003)	(0.013)	(0.017)	(0.003)	(0.018)	(0.022)
Single	-0.009*	-0.035*	-0.045*	-0.008**	-0.046**	-0.055**
	(0.006)	(0.022)	(0.029)	(0.004)	(0.026)	(0.031)
Married	0.007**	0.028**	0.036**	0.011***	0.065***	0.079***
	(0.004)	(0.033)	(0.019)	(0.003)	(0.018)	(0.022)

*** significant at 1% level, ** significant at 5% level, * significant at 10% level
Standard errors are given in parentheses.
$^{\theta}$The marginal effect of income is calculated including income^2.

TABLE 4.8 MARGINAL EFFECTS FOR IHS HETEROSCEDASTIC INFREQUENCY OF PURCHASE MODEL

	1987			1994		
	Prob.	**Cond.**	**Uncond.**	**Prob.**	**Cond.**	**Uncond.**
Continuous						
Income$^{\theta}$	0.032***	0.573***	0.584***	0.026***	0.401***	0.412***
	(0.004)	(0.055)	(0.033)	(0.003)	(0.034)	(0.028)
Age	0.003***	0.126***	0.123***	0.007***	0.178***	0.176***
	(0.001)	(0.011)	(0.008)	(0.001)	(0.013)	(0.010)
Discrete						
All Working	-0.008***	-0.048***	-0.056***	-0.005*	-0.032*	-0.039*
	(0.003)	(0.017)	(0.020)	(0.003)	(0.020)	(0.024)
Urban	-0.012***	-0.071***	-0.084***	-0.018***	-0.106***	-0.128***
	(0.002)	(0.013)	(0.015)	(0.003)	(0.018)	(0.021)
Children	-0.007***	-0.044***	-0.051***	0.004	0.026	0.032
	(0.003)	(0.018)	(0.021)	(0.004)	(0.022)	(0.027)
Gender	-0.001	-0.006	-0.007	-0.002	-0.011	-0.014
	(0.003)	(0.018)	(0.022)	(0.003)	(0.020)	(0.024)
Education	-0.014***	-0.085***	-0.100***	-0.027***	-0.158***	-0.192***
	(0.003)	(0.018)	(0.021)	(0.004)	(0.024)	(0.028)
Social1	-0.014***	-0.084***	-0.099***	-0.020***	-0.117***	-0.141***
	(0.003)	(0.019)	(0.021)	(0.003)	(0.021)	(0.025)
Social2	-0.005**	-0.032**	-0.038**	-0.006**	-0.035**	-0.043**
	(0.002)	(0.015)	(0.017)	(0.003)	(0.018)	(0.022)
Single	-0.011***	-0.067***	-0.079***	-0.011***	-0.069***	-0.083***
	(0.004)	(0.024)	(0.028)	(0.004)	(0.026)	(0.031)
Married	0.008***	0.046***	0.054***	0.012***	0.072***	0.087***
	(0.003)	(0.016)	(0.019)	(0.003)	(0.021)	(0.025)

*** significant at 1% level, ** significant at 5% level, * significant at 10% level
Standard errors are given in parentheses.
$^{\theta}$The marginal effect of income is calculated including income^2.

TABLE 4.9 ELASTICITY ESTIMATES AND DISCRETE EFFECTS FOR IHS HETEROSCEDASTIC INFREQUENCY OF PURCHASE MODEL

	1987			1994		
	Prob.	**Cond.**	**Uncond.**	**Prob.**	**Cond.**	**Uncond.**
Elasticities						
Income$^{\theta}$	0.032***	0.365***	0.397***	0.033***	0.270***	0.303***
Age	0.016***	0.424***	0.440***	0.039***	0.517***	0.556***
Discrete Effects						
All Working	-0.009***	-0.032***	-0.041***	-0.006*	-0.018*	-0.024*
Urban	-0.012***	-0.049***	-0.061***	-0.019***	-0.061***	-0.080***
Children	-0.004***	-0.034***	-0.038***	0.005	0.015	0.020
Gender	-0.001	-0.004	-0.005	-0.002	-0.006	-0.008
Education	-0.015***	-0.057***	-0.072***	-0.030***	-0.089***	-0.119***
Social 1	-0.015***	-0.056***	-0.071***	-0.022***	-0.066***	-0.088***
Social 2	-0.006**	-0.022**	-0.028**	-0.007**	-0.020**	-0.027**
Single	-0.013***	-0.044***	-0.057***	-0.013***	-0.039***	-0.052***
Married	0.008***	0.031***	0.039***	0.013***	0.041***	0.054***

*** significant at 1% level, ** significant at 5% level, * significant at 10% level
Significance levels are based on the significance of the underlying marginal effects.
$^{\theta}$The marginal effect of income is calculated including income^2.

TABLE 4.10 UNCONDITIONAL INCOME ELASTICITY ESTIMATES EVALUATED AT 1987 SAMPLE MEANS FOR IHS HETEROSCEDASTIC INFREQUENCY OF PURCHASE MODEL

	1987		1994♣
Unconditional Income Elasticity[θ]	0.397***		0.299***
Difference $z = 2.326$ Stat = 21.86[❑]		0.098***	

*** significant at 1% level, ** significant at 5% level, * significant at 10% level
Significance levels are based on the significance of the underlying marginal effects.
[θ]The marginal effect of income is calculated including income[2].
[♣]Evaluated at 1987 mean adjusted to 1994 market prices using the Consumer Price Index (Central Statistics Office, 1988, 1995).
[❑]This test is constructed as follows (Newbold, 1995):

$$H_0 : E_{87} - E_{94} = 0$$

$$\text{Reject } H_0 \text{ if } \frac{E_{87} - E_{94}}{\sqrt{\frac{s_{87}^2}{n_{87}} + \frac{s_{94}^2}{n_{94}}}} > z_\alpha$$

where E_{87} and E_{94} refer to the unconditional elasticities presented in Table 4.10 in 1987 and 1994 respectively, s_{87}^2 and s_{94}^2 refer to the sample variances, and n_{87} and n_{94} refer to the sample sizes.

4B Appendices

Appendix 4A **PROBIT MODELS OF THE DECISION TO PARTICIPATE/PURCHASE MEAT**

Variable	1987	1994
One	1.341***	1.176***
	(0.187)	(0.152)
Age	0.101***	0.111***
	(0.024)	(0.019)
All Working	0.073	0.127*
	(0.092)	(0.019)
Urban	0.024	-0.148**
	(0.077)	(0.069)
Children	0.565***	0.563***
	(0.098)	(0.078)
Gender	0.357***	0.235***
	(0.084)	(0.067)
Education	0.042	-0.122
	(0.086)	(0.076)
Social1	-0.305***	-0.159**
	(0.100)	(0.086)
Social2	-0.116	-0.077
	(0.095)	(0.082)
Single	-0.740***	-0.590***
	(0.110)	(0.088)
Married	0.269***	0.371***
	(0.107)	(0.090)
Log Likelihood	-782.12	-1113.85

*** significant at 1% level, ** significant at 5% level, * significant at 10% level
Standard errors are written in parentheses.
Estimated using the Maxlik procedure in Gauss version 3.5.

EXAMPLES OF GAUSS PROCEDURES

Data Labels

```
Meat=da[.,1]
Constant=da[.,2]
Income=da[.,3]
Income2=da[.,4]
Age=da[.,5]
All-working=da[.,6]
Urban=da[.,7]
Children=da[.,8]
Gender=da[.,9]
Education=da[.,10]
Social1=da[.,11]
Social2=da[.,12]
Single=da[.,13]
Married=da[.,14]
```

Example of Maxlik procedure used to estimate the IHS heteroscedatsic tobit model (Meat Expenditure 1994)

```
proc lpr(b,da);
local  Y,d,X,Z,colsx,colsz,sig,xb,xbs,tbcd,ihs,yt,ext,j;
Y=da[.,1];
d=da[.,1] ./=0;
X=da[.,2 3 4 5 6 7 8 9 10 11 12 13 14];
Z=da[.,2 3 5];
colsx=cols(x);
colsz=cols(z);
Sig=exp(Z*b[colsx+1:colsx+colsz,.]);
xb=x*b[ 1:colsx,.];
xbs=xb./sig;
tbcd=cdfn(xbs);
ihs=b[colsx+colsz+1];
if ihs<0;
retp(error(0));
endif;
yt=(log(ihs.*y+((ihs^2).*(Y^2)+1)^(1/2)))./ihs;
ext=(1+(ihs^2).*(Y^2));
j=((yt-xb)./sig);
retp((1-d).*(log(1-tbcd))+(d).*(-log(sqrt(2*pi))-((j.*j)/2) -log(sig) -(1/2)*log(ext)));
endp;
b1={Starting Values};
__title="IHS Het Tobit Meat 1994";
_max_CovPar=3;
_max_GradTol=1e-5;
{b,f,g,cov,ret}=maxlik(data94,0,&lpr,b1);
call maxprt(b,f,g,cov,ret);
```

Example of Maxlik procedure used to estimate the IHS heteroscedatsic double-hurdle model (Meat Expenditure 1994)

```
proc lpr(b,da87);
local  Y,d,W,X,Z,colsw,colsx,colsz,sig,wb,xb,xbs,tbcd,pbcd,ihs,yt,ext,j,p;
Y=da[.,1];
d=da[.,1] ./=0;
W=da[.,2 5 6 7 8 9 11 13 14];
X=da[.,2 3 4 5 6 7 8 9 10 11 12 13 14];
Z=da[.,2 3 5];
colsw=cols(w);
colsx=cols(x);
colsz=cols(z);
sig=exp(z*b[colsw+colsx+1:colsw+colsx+colsz,.]);
wb=w*b[1:colsw,.];
xb=x*b[colsw+1:colsw+colsx,.];
xbs=xb./sig;
tbcd=cdfn(xbs);
pbcd=cdfn(wb);
ihs=b[colsw+colsx+colsz+1];
if ihs<0;
retp(error(0));
endif;
yt=log(ihs.*Y+((ihs^2).*(Y^2)+1)^(1/2))./IHS;
ext=(1+(ihs^2).*(Y^2));
j=((yt-xb)./sig);
p=1-pbcd.*tbcd;
retp((1-d).*(log(p))+(d).*(log(pbcd)-((j^2)/2)-log(sqrt(2*pi))-log(sig) -(1/2)*log(ext)));
endp;
b1={Starting Values};
__title="IHS Het DH Meat 1994";
_max_CovPar=3;
_max_GradTol=1e-5;
{b,f,g,cov,ret}=maxlik(data94,0,&lpr,b1);
call maxprt(b,f,g,cov,ret);
```

Example of Maxlik procedure used to estimate the IHS heteroscedatsic infrequency of purchase model (Meat Expenditure 1994)

```
proc lpr(b,da);
local  Y,d,R,X,Z,colsr,colsx,colsz,sig,rb,xb,xbs,tbcd,rbcd,ihs,yrt,extr,jr,p;
Y=da[.,1];
d=da[.,1] ./=0;
R=da[.,2 5 6 7 8 9 11 13 14];
X=da[.,2 3 4 5 6 7 8 9 10 11 12 13 14];
Z=da[.,2 3 5];
colsr=cols(r);
colsx=cols(x);
colsz=cols(z);
Sig=exp(z*b[colsr+colsx+1:colsr+colsx+colsz,.]);
rb=r*b[ 1:colsr,. ];
xb=x*b[colsr+1:colsr+colsx,. ];
xbs=xb./sig;
tbcd=cdfn(xbs);
rbcd=cdfn(rb);
ihs=b[ colsr+colsx+colsz+1];
if ihs<0;
retp(error(0));
endif;
yrt=log(ihs*rbcd.*y+((IHS^2)*(rbcd^2).*(Y^2)+1)^(1/2))/IHS;
extr=(1+(ihs^2)*(rbcd^2).*(Y^2));
jr=((yrt-xb)./sig);
p=1-rbcd*tbcd
retp((1-d).*(log(p))+(d).*(2*log(rbcd) -((jr^2)/2)-log(sqrt(2*pi)) -log(sig) -(1/2)*log(extr)));
endp;
b1={Starting Values};
__title="IHS Het IFP Meat 1994";
_max_CovPar=3;
_max_GradTol=1e-5;
{b,f,g,cov,ret}=maxlik(data94,0,&lpr,b1);
call maxprt(b,f,g,cov,ret);
```

Appendix 4C LIKELIHOOD RATIO TESTS OF HOMOSCEDASTICITY RESTRICTION

	H_0=Homoscedastic Error Structure H_1=Heteroscedastic Error Specification	
	Tobit Model	
	1987	**1994**
Test Statistic	482.00	417.19
Critical Value $\chi^2_{2,0.01} = 9.21$	Reject null hypothesis	Reject null hypothesis
	Double Hurdle Model	
	1987	**1994**
Test Statistic	494.08	423.50
Critical Value $\chi^2_{2,0.01} = 9.21$	Reject null hypothesis	Reject null hypothesis
	Infrequency of Purchase Model	
	1987	**1994**
Test Statistic	481.58	468.07
Critical Value $\chi^2_{2,0.01} = 9.21$	Reject null hypothesis	Reject null hypothesis

Appendix 4D LOG LIKELIHOOD VALUES OF STANDARD HETEROSCEDASTIC MODELS V'S IHS HETEROSCEDASTIC MODELS

	Tobit Model	
	1987	**1994**
Standard Hetero. Model	-8035.32	-8933.67
IHS Hetero. Model	-5306.60	-6138.78
	Double Hurdle Model	
	1987	**1994**
Standard Hetero. Model	-8030.98	-8930.60
IHS Hetero. Model	-5298.09	-6127.38
	Infrequency of Purchase Model	
	1987	**1994**
Standard Hetero. Model	-8008.81	-8908.31
IHS Hetero. Model	-5286.38	-6120.40

Appendix 4E **LIKELIHOOD RATIO TESTS OF TOBIT SPECIFICATION**

	1987	1994
	H_0=Tobit Specification **H_1=Double Hurdle Specification**	
Test Statistic	17.02	28.81
Critical Value	$\chi^2_{8,0.05} = 15.51$	$\chi^2_{9,0.01} = 21.67$
	Reject null hypothesis at 5% significance level	Reject null hypothesis

	1987	1994
	H_0=Tobit Specification **H_1=Infrequency of Purchase Specification**	
Test Statistic	40.44	36.76
Critical Value $\chi^2_{9,0.01} = 21.67$	Reject null hypothesis	Reject null hypothesis

Appendix 4F **VUONG'S TEST FOR MODEL SPECIFICATION**

	1987	1994
	H_0=IFP and DH Models are equivalent[*]	
Test Statistic	-3.536	-1.314
Critical Value z = 2.326	Reject null in favour of IFP model	Do not reject null

DH: Double Hurdle Model, IFP: Infrequency of Purchase Model, H_0: Null Hypothesis

[*] See Chapter 2, Section 2.7.

CHAPTER 5

AN ECONOMETRIC ANALYSIS OF IRISH HOUSEHOLD EXPENDITURE ON DISAGGREGATED MEAT EXPENDITURE CATEGORIES

5.1 Introduction

In this chapter, Irish households' expenditure patterns on various meat products are analysed using tobit, double-hurdle and infrequency of purchase models developed in Chapter 2. While in Chapter 4 aggregate meat expenditure patterns were analysed, in this chapter, meat is disaggregated into seven sub-expenditure categories for both 1987/8 and 1994/5 Household Budget Survey datasets. The way in which income and households' differing socio-economic characteristics impact on households' decisions regarding expenditure on these individual meat items is analysed.

In Chapter 1, it was argued that lifestyles increasingly impact on consumers' decisions to consume meat (Bansback, 1995, Bansback *et al.*, 1998, McCarthy *et al.*, 1998). In Chapter 4, Irish households' aggregate meat expenditure patterns are analysed revealing significant differences between the meat expenditure decisions of different household groups. This chapter aims to examine this trend further, by disaggregating meat expenditure and analysing the pattern of expenditure of different household groups on various meat items. The differences in the lifestyles of these household groups, leading to a demand for certain attributes of meat products, will be used to explain their different expenditure patterns. The main hypothesis is that, aside from price and income considerations, certain households demand attributes in meat products that complement their lifestyle choices. In Chapter 4, it is revealed that household characteristics such as the age of the head of household, working status, household location, the presence of children, education level and social status of the head of household and marital status of the adults in the household, all impact on household meat expenditure decisions. The main explanation given for the differences in the expenditure patterns of these household groups is a greater preference for convenience among certain household groups compared with other households leading to these households spending less on meat and more on other convenient alternatives. In this chapter the degree to which this preference impacts on different meat expenditure categories is explored. Another important attribute, proposed in Chapter 1 and Chapter 4, is concern regarding the healthiness of meat and meat products. Due to the diversity of meat products composing the aggregate meat expenditure category this issue could not be addressed in detail in Chapter 4. In this chapter, however, health concerns are given greater consideration as meat is disaggregated into seven sub-expenditure categories each of which can be assigned different degrees of perceived healthiness.

Section 5.2 discusses the specification of the models of meat expenditure considered in this chapter while Section 5.3 deals with the estimation of each of the models in question. The empirical results are analysed in Section 5.4 and Section 5.5 summarises the chapter.

5.2 Specification

In this analysis, meat expenditure is disaggregated into seven categories; beef, lamb, pork, pork products, bacon & ham, chicken and minced meat (see Chapter 3, Section 3.4.1, for a detailed description of these variables). In Chapter 1, Section 1.2.2, the disaggregated meat expenditure categories used in this analysis were described in terms of the attributes of convenience and perceived healthiness they possess.

In terms of convenience, beef, lamb and bacon & ham are considered traditional meat products purchased for consumption in a family-type meal situation. While pork and chicken can be consumed in the same manner, they include more convenient type cuts easier to prepare than the traditional cuts and requiring less time. Pork products can also be viewed in a similar way. While they are an inconvenient breakfast to prepare, they can be quickly prepared as an evening meal centre. Finally, the most convenient meat category is minced meat which is versatile and requires less cooking time than other meat cuts.

With regard to perceived healthiness, chicken is considered the healthiest meat alternative with no distinction made between other red meat cuts. Also important are healthier alternatives to meat such as fish and vegetarianism.

As discussed in Chapter 3, information on the value of household expenditure only is collected and so quantity and quality effects cannot be separately identified.

Furthermore information on meat consumption out of the home cannot be ascertained from the survey.

Each dependent variable is assumed to be expressible as a linear function of income, income squared and a vector of socio-economic variables, assumed to underpin tastes and preferences, listed in Table 5.1 (see Chapter 3, Section 3.4.2, for a detailed description of these variables). The expenditure equations for each type of meat are individually estimated (see Chapter 3, Section 3.4.2). As is the case for aggregate meat expenditure, the tobit, double-hurdle and infrequency of purchase models are applied to each individual meat expenditure equation. All explanatory variables are included as regressors in the tobit model. As discussed in Chapter 4, Section 4.2.2, however, theory provides no guidance as to which explanatory variables to include in the first and second hurdles of the double-hurdle and infrequency of purchase models. If the same set of regressors is included in each hurdle, the model may not identify the parameters of the model correctly and as a result certain exclusion restrictions must be imposed (Jones, 1992, Yen *et al.*, 1996). As with the aggregate meat expenditure model, economic factors, namely income and income squared, are excluded from the first equations of the double-hurdle and infrequency of purchase models. As before, probit models are also estimated for each meat expenditure category in each year (see Appendix 5A). Parameters found to be statistically insignificant in both 1987 and 1994, for a particular meat expenditure category, are also excluded from the first hurdle of both the double-hurdle and infrequency of purchase models (Su and Yen, 1996). Variables included in the first hurdles for each expenditure category are presented in Table 5.2. The variance equation (see Chapter 2, Equation 2.25) is specified as a function of the continuous variables of the model (Yen and Su, 1995, Jensen and Yen, 1996, Su and Yen, 1996).[28]

5.3 Estimation

The tobit, double-hurdle and infrequency of purchase models, with specification adjustments for heteroscedasticity and non-normality, are estimated for each meat expenditure category for each year by maximising the relevant log likelihood function, as detailed in Chapter 2, Section 2.6, using the Maxlik procedure in Gauss version 3.5 (for examples of the procedures used see Chapter 4, Appendix 4B). Likelihood ratio tests reject the restricted model of homoscedasticity in favour of the alternative variance specification in all cases (see Appendix 5B). The significance of the heteroscedasticity parameters also justifies the use of the variance equation (see Tables 5.3 and 5.4). Improved log-likelihood values (see Appendix 5C) and the significance of the θ parameter justifies the use of the IHS specification (see Tables 5.3 and 5.4). The Tobit specification is rejected in all cases in favour of the two alternative models (see Appendix 5D). Finally, Vuong's (1989) non-nested test of model specification, detailed in Chapter 2, Section 2.7, is used to determine, between the double-hurdle and infrequency of purchase models, the most appropriate model for each meat category (see Appendix 5E).

[28] All continuous variables were considered in the original specification of the variance equation. The final specification includes a constant term, Income and Age.

5.4 Empirical Results

The maximum likelihood estimates for the IHS heteroscedastic double-hurdle and infrequency of purchase models for 1987 are presented in Table 5.3 and for 1994 in Table 5.4. Marginal effects and associated standard errors, based on the most appropriate model for each meat category, are calculated as detailed in Chapter 2, Section 2.8. These are presented in Table 5.5 for 1987 and Table 5.6 for 1994.

5.4.1 General Findings

Vuong's (1989) non-nested test for model specification identifies the infrequency of purchase model as the appropriate choice for household expenditure on beef, pork products and chicken. This implies that zero expenditures are better explained by non-purchase than strict non-participation. On the other hand, the double-hurdle model is identified as the appropriate choice for modelling household expenditure on lamb, pork, bacon & ham and minced meat. This implies that a conscious abstention from purchasing these meat items is a more appropriate explanation for zero observations than infrequency of purchase.

Income squared is included in the analysis to capture the possibility of a non-linear relationship between income and meat expenditure. As with aggregate meat expenditure (see Chapter 4, Section 4.6.1), the results confirm the same significant non-linear relationship for all meat categories with a positive coefficient for income and a negative coefficient for income squared (see Tables 5.3 and 5.4). This implies that, at low-income levels, as income increases so too will meat expenditure on each individual meat item, but that as income increases further, the increases in meat expenditure will be at a decreasing rate.

The meat dummy variable included in the analysis attempts to ascertain the degree to which purchases of individual meat items are related to each other. The dummy variable used in this analysis takes a value of one if the household purchases a meat item other than the particular dependent variable, and zero otherwise. As pointed out in Chapter 3, Section 3.4.2, this variable is endogenous in that it will be related to the other economic and socio-economic variables included in the analysis. In order to ascertain the extent to which this could affect the results of the model, each meat dummy variable is regressed on the other explanatory variables in the model using a probit model. The meat dummy variable in the original regression is then replaced with the residuals from this model to assess the degree to which eliminating common endogenous factors and including 'other' factors captured by the residuals impacts on the results of the original model.[29] Comparing the results across the two models reveals few change in the parameters of the model or the log likelihood values (see Appendix 5F). Furthermore, likelihood ratio tests fail to reject the restricted model where endogeneity is not accounted for. This suggests that the endogeneity of the meat dummy variable does not significantly impact on the results of the models and so can justifiably be included in its original form.

The unconditional discrete effect of the meat dummy is positive and significant for all categories with the exception of beef expenditure in 1987 where the effect is negative and insignificant (see Tables 5.7 and 5.8). For all meat categories, the effect on the

[29] The standard tobit specification is used for this purpose.

probability of purchase is positive and significant. This suggests that households either purchase/consume a range of meats or do not purchase/consume any meat products at all. However, the effect of this variable on the conditional level of expenditure is insignificant for chicken and minced meat in 1987 and bacon & ham in 1994, implying that once the decision to participate has been made or a purchase has taken place, the fact that other meat is also being purchased will not affect the level of expenditure on these meat items. For some items, namely beef, lamb and bacon & ham in 1987 and beef, lamb and minced meat in 1994, the effect on the conditional level of expenditure is negative and significant. These results suggest that decisions regarding expenditure on different meat expenditure categories may not be independent of each other and may be more appropriately modelled within a demand system.[30]

5.4.2 Elasticity Estimates and Discrete Effects

Elasticity estimates, calculated at the mean of each variable, and discrete effects, calculated as detailed in Chapter 2, Section 2.8.3, for 1987 and 1994 are presented in Tables 5.7 and 5.8 respectively, based on the most appropriate model for each meat category.

Income

The income elasticities discussed in this section incorporate the non-linear effect of income squared discussed above. The overall income elasticities are positive and significant for all meat categories in both 1987 and 1994, however, the magnitudes of

[30] Since the systems approach has not been extended to incorporate some of the flexible features of the methodologies applied in this thesis, it is not considered in this analysis.

the elasticities are quite small. In 1987 the highest income elasticity is for expenditure on beef at 0.400 with minced meat having the lowest income elasticity at 0.159. Similarly in 1994, the highest income elasticity is for expenditure on beef at 0.393, however, bacon & ham have the lowest income elasticity at 0.129.

Evaluating 1994 elasticities based on 1987 means, adjusted for changes in the money value of income over time, allows an accurate indication of the changing influence of income on individual meat expenditures between the two years (see Table 5.9). In Chapter 4, Section 4.6.1, it was seen that the aggregate meat expenditure level of Irish households is less responsive to changes in household income levels in 1994 compared with 1987. The magnitude of the elasticities associated with individual meat expenditure categories have also declined with the exception of minced meat where the income elasticity has increased between 1987 and 1994. All differences are significant at the 1 per cent level (see Table 5.9). For lamb, pork, pork products and bacon & ham the elasticity has declined by around a half, for chicken by around a third, but for beef the decline is small.

With the exception of minced meat, these results are consistent with the literature on the changing influences on meat demand in Europe and America over the last decade suggesting that the influence of income is declining in importance while other socio-economic factors are having more of an effect on meat expenditure. The increase in the elasticity for minced meat implies that households in 1994 are more responsive to income changes compared with those in 1987 in relation to their expenditure on this meat category. This result is capturing either an increase in the willingness of higher income earners to purchase minced meat at higher income levels, or an increase in their willingness to pay for a higher quality product.

The income elasticities associated with the conditional level of expenditure are positive and significant for all meat categories in each year. The income elasticities associated with the probability of observing a zero expenditure are also positive and significant for all meat categories with the exception of bacon & ham expenditure in 1994. This implies that income not only has a positive effect on the amount of expenditure on the particular meat item but also positively affects the probability of observing a non-zero expenditure on that meat item. The largest of these elasticities is for beef expenditure in both 1987 and 1994 where the elasticity associated with this probability represents approximately one third of the overall unconditional elasticity. In all other cases the proportion of the elasticity attributable to the probability of observing a zero expenditure is relatively very small.

Boyle (1996) estimates expenditure elasticities for four meat expenditure categories, beef, lamb, pigmeat and chicken, using an Almost Ideal Demand System approach based on time series observations between 1974 and 1990. Also presented in that paper are estimates from other similar studies conducted in other countries. Table 5.10 presents the expenditure elasticities presented in that paper alongside the expenditure elasticities estimated in this analysis.

In all cases, the elasticities estimated in this analysis are lower than those referenced in Boyle's (1996) paper. One possible explanation for this is that in this thesis, income elasticity estimates account for the non-linear relationship between income and meat expenditure by including the marginal effect of income squared in the calculation of the elasticity. Table 5.11 illustrates the degree to which income squared reduces the magnitude of the elasticity for each meat category. In general, however, income elasticity estimates based on cross-sectional data will be lower in magnitude than time series estimates. The main reason for this is that in cross-sectional analyses of this kind, socio-economic effects are distinguished from income effects. Time series demand analyses often do not include socio-economic effects and therefore income elasticities can be overstated since not only are they capturing the relationship between income and expenditure but they are also taking account of additional socio-economic effects which are often positively collinear with income. This emphasises the advantage of estimating expenditure elasticities using cross-sectional data compared with time series data.

Age

The ordinal nature of the age variable implies that elasticities associated with it cannot be interpreted in the same way as other continuous variables (see Chapter 3, Section 3.4.2). In Chapter 4, Section 4.6.2, age was seen to have a positive and significant effect on aggregate meat expenditure. This result is also observed for expenditure on beef, lamb[31], pork, pork products, bacon & ham and chicken in each year.

For beef, lamb and bacon & ham in both years, and pork and pork products in 1994 the effects of age on the probability of purchase/participation and conditional level of expenditure are also positive. For pork expenditure in 1987, the age elasticity associated

[31] The positive effect of age on lamb expenditure was also identified by the Meat and Livestock Commission (2001) who identified that the 45+ age group purchase 70% of total lamb sales.

with the probability of participating in the pork market is significant and negative. For chicken expenditure in both years and pork products in 1987, the overall positive effect is attributable to the effect on the conditional level of expenditure with the effect on the probability of participation/purchase being insignificant in each case. Age has a significant negative effect on minced meat expenditure in both years, despite the fact that the effect on the conditional level of expenditure is significantly positive in both years. This implies that the older the head of household the less likely they are to participate in the minced meat market leading to age having an overall negative effect on this meat category.

In general, given the datasets, it is not possible to decipher whether the overall positive effect of age on beef, lamb, pork, pork products, bacon & ham and chicken is attributable to older households purchasing a greater physical quantity of these goods than younger headed households, or to older households paying more for higher quality products. Two possible explanations for this result are proposed Chapter 4, Section 4.6.2. Firstly, a possible explanation is that younger generations have a preference for a more convenient lifestyle and so relative to older households purchase less meat. The disaggregated analysis reveals this to be the case for all meat expenditure categories with the exception of a more conveniently prepared cut of meat, minced meat. The second possible explanation suggests that younger headed households perceive meat to be less healthy than other products. The Meat and Livestock Commission (2001) identified that younger consumers purchase significantly less red meat than older generations. However, in this analysis the results do not suggest a preference for white over red meats or even traditional over non-traditional cuts of meat, so the former explanation is more plausible. Furthermore, in 1994, the correlation between age and expenditure on prepared consumer foods is –0.218. In a similar light, the correlation between age and expenditure on food consumed away from home is –0.230. Both of these figures suggest that age is negatively related to expenditure on convenient alternatives to meat providing evidence of the preference for convenience among younger generations. Importantly, the fact that the elasticity has increased between 1987 and 1994 for more traditional cuts of meat, beef, lamb, pork, pork products, bacon & ham, suggests that the gap between the older and younger generations in terms of their preferences for meat is widening, as was the case for aggregate meat expenditure (see Chapter 4, Section 4.6.2)

All-Working Households

The first discrete variable captures the effect of an all-working household compared with a household where at least one adult does not have a job. Generally, the overall effect of all-working households is negative but is only significant for bacon & ham, chicken and minced meat in both years and pork and pork products in 1987. This significant negative effect is driven by the negative effect of all working household on the probability of participation/purchase of these meat items. Even though the effect of this variable on the unconditional level of expenditure on pork in 1994 is insignificant, it has a significant negative effect on the probability of participation in this year. These results suggests that all working households purchase less of these meat items suggesting that cooking meat in the home is less of a preference for all-working households, compared to households where at least one adult member remains in the home.

In Chapter 4, Section 4.6.3, it was observed that all working households had a negative effect on aggregate meat expenditure in both 1987 and 1994. This effect was attributed to the time constraints imposed by all adult members working leading to all-working households having a stronger preference for convenience in the preparation of food than other households, resulting in the purchase of less meat. The negative results observed in this analysis, reveal that the negative relationship between this variable and aggregate meat expenditure is attributable to expenditures on bacon & ham, chicken and minced meat. Since this result does not suggest a preference for more convenient cuts of meat among all-working households, such as chicken and minced meat, it is likely that all-working households substitute eating out of home for all types of home-cooking. This possibility is explored in more detail in Chapter 6.

Significant effects are also observed on the probability of participation/purchase and conditional levels of expenditure on beef in both years despite the fact that the overall effect of this variable is insignificant in each case. In both years, all working households are more likely to purchase beef than other households, but conditional on purchase, spend less on average than other households. Due to the fact that beef expenditure is modelled using an infrequency of purchase model, this positive effect on the probability of purchasing beef suggests that all working households purchase beef more frequently than the base household type. Either all-working households eat beef more often or they shop more regularly than other households. Given that the effect on the conditional level of expenditure is negative, the latter hypothesis is more plausible.

Urban

The effect that living in urban areas has on meat expenditure is consistent across both years. In both years, urban households spend significantly less on beef, lamb, pork products and bacon & ham and significantly more on pork and minced meat than rural households. The effect on the unconditional level of chicken expenditure is insignificant in 1994 but significant and positive in 1987. Chapter 4, Section 4.6.4, revealed that urban households spend less on aggregate meat expenditure than rural households. It was suggested that the significant difference between meat expenditure of urban and rural households could be due to a difference in the lifestyles of urban and rural dwellers in terms of the amount of time available or willingly given to preparing home cooked meals, due to such factors as urban dwellers facing greater time constraints in commuting to and from work, due to traffic congestion or urban dwellers having more opportunity to eat out of home. The results observed in this analysis add weight to this argument with urban households spending more than rural households on what could be described as conveniently prepared cuts of meat, like pork, minced meat, and chicken in 1987, and less on other traditional cuts of meat, re-enforcing the argument that urban households have a greater preference for time-saving while cooking than their rural counterparts.

The difference between the expenditure patterns of urban and rural dwellers with regard to aggregate meat expenditure was seen to be increasing over time in Chapter 4, Section 4.6.4. Examination of the disaggregated meat expenditure results reveals that this divergence in expenditure patterns of urban and rural households is attributable to household expenditure on beef and pork products. For all other meat expenditure categories the magnitude of the effect has declined between 1987 and 1994. The declining magnitudes could be attributed to a number of factors such as greater supermarket penetration of rural areas making more frequent purchase a possibility for rural dwellers or the growth in the number of commuters living in rural areas leading to a convergence in households' preferences and habits. Nevertheless, as the aggregate meat expenditure analysis and the results for the beef and pork products categories in this analysis show, there is still a distinct difference in the expenditure decisions of urban and rural households, a difference which is diverging over time.

In most cases, the urban effect is the same on the probability of participation/purchase and conditional level of expenditure as the overall effect. There are, however, some exceptions. Urban households are more likely to purchase beef in 1987 and chicken in both years than rural households. However, conditional on purchasing these meat items, they spend on average less than rural households. For both of the these meat expenditure equations the overall negative effect is driven by the effect on the conditional level of expenditure, that is of all households that purchased beef in 1987 and chicken in both years, urban households spend on average less than rural households. The positive effect on the probability of purchase is not surprising considering both of these meat expenditure categories are modelled using an infrequency of purchase model. This implies that the positive effect of the urban variable on the probability of purchase is due to the fact that urban households shop more frequently than their rural counterparts, perhaps due to the close proximity of urban dwellers to retail outlets. The negative effects observed on the conditional level of expenditure are consistent with the conclusions drawn above.

Children

The overall effect of the presence of children is similar in both 1987 and 1994. A significant negative effect is observed for pork products in both years. This result is surprising since sausages in particular are considered the most suitable cut of meat for children (Meat and Livestock Commission, 1988, 1992). Significant negative results are also observed for beef and lamb in 1987, while a significant positive effect is observed for unconditional expenditure on pork and minced meat in both years. In 1994, however, preferences of households with children can be more clearly identified through analysing the effect on the probability of participation/purchase and the effect on the conditional level of expenditure. Households with children are more likely to purchase all meat items than households without, indicating more of a preference for home cooked meals with a meat meal centre by these households. At the same time, participating households with children spend less per capita on meat than households without. This implies that either participating households with children purchase less physical quantity per capita of individual meat items than households without, despite the imposition of adult equivalence adjustments, or they purchase cheaper cuts. Considering the physical nutritional requirements of children are less than that of an adult, the former explanation seems more plausible.

Contrary to the results observed in this disaggregated analysis of households meat expenditure, the results observed for aggregate meat expenditure, discussed in Chapter 4, Section 4.6.5, reveal no significant difference in the aggregate meat expenditure decisions of households with children and households without, in 1994. This emphasises the benefit of disaggregating food items, composed of a number of different categories in terms of the nature and quality of the products and the attributes they offer the end consumer, in expenditure analyses of this kind.

Gender

In Chapter 4, Section 4.6.6 the gender of the head of household was seen to have an insignificant effect on household aggregate meat expenditure. In this disaggregated analysis of meat expenditure patterns, gender is a significant explanatory factor for a number of meat categories in both years. In 1987, a significant negative overall effect is observed on unconditional household expenditure on pork products and bacon & ham, while in 1994 a significant negative effect is observed on unconditional household expenditure on beef, pork, pork products and bacon & ham. Female-headed households have a significant positive effect on overall expenditure on chicken and minced meat in both years. These effects are equally distributed among the probability of purchase and the conditional level of expenditure in each case. Burton *et al.* (1996) found a negative relationship between female-headed households and household aggregate meat expenditure in the UK. In this case the negative effect is related to the more traditional cuts of meat, like beef, pork products and bacon & ham, while positive effects are observed for chicken and minced meat.

In Chapter 3, Section 3.4.2, it was noted that female-headed households are not traditional family-type households. Controlling for other factors, gender alone significantly affects disaggregated meat expenditure patterns. There are two possible explanations for these results. Firstly, it is possible the females in general are more health conscious than males and so purchase less red meat, like beef and more white meats like chicken. They also purchase less pork products which particularly suffer from a poor health image (Meat and Livestock Commission, 1993). On the other hand, since female-headed households are less family-type households, they may also have less of a preference for family-type meals and so place more emphasis on convenience. This may explain the positive result for minced meat and the negative result for traditional cuts of meat. However, since male-headed households spend on average £0.81 more than female-headed households on food consumed away from home in 1994, the former explanation is more plausible.

Education

As with aggregate meat expenditure, the effect the education level of the household head has on meat expenditure is similar in both 1987 and 1994. In both years, the education level of the household head has a significant negative effect on the unconditional level of expenditure on pork products and bacon & ham, and a significant positive effect on lamb. In 1994, a significant negative effect is observed for minced meat expenditure. In both years, the effect on the probability of purchase is positive for beef and lamb but for other categories, where significant, is negative. As with Burton *et al.* (1996) in the UK, a negative relationship was found between the education level of the head of household and household expenditure on aggregate meat (see Chapter 4, Section 4.6.7). One possible explanation given for this result was that at higher levels of education, individuals are more health conscious and so perceive meat in general to have certain health implications, an attitude reflected in meat purchasing decisions. In this analysis, a negative effect is observed for most individual meat categories with the exception of beef and lamb. A possible explanation may be that educated households spend more on higher quality cuts of beef and lamb than other households, for example Sunday roasts etc. This could be attributed to a 'snob effect' whereby despite an overall negative attitude toward meat, the meat consumed by educated households are most likely to be higher quality traditional cuts of meat compared with other less educated households who purchase more of all other types of meat.

Social Status

The social status of the head of household has a similar effect on households' meat expenditure patterns as the education level of the head of household. In 1987, professional households spend significantly less on pork products and bacon & ham and significantly more on beef and lamb, than the base category, manual and agricultural workers and farmers. Households of an intermediate social status follow the same pattern but have an insignificant overall effect on beef, spend significantly more on pork and less on minced meat than the base category. In the same year, intermediate households have a greater probability of purchasing pork than the base category while both professional households and intermediate households have a greater probability of purchasing beef, lamb and chicken than the base category. The effect of these variables on the probability of purchasing all other meat items is negative. The effect of social status on the conditional level of expenditure, where significant, is negative. That is, conditional on purchase, households of a professional or intermediate social status spend significantly less on almost all meat items than the base category. The pattern observed here is similar to that of the education variable with negative effects on most meat categories with the exception of beef, lamb and to some extent pork where some positive effects are observed.

In 1994, the negative relationship between social status and meat expenditure is more obvious. Overall, professional households spent significantly less on lamb, pork products, bacon & ham, chicken and minced meat and significantly more on beef than the base category, manual and agricultural workers and farmers, with no significant effect on expenditure on pork. Households of an intermediate social status, salaried employees and other non-manual workers, differ from the base category in expenditure on beef and pork, where the effect is positive, and on bacon & ham, where the effect is negative, as with the higher professional group. The probability of purchasing beef is higher for both professional and intermediate households compared with the base category, while the probability of purchasing lamb and pork is higher for the intermediate group only. The effect of social status on the probability of purchasing all other meat items where significant is negative.

There are two possible explanations for the results observed for the social status variables. As is the case for educated households, these results could reflect a negative perception of meat products in general among households of a professional and intermediate social status, with exceptions for beef and in some cases lamb and pork. The latter results most likely reflect a 'snob' related preference for higher quality traditional cuts of meat compared with other households. Tomlinson (1994) identifies distinct differences in the food preferences of households of different social status. Consistent with the positive effect of social status on beef observed in this analysis, he also concludes that the 'bourgeoisie', or professional social class have a preference for beef compared to working class groups.

An alternative explanation, as suggested in Chapter 4, Section 4.6.7, could be that professional households face greater time constraints and therefore have a greater preference for time-saving in meal preparation. As a result they purchase less meat in general and substitute eating out of home for preparing home cooked meals. In 1994, manual and agricultural workers, and farmers, the base social status category, spend 75 per cent less than professional households on food consumed out of home, suggesting that this explanation is also a strong possibility. This result is also consistent with Tomlinson's (1994) findings, who identifies a preference for restaurant food and take-aways among the bourgeoisie compared with the working class. The results observed in this analysis, therefore, are most likely explained with a combination of the two explanations given here. Firstly, households of a higher social status face greater time constraints and therefore substitute eating out of home, in the form of take-aways and restaurant meals, for home-cooked meals to a greater extent than other households, and therefore spend less on meat in general. However, they also have a 'bourgeoisie' preference, reflected in their preference for restaurant meals and for traditional meat meal centres when cooking in the home, and therefore spend more on beef and lamb than other household groups.

Marital Status

The overall effect of single adult households, relative to the base category which is households containing two or more unmarried adults, is negative and significant for lamb, pork and bacon & ham in both years and is positive and significant for pork products in 1994. As with overall meat expenditure (see Chapter 4, Section 4.6.8) the effect of single adult households on individual meat expenditure categories changed very little between 1987 and 1994. Single adult households are less likely to purchase all meat categories than the base category. Similar to the effect on the aggregate meat category described in Chapter 4, Section 4.6.8, this could be attributed to the fact that single adult households have less of an incentive to cook meat centred home cooked meals for one person compared to other households who have more than one adult to cook for. This point is reinforced by the fact that, in 1994, for each meat market with the exception of beef, non-participating single adult households spend substantially more on food consumed out of home than participating single adult households (see Table 5.12). On the other hand, conditional on purchase, single adult households spend more on all meat categories than other participating households. Since all expenditures are adjusted to adult equivalent levels, a possible explanation for the positive effect of participating single adult households on meat expenditure, could be that since these households are purchasing meat for one household member they are more willing to pay for higher quality products.

In the case of single adult households, an interesting observation is that there are two types of meat purchasing single adult households: traditional meat purchasers and more convenient meat purchasers. Table 5.13 illustrates distinct differences in some of the other socio-economic characteristics of participating compared with non-participating single adult households in 1994. Purchasers of beef, lamb, pork products and bacon & ham are distinct from those who purchase pork, chicken and minced meat. Single adult participators in the former categories are older on average than single adult non-participators. Fewer live in urban areas and fewer have children (with the exception of pork products). On the other hand, single adult households who purchase pork, chicken and minced meat, are younger on average than non-participators, are more likely to live in urban areas and a greater number have children.

Chapter 4, Section 4.6.8 revealed a positive effect of married households on aggregate meat expenditure compared to the base category. For the individual meat categories, married households have a positive effect on the unconditional level of expenditure on lamb, chicken and minced meat in both years and beef in 1994, and a significant negative effect on bacon & ham in 1987. A positive effect is observed on the probability of purchasing beef, lamb, chicken and minced meat and on expenditure on minced meat conditional on purchase in both years. There are very few significant differences in the conditional level of expenditure of these households on individual meat items and so the effect on the probability of purchase drives the overall positive effects. This would suggest that married households purchase more meat than the base category as opposed to paying a higher price for higher quality products. As suggested in Chapter 4, Section 4.6.8, this result could be explained by the fact that married households place more value on the family eating occasion and hence cook a greater amount of home-cooked meals than other households and therefore purchase a greater quantity of certain individual meat items.

5.5 Summary and Conclusions

In this chapter tobit, double-hurdle and infrequency of purchase models, adjusted for heteroscedasticity and non-normality, are applied to Irish households' disaggregated meat expenditure patterns. The tobit model is rejected in all cases and Vuong's (1989) non-nested test of model specification is used to choose between the double-hurdle and infrequency of purchase models as to the appropriate model choice for each individual meat expenditure category.

Income elasticities associated with individual meat expenditure categories are low in magnitude, particularly compared with estimates for similar meat categories reported in the literature (Boyle, 1996). This is mainly attributed to the fact that in cross-sectional demand analyses, compared with demand studies based on time series data, socio-economic factors are taken into account reducing the magnitudes of the income effects. Furthermore, in this analysis the inclusion of the income squared term also reduces the magnitude of the income elasticities. As with aggregate meat expenditure, between 1987 and 1994 the magnitude of the income elasticity, evaluated at constant income levels, has declined for each meat expenditure category with the exception of minced meat. Because at the same time average income levels have increased, this combined with the observed non-linear relationship between income and expenditure provides evidence that meat expenditure decisions are influenced to a lesser degree by income at higher income levels.

The socio-economic variables included in this analysis attempt to capture significant differences in different household groups in terms of the attributes of meat products they demand, as discussed in Section 5.1. In this chapter, as with Chapter 4, it was argued that both convenience and perceived healthiness can be given as valid explanations for observed differences in expenditure patterns. Younger headed households, urban households and single adult households all exhibit preferences for convenience in home-cooking activities. This is deduced from the fact that these household groups spend less on traditional cuts of meat and more on the more conveniently prepared, time-saving meats compared with other households. For younger headed households and urban households this preference could be attributed to differences in lifestyles in terms of the pace of life they lead compared with other households. For single adult households this can be attributed to the fact that these household groups are not typical family-type households and so are less likely to engage in family meal eating occasions with traditional meat meal centres than other households are. On the other hand, they are more likely to purchase more convenient cuts which better suit their non-family oriented eating activities.

Female-headed households spend less on red meats, like beef, and more on white meats, like chicken, than male-headed households. It is therefore suggested that female-headed households are more health conscious than male-headed households and this is reflected in their meat expenditure patterns.

All working households have a negative relationship with meat expenditure. This negative effect is observed on all meat expenditure categories, convenient or otherwise, indicating that all-working households have a preference against cooking all types of meat in the home when compared with other households.

The results for the education and social status variables can be explained with a combination of preferences; a preference for convenience combined with a 'snob' or 'bourgeoisie' preference. While educated households and households of a professional social status face greater time constraints than other households, and therefore have a greater preference for time-saving while cooking, they also choose traditional rather than convenient cuts of meat when choosing to cook in the home as the perceive them to be of better quality or more in keeping with their social standards.

Finally, households with children and married households are more likely to purchase meat items than all other households indicating a greater preference for the family meal-eating occasion, with a traditional meat meal centre compared with other households.

It is difficult to correctly deduce the reasons for the observed expenditure patterns of different household groups without specific data on the attitudes of individual households. This is particularly the case when making deductions about different degrees of health consciousness of different households. Households' preferences for convenience, however, can be explored through analysing their expenditure patterns on convenient alternatives to meat. In Chapter 6, household expenditure on prepared meals is analysed in an attempt to determine the socio-economic household groups exhibiting this preference for convenience in the home.

5A Tables

TABLE 5.1 EXPLANATORY VARIABLES IN EXPENDITURE EQUATIONS

Income
$Income^2$
Age
All-working
Urban
Children
Gender
Education
Social Status
Marital Status
Meat Dummy

TABLE 5.2 EXPLANATORY VARIABLES IN PROBIT PARTICIPATION/PURCHASE EQUATIONS

Beef	Lamb	Pork	Pork Products	Bacon & Ham	Chicken	Mince
Age	Age	Age	Age	Age	All-working	Age
All-working	Urban	All-working	All-working	All-working	Urban	All-working
Urban	Children	Urban	Urban	Urban	Children	Urban
Children	Gender	Children	Children	Children	Gender	Children
Education	Education	Gender	Gender	Gender	Education	Gender
Social Status	Social Status	Social Status	Education	Education	Social Status	Education
Marital Status	Marital Status	Single adult	Social1	Social Status	Single adult	Marital Status
Meat Dummy	Meat Dummy	Meat Dummy	Marital Status	Single adult	Meat Dummy	Meat Dummy
			Meat Dummy	Meat Dummy		

TABLE 5.3 MAXIMUM LIKELIHOOD ESTIMATES OF IHS HETEROSCEDASTIC DOUBLE-HURDLE AND INFREQUENCY OF PURCHASE MODELS 1987

	Beef (IFP)			Lamb (DH)			Pork (DH)			Pork Products (IFP)		
	Part	**Exp**	**Hetero**	**Part**	**Exp**	**Hetero**	**Part**	**Exp**	**Hetero**	**Part**	**Exp**	**Hetero**
One	-1.310***	-0.068**	-2.082***	-1.431***	0.249***	-1.366***	-1.124***	0.099***	-1.527***	0.080	0.090***	-1.912***
Income		0.111***	0.002		0.197***	0.076***		0.197***	0.094***		0.093***	0.120***
Income^2		-0.019***			-0.034***			-0.045***			-0.019***	
Age	0.018	0.015***	0.040***	0.087***	0.023***	0.048***	-0.036***	0.018***	0.059***	0.113***	0.018***	0.074***
All Work	0.073*	0.006			-0.013		-0.147***	-0.008		-0.062	-0.10*	
Urban	0.156***	-0.016***		-0.053	-0.067***		0.484***	-0.026***		0.216***	-0.013***	
Children	0.094***	-0.023***		0.021	-0.080***		0.346***	-0.068***		3.332***	-0.009*	
Gender		-0.005		0.105**	-0.013		0.045	-0.022**		0.192**	-0.018*	
Education	0.116***	-0.003		0.222***	-0.003		0.057	-0.015**		-0.018	-0.019***	
Social1	0.143***	0.018***		0.164***	-0.019		0.060	-0.010		-0.024	-0.038***	
Social2	0.153***	0.008		0.136***	-0.008		0.149***	-0.001			-0.009*	
Single	-0.290***	-0.008		-0.317***	0.038**		-0.450***	0.050***		-0.658***	0.005	
Married	0.060*	0.006		0.141***	-0.006			-0.004		0.316*	-0.002	
Meat Dummy	0.710***	0.073***		0.675***	-0.092**		1.043***	0.049*		0.582***	0.079***	
IHS		2.441***			1.334***			1.199***			1.416***	
Log Likelihood		-2407.41			-2627.58			-2501.46			-1855.92	

*** significant at 1% level, ** significant at 5% level, * significant at 10% level

For space reasons standard errors are reported in Appendix 5G.

TABLE 5.3 (CONTINUED) **MAXIMUM LIKELIHOOD ESTIMATES OF IHS HETEROSCEDASTIC DOUBLE-HURDLE AND INFREQUENCY OF PURCHASE MODELS 1987**

	Bacon & Ham (DH)			Chicken (IFP)			Minced Meat (DH)		
	Part	**Exp**	**Hetero**	**Part**	**Exp**	**Hetero**	**Part**	**Exp**	**Hetero**
One	-0.698***	0.353***	-1.742***	-0.270***	-0.061**	-1.614***	-0.768***	0.098***	-2.129***
Income		0.175***	0.152***		0.163***	0.143***		0.040***	0.093***
Income^2		-0.045***			-0.027***			-0.006*	
Age	0.125***	0.017***	0.084***		0.020***	0.063***	-0.119***	0.007***	0.039***
All Work	-0.100*	-0.012		-0.093**	-0.020**		-0.179***	0.015***	
Urban	-0.412***	-0.065***		0.197***	0.004		0.477***	0.013***	
Children	0.431***	-0.111***		0.437***	-0.018**		0.618***	-0.026***	
Gender	-0.147***	-0.053***		0.100**	0.026***		0.172***	0.012**	
Education	-0.074	-0.009		0.023	0.003		-0.040	-0.002	
Social1	-0.141**	-0.059***		0.153***	-0.013*			-0.000	
Social2	-0.087	-0.030***		0.092**	-0.005			-0.007	
Single	-0.544***	0.069***		-0.461***	0.010		-0.337***	0.043***	
Married		-0.040***		0.074*	0.017**		0.129***	0.014***	
Meat Dummy	0.707***	-0.079***		0.589***	0.165***		0.719***	0.003	
IHS		1.200***			0.857***			2.213***	
Log Likelihood		-2596.14			-2864.74			-1486.21	

*** significant at 1% level, ** significant at 5% level, * significant at 10% level

For space reasons standard errors are reported in Appendix 5G.

TABLE 5.4 MAXIMUM LIKELIHOOD ESTIMATES OF IHS HETEROSCEDASTIC DOUBLE-HURDLE AND INFREQUENCY OF PURCHASE MODELS 1994

	Beef (IFP)			Lamb (DH)			Pork (DH)			Pork Products (IFP)		
	Part	**Exp**	**Hetero**	**Part**	**Exp**	**Hetero**	**Part**	**Exp**	**Hetero**	**Part**	**Exp**	**Hetero**
One	-1.278***	-0.151***	-1.961***	-1.712***	0.235***	-1.335***	-1.256***	0.166***	-1.452***	0.239	0.077***	-1.646***
Income		0.104***	0.060***		0.081***	0.064***		0.083***	0.052**		0.062***	0.062***
$Income^2$		-0.013***			-0.011**			-0.012***			-0.009***	
Age	0.042***	0.027***	0.057***	0.111***	0.033***	0.036***	0.026**	0.016***	0.051***	0.066***	0.024***	0.069***
All Work	0.069*	0.006			0.004		-0.121***	0.017**		-0.131	-0.002	
Urban	0.090***	-0.025***		0.010	-0.073***		0.307***	-0.051***		0.097	-0.022***	
Children	0.292***	-0.000		0.217***	-0.072***		0.345***	-0.054***		1.790***	-0.010	
Gender		-0.012*		0.089*	-0.022*		-0.054	-0.018*		-0.001	-0.026***	
Education	0.095***	-0.000		0.063	0.017		0.013	-0.008		-0.108	-0.030***	
Social1	0.158***	0.014*		-0.004	-0.024**		0.077*	-0.012		0.047	-0.042***	
Social2	0.124***	0.016**		0.093*	-0.024**		0.155***	0.002			-0.007	
Single	-0.186***	0.006		-0.329***	0.037**		-0.442***	0.051***		-0.572***	0.016*	
Married	0.114***	0.018***		0.172***	-0.006			-0.009		0.071	-0.006	
Meat Dummy	0.570***	0.102***		0.947***	-0.065		0.892***	0.063**		0.656***	0.117***	
IHS		1.735***			1.359***			1.265***			1.116***	
Log Likelihood		-2740.55			-2822.58			-2681.55			-2475.87	

*** significant at 1% level, ** significant at 5% level, * significant at 10% level
For space reasons standard errors are reported in Appendix 5G.

TABLE 5.4 (CONTINUED) **MAXIMUM LIKELIHOOD ESTIMATES OF IHS HETEROSCEDATIC DOUBLE-HURDLE AND INFREQUENCY OF PURCHASE MODELS 1994**

	Bacon & Ham (DH)			Chicken (IFP)			Minced Meat (DH)		
	Part	**Exp**	**Hetero**	**Part**	**Exp**	**Hetero**	**Part**	**Exp**	**Hetero**
One	-0.924***	0.253***	-1.453***	0.107	-0.070**	-1.033***	-0.690***	0.163***	-2.014***
Income		0.068***	0.103***		0.191***	0.088***		0.050***	0.096***
$Income^2$		-0.014**			-0.028***			-0.008***	
Age	0.129***	0.035***	0.063***		0.029***	0.051***	-0.104***	0.008***	0.041***
All Work	-0.155***	0.008		-0.078*	-0.033***		-0.181***	0.009	
Urban	-0.293***	-0.062***		0.178***	0.012		0.212***	-0.001	
Children	0.358***	-0.111***		0.843***	0.001		0.494***	-0.025***	
Gender	-0.142***	-0.015		0.241***	0.041***		0.179***	0.003	
Education	-0.105**	-0.007		0.032	0.007		-0.090**	0.003	
Social1	-0.182***	-0.065***		0.164***	-0.026**			-0.005	
Social2	-0.059	-0.046***		0.069	-0.006			0.002	
Single	-0.516***	0.079***		-0.601***	0.008		-0.350***	0.070***	
Married		-0.011		0.315***	0.041***		0.095**	0.004	
Meat Dummy	0.637***	0.020		0.508***	0.216***		0.617***	-0.034	
IHS		0.998***			0.547***			1.935***	
Log Likelihood		-2782.48			-3590.13			-1797.31	

*** significant at 1% level, ** significant at 5% level, * significant at 10% level
For space reasons standard errors are reported in Appendix 5G.

TABLE 5.5 MARGINAL EFFECTS FOR IHS HETEROSCEDASTIC DOUBLE-HURDLE AND INFREQUENCY OF PURCHASE MODELS 1987

	Beef (IFP)			Lamb (DH)			Pork (DH)			Pork Products (IFP)		
	Prob.	**Cond.**	**Uncond.**	**Prob.**	**Cond.**	**Uncond.**	**Prob.**	**Cond.**	**Uncond.**	**Prob.**	**Cond.**	**Uncond.**
Continuous												
Income$^{\theta}$	0.051***	0.140***	0.072***	0.036***	0.135***	0.065***	0.038***	0.112***	0.069***	0.020***	0.069***	0.068***
Age	0.012***	0.032***	0.016***	0.030***	0.036***	0.027***	-0.012***	0.030***	0.009***	-0.002	0.029***	0.025***
Discrete												
All Working	0.027**	-0.026*	0.005	-0.004	-0.011	-0.006	-0.052***	-0.006	-0.025***	-0.008**	-0.008**	-0.010**
Urban	0.038***	-0.110***	-0.016***	-0.039***	-0.054***	-0.038***	0.146***	-0.020***	0.054***	-0.010***	-0.010***	-0.013***
Children	0.014	-0.090***	-0.022***	-0.019*	-0.064***	-0.032***	0.082***	-0.051***	0.012*	-0.003	-0.009**	-0.009**
Gender	-0.004	-0.010	-0.005	0.029**	-0.011	0.011	0.005	-0.017**	-0.005	-0.015***	-0.015***	-0.019***
Education	0.035***	-0.064***	-0.003	0.070***	-0.003	0.033***	0.012	-0.011**	-0.007	-0.016***	-0.015***	-0.019***
Social1	0.057***	-0.040**	0.017***	0.047***	-0.015*	0.017**	0.015	-0.007	0.006	-0.033***	-0.031***	-0.039***
Social2	0.054***	-0.063***	0.008	0.041***	-0.006	0.018**	0.048***	-0.001	0.021***	-0.008**	-0.007**	-0.009**
Single	-0.097***	0.133***	-0.007	-0.090***	0.030**	-0.033***	-0.125***	0.037***	-0.037***	0.003	0.004	0.005
Married	0.023**	-0.020	0.005	0.043***	-0.005	0.019**	-0.002	-0.003	-0.002	-0.001	-0.002	-0.002
Meat Dummy	0.273***	-0.226***	0.069***	0.187***	-0.073**	0.065***	0.363***	0.037*	0.175***	0.068***	0.064***	0.081***

*** significant at 1% level, ** significant at 5% level, * significant at 10% level

For space reasons standard errors are reported in Appendix 5H.

$^{\theta}$The marginal effect of income is calculated including income^2.

TABLE 5.5 (CONTINUED) **MARGINAL EFFECTS FOR IHS HETEROSCEDASTIC DOUBLE-HURDLE AND INFREQUENCY OF PURCHASE MODELS 1987**

	Bacon & Ham (DH)			**Chicken (IFP)**			**Minced Meat (DH)**		
	Prob.	**Cond.**	**Uncond.**	**Prob.**	**Cond.**	**Uncond.**	**Prob.**	**Cond.**	**Uncond.**
Continuous									
Income$^{\theta}$	0.020***	0.110***	0.067***	0.039***	0.150***	0.118***	0.008**	0.035***	0.017***
Age	0.036***	0.036***	0.034***	0.000	0.039***	0.025***	-0.042***	0.011***	-0.005***
Discrete									
All Working	-0.038**	-0.009	-0.021***	-0.036***	0.001	-0.019***	-0.052***	0.012***	-0.007*
Urban	-0.164***	-0.050***	-0.097***	0.055***	-0.038***	0.006	0.174***	0.010***	0.045***
Children	0.084***	-0.085***	-0.008	0.105***	-0.111***	-0.012*	0.197***	-0.021***	0.037***
Gender	-0.073***	-0.041***	-0.053***	0.041***	0.003	0.025***	0.067***	0.009**	0.020***
Education	-0.028**	-0.007	-0.016**	0.008	-0.002	0.003	-0.015	-0.001	-0.004
Social1	-0.074***	-0.045***	-0.056***	0.033**	-0.045***	-0.010	-0.000	-0.000	0.000
Social2	-0.042***	-0.023***	-0.031***	0.021*	-0.024***	-0.004	-0.004*	-0.005*	-0.003*
Single	-0.140***	0.053***	-0.032***	-0.116***	0.108***	0.004	-0.089***	0.035***	-0.006
Married	-0.019***	-0.031***	-0.025***	0.029**	0.000	0.016**	0.054***	0.011***	0.017***
Meat Dummy	0.188***	-0.061***	0.049***	0.251***	0.027	0.158***	0.252***	0.002	0.060***

*** significant at 1% level, ** significant at 5% level, * significant at 10% level

For space reasons standard errors are reported in Appendix 5H.

$^{\theta}$The marginal effect of income is calculated including income^2.

TABLE 5.6 MARGINAL EFFECTS FOR IHS HETEROSCEDASTIC DOUBLE-HURDLE AND INFREQUENCY OF PURCHASE MODELS 1994

	Beef (IFP)			Lamb(DH)			Pork (DH)			Pork Products (IFP)		
	Prob.	**Cond.**	**Uncond.**	**Prob.**	**Cond.**	**Uncond.**	**Prob.**	**Cond.**	**Uncond.**	**Prob.**	**Cond.**	**Uncond.**
Continuous												
Income$^{\theta}$	0.035***	0.143***	0.073***	0.012***	0.067***	0.032***	0.014***	0.058***	0.031***	0.016***	0.046***	0.046***
Age	0.023***	0.044***	0.030***	0.044***	0.039***	0.037***	0.009**	0.028***	0.016***	0.005***	0.034***	0.031***
Discrete												
All Working	0.025**	-0.029*	0.005	0.001	0.003	0.002	-0.034**	0.013**	-0.010	-0.007	0.001	-0.002
Urban	0.015*	-0.092***	-0.023***	-0.023**	-0.060***	-0.034***	0.084***	-0.040***	0.022***	-0.013***	-0.019***	0.022***
Children	0.094***	-0.164***	0.000	0.046***	-0.058***	0.000	0.095***	-0.043***	0.026***	0.072***	-0.048***	-0.009*
Gender	-0.007*	-0.019*	-0.011**	0.021*	-0.018**	0.003	-0.025*	-0.014*	-0.017**	-0.020***	-0.020***	-0.025***
Education	0.030**	-0.053***	0.000	0.027**	0.014*	0.018**	0.002	-0.006	-0.002	-0.028***	-0.021***	-0.029***
Social1	0.059***	-0.065***	0.013*	-0.010	-0.019**	-0.012*	0.022	-0.009	0.006	-0.030***	-0.034***	-0.041***
Social2	0.049***	-0.043**	0.015**	0.021*	-0.020**	0.003	0.053***	0.002	0.025***	-0.005	-0.005	-0.006
Single	-0.056***	0.114***	0.006	-0.095***	0.030**	-0.034***	-0.129***	0.041***	-0.042***	-0.013	0.025***	0.015**
Married	0.047***	-0.034**	0.017***	0.054***	-0.005	0.024***	-0.003	-0.007	-0.005	-0.001	-0.006	-0.006
Meat Dummy	0.242***	-0.151***	0.095***	0.288***	-0.053*	0.119***	0.324***	0.050**	0.171***	0.118***	0.076***	0.114***

*** significant at 1% level, ** significant at 5% level, * significant at 10% level

For space reasons standard errors are reported in Appendix 5H.

$^{\theta}$The marginal effect of income is calculated including income^2.

TABLE 5.6 MARGINAL EFFECTS FOR IHS HETEROSCEDASTIC DOUBLE-HURDLE AND INFREQUENCY OF PURCHASE MODELS 1994 (CONTINUED)

	Bacon & Ham (DH)			**Chicken (IFP)**			**Minced Meat (DH)**		
	Prob.	**Cond.**	**Uncond.**	**Prob.**	**Cond.**	**Uncond.**	**Prob.**	**Cond.**	**Uncond.**
Continuous									
Income$^{\theta}$	-0.002	0.059***	0.024***	0.038***	0.135***	0.128***	0.004*	0.041***	0.015***
Age	0.047***	0.047***	0.045***	0.002	0.045***	0.035***	-0.036***	0.013***	-0.006***
Discrete									
All Working	-0.050***	0.006	-0.023***	-0.026***	-0.013	-0.029***	-0.058***	0.008***	-0.014***
Urban	-0.119***	-0.048***	-0.082***	0.032***	-0.018**	0.011	0.071***	-0.001	0.020***
Children	0.086***	-0.086***	0.008	0.126***	-0.126***	0.001	0.157***	-0.022***	0.038***
Gender	-0.053***	-0.012	-0.033***	0.055***	-0.005	0.037***	0.062***	0.002	0.019***
Education	-0.038***	-0.006	-0.022***	0.008	0.001	0.007	-0.029***	0.003	-0.007**
Social1	-0.082***	-0.051***	-0.065***	0.013	-0.044***	-0.023**	-0.002**	-0.004**	-0.002**
Social2	-0.035***	-0.036***	-0.033***	0.007	-0.015	-0.006	0.001	0.002	0.001
Single	-0.150***	0.061***	-0.052***	-0.086***	0.097***	0.008	-0.091***	0.059***	-0.006
Married	-0.003	-0.008	-0.005	0.066***	-0.016	0.037***	0.034***	0.003	0.011***
Meat Dummy	0.222***	0.015	0.123***	0.174***	0.087***	0.193***	0.196***	-0.029***	0.047***

*** significant at 1% level, ** significant at 5% level, * significant at 10% level

For space reasons standard errors are reported in Appendix 5H.

$^{\theta}$The marginal effect of income is calculated including income^2.

TABLE 5.7 **ELASTICITY ESTIMATES AND DISCRETE EFFECTS FOR IHS HETEROSCEDASTIC DOUBLE-HURDLE AND INFREQUENCY OF PURCHASE MODELS 1987**

	Beef (IFP)			Lamb (DH)			Pork (DH)			Pork Products (IFP)		
	Prob.	**Cond.**	**Uncond.**	**Prob.**	**Cond.**	**Uncond.**	**Prob.**	**Cond.**	**Uncond.**	**Prob.**	**Cond.**	**Uncond.**
Elasticities												
Income$^{\theta}$	0.147***	0.253***	0.400***	0.095***	0.259***	0.355***	0.076***	0.240***	0.317***	0.022***	0.181***	0.202***
Age	0.178***	0.303***	0.481***	0.427***	0.361***	0.788***	-0.121***	0.345***	0.224***	-0.099	0.398***	0.389***
Discrete Effects												
All Work	0.084**	-0.049*	0.035	-0.013	-0.022	-0.034	-0.110***	-0.015	-0.124***	-0.010**	-0.022**	-0.032**
Urban	0.119***	-0.220***	-0.101***	-0.111***	-0.112***	-0.223***	0.311***	-0.046***	0.266***	-0.012***	-0.029***	-0.040***
Children	0.045	-0.176***	-0.131***	-0.054*	-0.133***	-0.187***	0.178***	-0.118***	0.059*	0.079	-0.117**	-0.039**
Gender	-0.011	-0.019	-0.030	0.084**	-0.022	0.062	0.009	-0.038**	-0.029	-0.018***	-0.041***	-0.059***
Education	0.108***	-0.120***	-0.012	0.201***	-0.005	0.195***	0.025	-0.025**	-0.001	-0.019***	-0.043***	-0.061***
Social1	0.180***	-0.073**	0.107***	0.132***	-0.031*	0.101**	0.032	-0.017	0.015	-0.039***	-0.085***	-0.124***
Social2	0.169***	-0.115***	0.054	0.117***	-0.013	0.105**	0.102***	-0.001	0.101***	-0.009**	-0.020**	-0.029**
Single	-0.290***	0.296***	0.006	-0.255***	0.063**	-0.192***	-0.275***	0.087***	-0.188***	0.002	0.013	0.015
Married	0.071**	-0.039	0.032	0.123***	-0.011	0.112**	-0.003	-0.006	-0.010	-0.002	-0.006	-0.007
Meat Dummy	0.673***	-0.832***	-0.158***	0.511***	-0.163**	0.348***	0.688***	0.081*	0.768***	0.092***	0.163***	0.255***

*** significant at 1% level, ** significant at 5% level, * significant at 10% level
Significance levels are based on significance levels of underlying marginal effect.
$^{\theta}$The marginal effect of income is calculated including income^2.

TABLE 5.7 (CONTINUED) ELASTICITY ESTIMATES AND DISCRETE EFFECTS FOR IHS HETEROSCEDASTIC DOUBLE-HURDLE AND INFREQUENCY OF PURCHASE MODELS 1987

	Bacon & Ham (DH)			Chicken (IFP)			Minced Meat (DH)		
	Prob.	**Cond.**	**Uncond.**	**Prob.**	**Cond.**	**Uncond.**	**Prob.**	**Cond.**	**Uncond.**
Elasticities									
Income$^{\theta}$	0.036***	0.237***	0.273***	0.056***	0.250***	0.307***	0.018**	0.141***	0.159***
Age	0.332***	0.406***	0.738***	0.001	0.345***	0.346***	-0.475***	0.226***	-0.249***
Discrete Effects									
All Work	-0.071**	-0.021	-0.092***	-0.057***	0.006	-0.051***	-0.124***	0.051***	-0.073*
Urban	-0.303***	-0.117***	-0.420***	0.087***	-0.078***	0.009	0.399***	0.043***	0.442***
Children	0.167***	-0.200***	-0.033	0.169***	-0.227***	-0.058*	0.454***	-0.091***	0.363***
Gender	-0.138***	-0.092***	-0.230***	0.064***	0.003	0.066***	0.158***	0.041**	0.198***
Education	-0.053**	-0.016	-0.068**	0.012	-0.005	0.007	-0.035	-0.006	-0.041
Social1	-0.140***	-0.102***	-0.242***	0.050**	-0.082***	-0.032	-0.001	-0.002	-0.002
Social2	-0.080***	-0.053***	-0.133***	0.033*	-0.046***	-0.013	-0.010*	-0.022*	-0.033*
Single	-0.288***	0.128***	-0.160***	-0.198***	0.255***	0.057	-0.217***	0.154***	-0.064
Married	-0.037***	-0.072***	-0.108***	0.046**	-0.003	0.042**	0.125***	0.046***	0.172***
Meat Dummy	0.402***	-0.151***	0.252***	0.416***	-0.056	0.360***	0.539***	0.010	0.548***

*** significant at 1% level, ** significant at 5% level, * significant at 10% level
Significance levels based on the significance levels of underlying marginal effects.
$^{\theta}$The marginal effect of income is calculated including income^2.

TABLE 5.8 ELASTICITY ESTIMATES AND DISCRETE EFFECTS FOR IHS HETEROSCEDASTIC DOUBLE-HURDLE AND INFREQUENCY OF PURCHASE MODELS 1994

	Beef (IFP)			**Lamb (DH)**			**Pork (DH)**			**Pork Products (IFP)**		
	Prob.	**Cond.**	**Uncond.**	**Prob.**	**Cond.**	**Uncond.**	**Prob.**	**Cond.**	**Uncond.**	**Prob.**	**Cond.**	**Uncond.**
Elasticities												
Income$^{\theta}$	0.117***	0.275***	0.393***	0.038***	0.165***	0.202***	0.039***	0.149***	0.188***	0.023***	0.128***	0.151***
Age	0.335***	0.365***	0.699***	0.572***	0.410***	0.982***	0.104**	0.309***	0.413***	0.030***	0.406***	0.436***
Discrete Effects												
All Working	0.072**	-0.046*	0.027	0.004	0.007	0.010	-0.081**	0.029**	-0.052	-0.009	0.004	-0.006
Urban	0.043	-0.153***	-0.110***	-0.056**	-0.126***	-0.182***	0.201***	-0.089***	0.112***	-0.015***	-0.046***	-0.061***
Children	0.264***	-0.274***	-0.011	0.117***	-0.121***	-0.004	0.225***	-0.093***	0.131***	0.138***	-0.183***	-0.045*
Gender	-0.019*	-0.031**	-0.049**	0.054*	-0.037**	0.016	-0.063**	-0.031*	-0.094**	-0.024***	-0.046***	-0.070***
Education	0.086**	-0.085***	0.001	0.068**	0.029*	0.097**	0.004	-0.013	-0.010	-0.034***	-0.048***	-0.082***
Social1	0.168***	-0.016***	0.152*	-0.025	-0.040**	-0.065*	0.051	-0.020	0.031	-0.037***	-0.078***	-0.115***
Social2	0.139***	-0.066**	0.073**	0.055*	-0.040**	0.015	0.125***	0.004	0.129***	-0.006	-0.012	-0.018
Single	-0.158***	0.199***	0.041	-0.243***	0.063**	-0.181***	-0.308***	0.090***	-0.218***	-0.026	0.071***	0.045**
Married	0.132***	-0.055**	0.077***	0.139***	-0.010	0.129***	-0.008	-0.016	-0.024	-0.002	-0.014	-0.016
Meat Dummy	0.586***	-0.420***	0.166**	0.664***	-0.116*	0.549***	0.662***	0.104**	0.766***	0.179***	0.140***	0.319***

*** significant at 1% level, ** significant at 5% level, * significant at 10% level

Significance levels are based on significance levels of underlying marginal effects.

$^{\theta}$The marginal effect of income is calculated including income^2.

TABLE 5.8 (CONTINUED) ELASTICITY ESTIMATES AND DISCRETE EFFECTS FOR IHS HETEROSCEDASTIC DOUBLE-HURDLE AND INFREQUENCY OF PURCHASE MODELS 1994

	Bacon & Ham (DH)			Chicken (IFP)			Minced Meat (DH)		
	Prob.	**Cond.**	**Uncond.**	**Prob.**	**Cond.**	**Uncond.**	**Prob.**	**Cond.**	**Uncond.**
Elasticities									
Income$^{\theta}$	-0.005	0.133***	0.129***	0.061***	0.215***	0.276***	0.013*	0.167***	0.180***
Age	0.561***	0.459***	1.020***	0.016	0.308***	0.325***	-0.538***	0.230***	-0.308***
Discrete Effects									
All Working	-0.117***	0.012	-0.105***	-0.036***	-0.017	-0.053***	-0.170***	0.027***	-0.143***
Urban	-0.280***	-0.093***	-0.373***	0.044***	-0.025**	0.019	0.210***	-0.003	0.207***
Children	0.202***	-0.167***	0.035	0.180***	-0.191***	-0.011	0.461***	-0.075***	0.386***
Gender	-0.124***	-0.023	-0.147***	0.071***	-0.003	0.067***	0.186***	0.009	0.194***
Education	-0.089***	-0.011	-0.100***	0.011	0.001	0.012	-0.087***	0.010	-0.077**
Social1	-0.192***	-0.095***	-0.287***	0.016	-0.057***	-0.042**	-0.006**	-0.015**	-0.021**
Social2	-0.082**	-0.068***	-0.149***	0.010	-0.020	-0.010	0.002	0.006	0.009
Single	-0.357***	0.121***	-0.236***	-0.138***	0.191***	0.054	-0.278***	0.215***	-0.063
Married	-0.008	-0.016	-0.025	0.089***	-0.021	0.067***	0.101***	0.012	0.113***
Meat Dummy	0.488***	0.029	0.517***	0.268***	0.075***	0.343***	0.524***	-0.104***	0.420***

*** significant at 1% level, ** significant at 5% level, * significant at 10% level
Significance levels are based on significance levels of underlying marginal effects.
$^{\theta}$The marginal effect of income is calculated including income^2.

TABLE 5.9 UNCONDITIONAL INCOME ELASTICITY ESTIMATES EVALUATED AT 1987 MEANS FOR THE IHS HETEROSCEDASTIC DOUBLE-HURDLE AND INFREQUENCY OF PURCHASE MODELS$^{\theta}$

	Beef (IFP)	Lamb (DH)	Pork (DH)	Pork Prod (IFP)	Bac& Ham (DH)	Chicken (IFP)	Mince (DH)
1987	0.400***	0.355***	0.317***	0.202***	0.273***	0.307***	0.159***
1994♣	0.387***	0.199***	0.185***	0.149***	0.127***	0.271***	0.177***
Difference	0.013***	0.156***	0.132***	0.053***	0.146***	0.036***	-0.018***
Stat❑	2.64	41.75	39.48	23.35	52.38	9.86	-8.77
$z = 2.326$							

*** significant at 1% level, ** significant at 5% level

Significance levels are based on significance levels of underlying marginal effects.

$^{\theta}$The marginal effect of income is calculated including income^2.

♣Evaluated at 1987 mean adjusted to 1994 market prices using the Consumer Price Index (Central Statistics Office, 1988, 1995).

❑ See Chapter 4, Table 4.10 for details of testing procedure.

TABLE 5.10 EXPENDITURE ELASTICITY ESTIMATES (BOYLE, 1996)

	Ireland (Boyle)	UK	France	US	Japan	Australia	Canada	Ireland (87)	Ireland (94)
Beef	1.19	1.32	0.89	0.97	1.83	1.61	1.61	0.40	0.31
Mutton/Lamb	1.21	1.07	1.52	1.26		0.85		0.35	0.16
Pigmeat	1.10	0.79	1.44	1.04	0.53	0.26	0.58	0.32♠	0.15♠
Chicken	0.88	0.98	1.77	0.77	1.60	0.17	0.97	0.31	0.22

Ireland – Boyle (1996)
UK – Burton and Young (1992)
France – Fulponi (1989)
US – Wellman (1992)
Japan – Hayes *et al.* (1990)
Australia – Alston and Chalfant (1987)
Canada – Chalfant *et al.* (1991)
Ireland 1987, 1994 – Estimates from this analysis presented in Tables 5.7 and 5.8
♠ Income elasticity associated with pork expenditure as defined in Chapter 3, Table 3.1.

TABLE 5.11 UNCONDITIONAL INCOME ELASTICITY ESTIMATES EXCLUDING THE EFFECT OF INCOME^2 FOR THE IHS HETEROSCEDASTIC DOUBLE-HURDLE AND INFREQUENCY OF PURCHASE MODELS

	Beef (IFP)	Lamb (DH)	Pork (DH)	Chicken (IFP)
1987	0.588	0.506	0.523	0.428
Difference	0.188	0.151	0.206	0.121
1994	0.548	0.280	0.280	0.401
Difference	0.155	0.078	0.092	0.125

TABLE 5.12 EXPENDITURE ON FOOD CONSUMED AWAY FROM HOME BY PARTICIPATING AND NON-PARTICIPATING SINGLE ADULT HOUSEHOLDS FOR EACH MEAT MARKET

	Beef		Lamb		Pork		Pork Products	
	Part	Non-Part	Part	Non-Part	Part	Non-Part	Part	Non-Part
Expenditure	5.620	4.928	3.888	5.591	3.322	5.737	3.862	7.277
Sample size	488	1566	601	1453	548	1506	1314	740

	Bacon & Ham		Chicken		Minced Meat	
	Part	Non-Part	Part	Non-Part	Part	Non-Part
Expenditure	2.530	6.150	4.198	5.954	2.994	5.592
Sample size	600	1454	1008	1046	395	1659

TABLE 5.13 SOCIO-ECONOMIC CHARACTERISTICS OF PARTICIPATING AND NON-PARTICIPATING SINGLE ADULT HOUSEHOLDS IN 1994

	Beef		Lamb		Pork		Pork Products	
	Part	Non-Part	Part	Non-Part	Part	Non-Part	Part	Non-Part
Age	6.000	5.717	6.270	5.584	5.746	5.798	5.864	5.643
Urban	0.693	0.697	0.679	0.703	0.772	0.669	0.681	0.723
Children	0.084	0.114	0.080	0.118	0.151	0.090	0.131	0.064
Sample size	488	1566	601	1453	548	1506	1314	740

	Bacon & Ham		Chicken		Minced Meat	
	Part	Non-Part	Part	Non-Part	Part	Non-Part
Age	6.348	5.552	5.741	5.826	5.256	5.910
Urban	0.585	0.742	0.726	0.667	0.787	0.675
Children	0.082	0.117	0.152	0.063	0.256	0.071
Sample size	600	1454	1008	1046	395	1659

Appendix 5A **PROBIT MODELS OF THE DECISION TO PARTICIPATE/PURCHASE DISAGGREGATED MEATS**

	1987							1994						
	Beef	**Lamb**	**Pork**	**Pork Prod.**	**Bac. & Ham**	**Chick.**	**Mince**	**Beef**	**Lamb**	**Pork**	**Pork Prod.**	**Bac. & Ham**	**Chick.**	**Mince**
One	-1.65***	-1.44***	-1.24***	0.10	-0.66***	-0.73***	-0.94***	-1.74***	-1.75***	-1.34***	0.08	-1.03***	-0.40***	-0.80***
	(0.155)	(0.140)	(0.145)	(0.126)	(0.128)	(0.124	(0.141)	(0.128)	(0.130)	(0.125)	(0.110)	(0.123)	(0.109)	(0.124)
Age	0.03***	0.08***	-0.02**	0.02**	0.09***	0.01	-0.10***	0.07***	0.11***	0.02**	0.01	0.12***	-0.01	-0.10***
	(0.012)	(0.01)	(0.01)	(0.014)	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)	(0.011)	(0.013)	(0.012)	(0.012)	(0.012)
All-Working	0.14***	0.03	-0.09**	-0.14***	-0.10***	-0.07**	-0.11***	0.12***	0.02	-0.08**	-0.13***	-0.14***	-0.08**	-0.15***
	(0.044)	(0.044)	(0.04)	(0.053)	(0.043)	(0.044)	(0.04)	(0.040)	(0.040)	(0.040)	(0.046)	(0.040)	(0.043)	(0.041)
Urban	0.08**	-0.11***	0.35***	0.07*	-0.39***	0.15***	0.43***	0.00	-0.06**	0.20***	-0.06*	-0.30***	0.11***	0.18***
	(0.035)	(0.035)	(0.03)	(0.044)	(0.034)	(0.035)	(0.035)	(0.034)	(0.034)	(0.034)	(0.040)	(0.034)	(0.036)	(0.035)
Children	0.00	-0.07**	0.19***	0.48***	0.19***	0.26***	0.49***	0.24***	0.10***	0.23***	0.48***	0.20**	0.35***	0.41***
	(0.042)	(0.042)	(0.04)	(0.051)	(0.042)	(0.041)	(0.042)	(0.040)	(0.040)	(0.039)	(0.045)	(0.041)	(0.041)	(0.040)
Gender	-0.02	0.07*	0.01	0.02	-0.18***	0.11***	0.17***	-0.05	0.04	-0.07**	-0.14***	-0.12***	0.20***	0.17***
	(0.047)	(0.046)	(0.04)	(0.053)	(0.045)	(0.045)	(0.047)	(0.041)	(0.040)	(0.040)	(0.044)	(0.041)	(0.042)	(0.042)
Education	0.11***	0.21***	0.05	-0.06	-0.06*	0.07**	-0.04	0.11***	0.08**	0.01	-0.17***	-0.10***	0.05	-0.06*
	(0.039)	(0.039)	(0.04)	(0.049)	(0.038)	(0.039)	(0.039)	(0.039)	(0.04)	(0.039)	(0.046)	(0.039)	(0.042)	(0.040)
Social1	0.25***	0.15***	0.07	-0.20***	-0.17***	0.09**	0.02	0.22***	-0.01	0.08**	-0.07*	-0.21***	0.13***	-0.01
	(0.047)	(0.046)	(0.045)	(0.058)	(0.046)	(0.046)	(0.047)	(0.045)	(0.045)	(0.044)	(0.052)	(0.045)	(0.048)	(0.046)
Social2	0.18***	0.12***	0.13***	0.00	-0.10***	0.07**	0.00	0.16***	0.06*	0.14***	0.06	-0.09**	0.07**	0.06
	(0.042)	(0.041)	(0.040)	(0.055)	(0.041)	(0.041)	(0.041)	(0.041)	(0.041)	(0.040)	(0.049)	(0.041)	(0.043)	(0.042)
Single	-0.32***	-0.29***	-0.37***	-0.29***	-0.38***	-0.37***	-0.28***	-0.19***	-0.27***	-0.34***	-0.25***	-0.39***	-0.44***	-0.27***
	(0.057)	(0.056)	(0.055)	(0.063)	(0.054)	(0.054)	(0.057)	(0.052)	(0.051)	(0.050)	(0.055)	(0.052)	(0.051)	(0.053)
Married	0.023	0.09**	-0.020	0.17***	0.02	0.09**	0.12***	0.10***	0.13***	0.01	0.06	0.04	0.16***	0.08**
	(0.043)	(0.042)	(0.042)	(0.055)	(0.042)	(0.042)	(0.042)	(0.040)	(0.040)	(0.040)	(0.049)	(0.041)	(0.043)	(0.041)
DM	0.83***	0.59***	0.98***	0.76***	0.60***	0.74***	0.68***	0.70***	0.85***	0.86***	0.78***	0.61***	0.72***	0.57***
	(0.124)	(0.104)	(0.116)	(0.066)	(0.091)	(0.086)	(0.110)	(0.092)	(0.095)	(0.092)	(0.058)	(0.084)	(0.064)	(0.091)

*** significant at 1% level, ** significant at 5% level, * significant at 10% level. Standard errors are written in parentheses.

Appendix 5B **LIKELIHOOD RATIO TESTS OF HOMOSCEDATICITY RESTRICTION**

H_0=Homoscedastic error structure, H_1=Heteroscedastic error specification

Tobit Model

	1987							1994						
	Beef	**Lamb**	**Pork**	**Pork Prod.**	**Bac. & Ham**	**Chick.**	**Mince**	**Beef**	**Lamb**	**Pork**	**Pork Prod.**	**Bac. & Ham**	**Chick.**	**Mince**
Test Statistic	96.10	85.23	169.86	399.54	201.18	305.10	157.82	157.33	112.46	172.33	299.53	135.70	231.13	126.02
Critical Value $\chi^2_{2,0.01} = 9.21$	Reject null	Reject null	Reject null	Reject null	Reject null	Reject null	Reject null	Reject null	Reject null	Reject null	Reject null	Reject null	Reject null	Reject null

Double Hurdle Model

	1987							1994						
	Beef	**Lamb**	**Pork**	**Pork Prod.**	**Bac. & Ham**	**Chick.**	**Mince**	**Beef**	**Lamb**	**Pork**	**Pork Prod.**	**Bac. & Ham**	**Chick.**	**Mince**
Test Statistic	72.02	96.71	141.20	397.27	207.75	235.95	72.87	129.35	138.41	213.36	283.76	125.24	166.32	83.13
Critical Value $\chi^2_{2,0.01} = 9.21$	Reject null	Reject null	Reject null	Reject null	Reject null	Reject null	Reject null	Reject null	Reject null	Reject null	Reject null	Reject null	Reject null	Reject null

Infrequency of Purchase Model

	1987							1994						
	Beef	**Lamb**	**Pork**	**Pork Prod.**	**Bac. & Ham**	**Chick.**	**Mince**	**Beef**	**Lamb**	**Pork**	**Pork Prod.**	**Bac. & Ham**	**Chick.**	**Mince**
Test Statistic	30.89	88.33	51.40	341.68	147.74	157.65	24.19	56.41	82.78	45.38	206.95	96.22	96.43	83.13
Critical Value $\chi^2_{2,0.01} = 9.21$	Reject null	Reject null	Reject null	Reject null	Reject null	Reject null	Reject null	Reject null	Reject null	Reject null	Reject null	Reject null	Reject null	Reject null

Appendix 5C **LOG LIKELIHOOD VALUES OF STANDARD HETEROSCEDASTIC MODELS V'S IHS HETEROSCEDASTIC MODELS**

Tobit Model

	1987							1994						
	Beef	**Lamb**	**Pork**	**Pork Prod.**	**Bac. & Ham**	**Chick.**	**Mince**	**Beef**	**Lamb**	**Pork**	**Pork Prod.**	**Bac. & Ham**	**Chick.**	**Mince**
Standard Hetero. Model	-3656.5	-3932.5	-4026.3	-4417.0	-4267.6	-4791.4	-2964.5	-4079.0	-4310.3	-3007.0	-4949.6	-4267.4	-5737.4	-3161.3
IHS Hetero. Model	-2790.7	-2944.6	-2784.5	-1962.7	-2879.7	-3131.7	-1836.4	-3106.4	-3131.5	-4239.8	-2634.4	-3114.9	-3816.9	-2220.0

Double Hurdle Model

	1987							1994						
	Beef	**Lamb**	**Pork**	**Pork Prod.**	**Bac. & Ham**	**Chick.**	**Mince**	**Beef**	**Lamb**	**Pork**	**Pork Prod.**	**Bac. & Ham**	**Chick.**	**Mince**
Standard Hetero. Model	-3389.3	-3759.0	-3843.4	-4375.7	-4082.1	-4615.0	-2705.4	-3824.6	-4150.9	-4049.4	-4881.1	-4035.3	-5591.6	-2851.5
IHS Hetero Model	-2412.4	-2627.6	-2501.7	-1872.0	-2596.1	-2879.7	-1486.2	-2744.8	-2822.6	-2681.6	-2536.3	-2782.5	-3606.7	-1797.3

Infrequency of Purchase Model

	1987							1994						
	Beef	**Lamb**	**Pork**	**Pork Prod.**	**Bac. & Ham**	**Chick.**	**Mince**	**Beef**	**Lamb**	**Pork**	**Pork Prod.**	**Bac. & Ham**	**Chick.**	**Mince**
Standard Hetero. Model	-3332.2	-3738.7	-3842.1	-4319.6	-4064.9	-4566.0	-2707.9	-3780.8	-4089.5	-3994.1	-4785.9	-4025.4	-5542.9	-2834.3
IHS Hetero. Model	-2407.4	-2630.5	-2507.5	-1855.9	-2605.9	-2864.8	-1491.9	-2740.5	-2823.9	-2682.7	-2475.9	-2791.5	-3590.2	-1803.7

Appendix 5D **LIKELIHOOD RATIO TESTS OF TOBIT SPECIFICATION**

H_0=Tobit Model
H_1=Double Hurdle Model

	1987							1994						
	Beef	**Lamb**	**Pork**	**Pork Prod.**	**Bac. & Ham**	**Chick.**	**Mince**	**Beef**	**Lamb**	**Pork**	**Pork Prod.**	**Bac. & Ham**	**Chick.**	**Mince**
Test Statistic	756.71	634.13	565.50	181.41	567.24	504.10	700.38	723.13	617.93	650.86	196.25	664.88	420.26	845.45
Critical Value $\chi^2_{11,0.01}=24.72$ $\chi^2_{10,0.01}=23.21$	Reject null	Reject null	Reject null	Reject null	Reject null	Reject null	Reject null	Reject null	Reject null	Reject null	Reject null	Reject null	Reject null	Reject null

H_0=Tobit Model
H_1=Infrequency of Purchase Model

	1987							1994						
	Beef	**Lamb**	**Pork**	**Pork Prod.**	**Bac. & Ham**	**Chick.**	**Mince**	**Beef**	**Lamb**	**Pork**	**Pork Prod.**	**Bac. & Ham**	**Chick.**	**Mince**
Test Statistic	766.63	628.36	553.99	213.61	547.80	533.85	688.99	731.65	615.30	648.56	317.06	646.74	453.37	832.67
Critical Value $\chi^2_{11,0.01}=24.72$ $\chi^2_{10,0.01}=23.21$	Reject null	Reject null	Reject null	Reject null	Reject null	Reject null	Reject null	Reject null	Reject null	Reject null	Reject null	Reject null	Reject null	Reject null

VUONG'S TEST FOR MODEL SPECIFICATION

	H_0=IFP and DH Models are equivalent[⁂]													
	1987							**1994**						
	Beef	**Lamb**	**Pork**	**Pork Prod.**	**Bacon & Ham**	**Chick.**	**Mince**[∀]	**Beef**	**Lamb**[Ψ]	**Pork**[♦]	**Pork Prod.**	**Bac. & Ham**	**Chick.**	**Mince**[∀]
Test Statistic	-2.644	2.340	2.874	-4.814	4.020	-4.274	2.156	-2.365	1.588	0.578	-4.814	3.978	-4.045	2.079
Critical Value z = 2.326	Reject in favour of IFP	Reject in favour of DH	Reject in favour of DH	Reject in favour of IFP	Reject in favour of DH	Reject in favour of IFP	Do not reject	Reject in favour of IFP	Do not reject	Do not reject	Reject in favour of IFP	Reject in favour of DH	Reject in favour of IFP	Do not reject

IFP – Infrequency of Purchase Model

DH – Double Hurdle Model

[⁂] See Chapter 2, Section 2.7.

[∀] One cannot discriminate between the DH and IFP specification for Minced Meat expendiutre in both 1987 and 1994. In this thesis the DH model is used to model Minced Meat expenditure.

[Ψ] One cannot discriminate between DH and IFP specifications for Lamb expenditure in 1994. The DH model is chosen for ease of comparison with the 1987 Lamb expenditure model.

[♦] One cannot discriminate between the DH and IFP specification for Pork expenditure in 1994. The DH model is chosen for ease of comparison with the 1987 Pork expenditure model.

Appendix 5F **ILLUSTRATION OF THE IMPACT OF THE ENDOGENOUS MEAT DUMMY VARIABLE ON THE MAXIMUM LIKELIHOOD ESTIMATES OF THE TOBIT MODEL**

	1987													
	Beef		**Lamb**		**Pork**		**Pork Products**		**Bacon & Ham**		**Chicken**		**Minced Meat**	
	1	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**
One	-4.286	-2.818	-3.823	-2.839	-2.409	-1.059	-0.157	0.326	-0.902	-0.261	-1.488	-0.535	-0.851	-0.391
Income	1.721	1.721	1.295	1.298	0.947	0.947	0.343	0.349	0.494	0.494	0.651	0.651	0.187	0.190
$Income^2$	-0.320	-0.320	-0.218	-0.218	-0.220	-0.220	-0.057	-0.059	-0.127	-0.127	-0.074	-0.074	-0.033	-0.035
Age	0.111	0.111	0.219	0.219	0.022	0.022	0.079	0.079	0.156	0.156	0.081	0.081	-0.044	-0.044
All Work	0.017	0.017	-0.156	-0.156	-0.192	-0.192	-0.047	-0.048	-0.126	-0.126	-0.187	-0.187	-0.042	-0.042
Urban	-0.027	-0.027	-0.366	-0.366	0.351	0.351	-0.062	-0.062	-0.590	-0.590	0.020	0.020	0.272	0.272
Children	-0.021	-0.021	-0.213	-0.213	0.075	0.075	0.001	0.001	-0.054	-0.054	0.064	0.064	0.250	0.250
Gender	-0.020	-0.020	0.150	0.150	0.019	0.019	-0.052	-0.052	-0.299	-0.299	0.215	0.215	0.145	0.146
Education	-0.100	-0.100	0.270	0.270	-0.036	-0.036	-0.090	-0.090	-0.105	-0.105	0.017	0.017	-0.029	-0.030
Social1	0.191	0.191	0.047	0.047	-0.030	-0.030	-0.216	-0.216	-0.331	-0.331	-0.080	-0.080	-0.013	-0.013
Social2	0.168	0.168	0.150	0.150	0.101	0.101	-0.067	-0.067	-0.205	-0.205	-0.025	-0.025	-0.034	-0.034
Single	-0.151	-0.151	-0.309	-0.309	-0.323	-0.323	-0.036	-0.036	-0.313	-0.313	-0.123	-0.123	-0.127	-0.127
Married	0.155	0.155	0.262	0.262	0.043	0.043	0.0015	0.002	-0.080	-0.080	0.163	0.163	0.092	0.092
DM	1.468		0.986		1.350		0.486		0.641		0.953		0.462	
Residual DM		1.468		0.985		1.350		0.475		0.641		0.953		0.461
Sigma	2.034	2.034	2.212	2.212	1.395	1.395	0.836	0.836	1.412	1.412	1.419	1.419	0.722	0.722
Log Likelihood	-7214	-7214	-7808	-7808	-8081	-8081	-8573	-8573	-8647	-8647	-9961	-9961	-5631	-5631
Likelihood Ratio Test Statistic▲	-0.0012		-0.0327		0.000		-0.5135		-0.0301		0.000		-0.1630	
Critical Value $\chi^2_{1,0.01} = 6.63$	Do not reject null		Do not reject null		Do not reject null		Do not reject null		Do not reject null		Do not reject null		Do not reject null	

▲ H_0: Original model

H_1: Model correcting for endogenous meat dummy variable.

ILLUSTRATION OF THE IMPACT OF THE ENDOGENOUS MEAT DUMMY VARIABLE ON THE MAXIMUM LIKELIHOOD ESTIMATES OF THE TOBIT MODEL (CONTINUED)

	1994													
	Beef		**Lamb**		**Pork**		**Pork Products**		**Bacon & Ham**		**Chicken**		**Minced Meat**	
	1	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**
One	-4.963	-3.571	-3.902	-2.353	-2.812	-1.357	-0.327	0.342	-1.933	-0.935	-1.523	-0.417	-0.932	-0.446
Income	1.412	1.435	0.486	0.525	0.530	0.537	0.267	0.287	0.120	0.136	0.784	0.814	0.077	0.087
$Income^2$	-0.201	-0.208	-0.064	-0.076	-0.084	-0.087	-0.036	-0.042	-0.036	-0.041	-0.106	-0.115	-0.017	-0.020
Age	0.236	0.236	0.280	0.279	0.085	0.085	0.091	0.091	0.260	0.260	0.089	0.089	-0.065	-0.065
All Work	0.023	0.022	0.001	-0.001	-0.084	-0.084	-0.024	-0.025	-0.142	-0.143	-0.179	-0.181	-0.103	-0.104
Urban	-0.161	-0.161	-0.336	-0.335	0.147	0.148	-0.134	-0.133	-0.559	-0.559	0.067	0.068	0.160	0.160
Children	0.370	0.368	0.010	0.008	0.209	0.209	0.017	0.016	0.045	0.045	0.157	0.156	0.321	0.321
Gender	-0.142	-0.141	0.073	0.073	0.063	-0.062	-0.134	-0.134	-0.224	-0.223	0.320	0.320	0.181	0.181
Education	-0.086	-0.086	0.142	0.141	-0.071	-0.071	-0.185	-0.185	-0.159	-0.159	-0.040	-0.040	-0.027	-0.027
Social1	0.095	0.093	-0.198	-0.202	-0.025	-0.026	-0.203	-0.205	-0.450	-0.452	-0.102	-0.105	-0.013	-0.014
Social2	0.159	0.157	-0.141	-0.016	0.129	0.129	-0.005	-0.006	-0.254	-0.255	-0.057	-0.059	0.046	0.045
Single	0.015	0.015	-0.365	-0.361	-0.397	-0.398	0.025	0.025	-0.476	-0.476	-0.186	-0184	-0.180	-0.180
Married	0.266	0.267	0.237	0.237	0.031	0.032	-0.025	-0.025	0.012	0.013	0.246	0.247	0.065	0.065
DM	1.705		1.569		1.459	1.447	0.680		1.008		1.123		0.492	
Residual DM		1.407		1.604				0.679		0.993		1.125		0.480
Sigma	2.251	2.251	2.134	2.134	1.748	1.748	1.029	1.029	1.799	1.799	1.709	1.708	1.034	1.034
Log Likelihood	-8205	-8204	-8641	-8639	-8521	-8521	-9843	-9842	-8602	-8602	-11855	-11854	-6042	-6042
Likelihood Ratio Test Statistic▲	0.9417		4.2884		-1.1300		1.0522		-1.1454		1.9893		-1.2508	
Critical Value $\chi^2_{1,0.01} = 6.63$	Do not reject null		Do not reject null		Do not reject null		Do not reject null		Do not reject null		Do not reject null		Do not reject null	

▲ H_0: Original model

H_1: Model correcting for endogenous meat dummy variable.

Appendix 5G STANDARD ERRORS OF MAXIMUM LIKELIHOOD ESTIMATES

	1987													
	Beef (IFP)		**Lamb (DH)**		**Pork (DH)**		**Pork Products (IFP)**		**Bacon & Ham (DH)**		**Chicken (IFP)**		**Minced Meat (DH)**	
	Purch.	**Exp.**	**Part.**	**Exp.**	**Part.**	**Exp.**	**Purch.**	**Exp.**	**Part.**	**Exp.**	**Purch.**	**Exp.**	**Part.**	**Exp.**
One	0.131	0.028	0.150	0.056	0.168	0.042	0.196	0.017	0.149	0.037	0.089	0.032	0.165	0.022
Income		0.013		0.026		0.022		0.012		0.021		0.017		0.010
Income^2		0.004		0.008		0.007		0.004		0.008		0.005		0.003
Age	0.012	0.002	0.014	0.004	0.015	0.003	0.030	0.002	0.018	0.003		0.002	0.015	0.001
All Work	0.039	0.007		0.013	0.055	0.010	0.103	0.006	0.057	0.010	0.042	0.009	0.053	0.006
Urban	0.030	0.005	0.042	0.010	0.045	0.008	0.075	0.004	0.047	0.007	0.036	0.007	0.041	0.004
Children	0.037	0.006	0.048	0.013	0.051	0.010	0.216	0.006	0.055	0.011	0.044	0.009	0.049	0.006
Gender		0.007	0.054	0.015	0.058	0.012	0.083	0.006	0.058	0.011	0.048	0.010	0.054	0.006
Education	0.034	0.004	0.047	0.011	0.051	0.008	0.107	0.005	0.052	0.008	0.036	0.008	0.043	0.005
Social1	0.041	0.007	0.055	0.014	0.059	0.011	0.108	0.006	0.062	0.010	0.052	0.009		0.005
Social2	0.036	0.006	0.050	0.012	0.055	0.009		0.005	0.056	0.008	0.046	0.008		0.005
Single	0.047	0.009	0.064	0.018	0.061	0.015	0.144	0.008	0.062	0.014	0.056	0.013	0.064	0.008
Married	0.036	0.006	0.051	0.013		0.009	0.167	0.005		0.009	0.048	0.008	0.052	0.005
DM	0.102	0.023	0.113	0.048	0.136	0.037	0.089	0.011	0.099	0.029	0.073	0.024	0.126	0.018
One (Het)		0.077		0.068		0.056		0.035		0.054		0.052		0.055
Income (Het)		0.013		0.011		0.009		0.006		0.009		0.008		0.010
Age (Het)		0.029		0.030		0.028		0.016		0.027		0.024		0.030
IHS		0.149		0.070		0.054		0.060		0.057		0.050		0.115

STANDARD ERRORS OF MAXIMUM LIKELIHOOD ESTIMATES (CONTINUED)

	1994													
	Beef (IFP)		**Lamb (DH)**		**Pork (DH)**		**Pork Products (IFP)**		**Bacon & Ham (DH)**		**Chicken (IFP)**		**Minced Meat (DH)**	
	Purch.	**Exp.**	**Part.**	**Exp.**	**Part.**	**Exp.**	**Purch.**	**Exp.**	**Part.**	**Exp.**	**Purch.**	**Exp.**	**Part.**	**Exp.**
One	0.112	0.029	0.146	0.055	0.148	0.040	0.162	0.019	0.138	0.048	0.112	0.040	0.136	0.025
Income		0.016		0.018		0.016		0.002		0.023		0.020		0.010
$Income^2$		0.004		0.005		0.004		0.012		0.007		0.005		0.003
Age	0.012	0.002	0.014	0.004	0.015	0.003	0.022	0.002	0.015	0.004		0.003	0.014	0.002
All Work	0.036	0.007		0.011	0.050	0.010	0.081	0.006	0.050	0.012	0.052	0.012	0.046	0.006
Urban	0.030	0.006	0.051	0.009	0.042	0.008	0.062	0.005	0.042	0.009	0.047	0.010	0.039	0.005
Children	0.036	0.008	0.048	0.012	0.048	0.010	0.275	0.007	0.049	0.013	0.093	0.012	0.045	0.007
Gender		0.007	0.050	0.012	0.048	0.011	0.076	0.007	0.047	0.012	0.052	0.013	0.046	0.007
Education	0.035	0.007	0.048	0.011	0.048	0.009	0.082	0.006	0.049	0.011	0.062	0.011	0.041	0.005
Social1	0.039	0.008	0.053	0.012	0.055	0.011	0.085	0.007	0.056	0.012	0.067	0.013		0.007
Social2	0.036	0.008	0.051	0.011	0.050	0.010		0.006	0.051	0.011	0.064	0.012		0.006
Single	0.044	0.011	0.060	0.016	0.053	0.014	0.113	0.009	0.054	0.016	0.077	0.016	0.058	0.009
Married	0.035	0.007	0.050	0.011		0.009	0.127	0.006		0.011	0.083	0.011	0.047	0.006
DM	0.074	0.020	0.102	0.046	0.106	0.033	0.076	0.012	0.094	0.035	0.075	0.028	0.100	0.022
One (Het)		0.082		0.063		0.067		0.039		0.063		0.045		0.069
Income (Het)		0.014		0.011		0.011		0.007		0.011		0.007		0.012
Age (Het)		0.023		0.022		0.024		0.014		0.025		0.015		0.026
IHS		0.117		0.067		0.053		0.048		0.055		0.029		0.107

Appendix 5H **STANDARD ERRORS OF MARGINAL EFFECTS 1987**

	Beef (IFP)			Lamb (DH)			Pork (DH)			Pork Products (IFP)		
	Prob.	**Cond.**	**Uncond.**	**Prob.**	**Cond.**	**Uncond.**	**Prob.**	**Cond.**	**Uncond.**	**Prob.**	**Cond.**	**Uncond.**
Income	0.005	0.028	0.008	0.005	0.019	0.009	0.006	0.013	0.009	0.005	0.008	0.007
Age	0.004	0.007	0.002	0.004	0.010	0.004	0.005	0.010	0.003	0.002	0.003	0.002
All Work	0.015	0.018	0.006	0.004	0.010	0.006	0.018	0.007	0.009	0.005	0.005	0.006
Urban	0.012	0.016	0.006	0.013	0.008	0.007	0.014	0.006	0.007	0.003	0.003	0.004
Children	0.014	0.018	0.006	0.015	0.010	0.008	0.016	0.008	0.008	0.005	0.005	0.006
Gender	0.004	0.012	0.006	0.017	0.012	0.009	0.018	0.009	0.009	0.005	0.005	0.006
Education	0.013	0.017	0.006	0.015	0.009	0.008	0.004	0.006	0.008	0.004	0.004	0.005
Social1	0.016	0.020	0.007	0.017	0.011	0.009	0.017	0.008	0.009	0.005	0.005	0.006
Social2	0.014	0.018	0.006	0.015	0.010	0.008	0.017	0.007	0.008	0.004	0.004	0.005
Single	0.019	0.024	0.011	0.020	0.015	0.011	0.019	0.011	0.010	0.007	0.006	0.008
Married	0.014	0.017	0.006	0.016	0.010	0.008	0.004	0.007	0.005	0.005	0.004	0.005
DM	0.041	0.061	0.026	0.037	0.039	0.025	0.043	0.028	0.024	0.009	0.010	0.011

STANDARD ERRORS OF MARGINAL EFFECTS 1987 (CONTINUED)

	Bacon & Ham (DH)			Chicken (IFP)			Minced Meat (DH)		
	Prob.	**Cond.**	**Uncond.**	**Prob.**	**Cond.**	**Uncond.**	**Prob.**	**Cond.**	**Uncond.**
Income	0.006	0.012	0.008	0.006	0.016	0.010	0.005	0.007	0.004
Age	0.005	0.011	0.004	0.002	0.005	0.003	0.005	0.003	0.002
All Work	0.018	0.007	0.009	0.014	0.010	0.008	0.018	0.004	0.005
Urban	0.014	0.005	0.007	0.012	0.008	0.006	0.014	0.004	0.004
Children	0.017	0.009	0.008	0.014	0.010	0.009	0.015	0.005	0.004
Gender	0.018	0.009	0.009	0.015	0.012	0.010	0.016	0.005	0.005
Education	0.016	0.006	0.008	0.013	0.010	0.007	0.019	0.004	0.004
Social1	0.019	0.008	0.009	0.016	0.011	0.009	0.004	0.004	0.003
Social2	0.017	0.006	0.008	0.014	0.010	0.007	0.003	0.004	0.002
Single	0.019	0.011	0.011	0.019	0.014	0.013	0.022	0.006	0.006
Married	0.004	0.007	0.005	0.015	0.011	0.008	0.017	0.004	0.004
DM	0.033	0.022	0.021	0.028	0.027	0.023	0.044	0.015	0.013

STANDARD ERRORS OF MARGINAL EFFECTS 1994

	Beef (IFP)			Lamb (DH)			Pork (DH)			Pork Products (IFP)		
	Prob.	**Cond.**	**Uncond.**	**Prob.**	**Cond.**	**Uncond.**	**Prob.**	**Cond.**	**Uncond.**	**Prob.**	**Cond.**	**Uncond.**
Income	0.005	0.026	0.009	0.004	0.012	0.007	0.003	0.011	0.007	0.005	0.007	0.006
Age	0.004	0.010	0.003	0.004	0.007	0.004	0.005	0.006	0.004	0.002	0.004	0.002
All Work	0.014	0.018	0.007	0.004	0.009	0.006	0.016	0.008	0.00	0.007	0.005	0.006
Urban	0.012	0.017	0.006	0.013	0.008	0.007	0.014	0.007	0.006	0.005	0.004	0.005
Children	0.014	0.020	0.009	0.015	0.010	0.008	0.015	0.008	0.008	0.011	0.008	0.006
Gender	0.004	0.012	0.006	0.016	0.010	0.009	0.016	0.009	0.008	0.007	0.005	0.007
Education	0.013	0.019	0.007	0.015	0.009	0.008	0.016	0.007	0.008	0.006	0.005	0.006
Social1	0.015	0.020	0.008	0.017	0.010	0.009	0.018	0.009	0.009	0.007	0.006	0.007
Social2	0.014	0.019	0.007	0.016	0.009	0.008	0.016	0.008	0.008	0.005	0.005	0.006
Single	0.018	0.024	0.011	0.019	0.014	0.011	0.017	0.011	0.010	0.011	0.008	0.009
Married	0.014	0.019	0.007	0.016	0.009	0.008	0.004	0.007	0.005	0.008	0.005	0.006
DM	0.030	0.053	0.021	0.034	0.038	0.025	0.035	0.026	0.021	0.013	0.012	0.012

STANDARD ERRORS OF MARGINAL EFFECTS 1994 (CONTINUED)

	Bacon & Ham (DH)			Chicken (IFP)			Minced Meat (DH)		
	Prob.	**Cond.**	**Uncond.**	**Prob.**	**Cond.**	**Uncond.**	**Prob.**	**Cond.**	**Uncond.**
Income	0.004	0.012	0.007	0.005	0.014	0.010	0.002	0.005	0.003
Age	0.005	0.008	0.005	0.002	0.005	0.004	0.004	0.005	0.002
All Work	0.016	0.009	0.009	0.010	0.011	0.010	0.013	0.003	0.004
Urban	0.014	0.007	0.008	0.009	0.009	0.009	0.011	0.002	0.004
Children	0.016	0.010	0.009	0.012	0.018	0.017	0.013	0.003	0.004
Gender	0.016	0.009	0.009	0.011	0.011	0.012	0.013	0.003	0.004
Education	0.016	0.008	0.009	0.011	0.011	0.010	0.011	0.002	0.004
Social1	0.018	0.010	0.010	0.013	0.013	0.012	0.001	0.002	0.001
Social2	0.017	0.008	0.009	0.012	0.012	0.010	0.001	0.002	0.001
Single	0.018	0.013	0.011	0.015	0.019	0.018	0.016	0.004	0.006
Married	0.003	0.009	0.005	0.014	0.014	0.011	0.013	0.003	0.004
DM	0.031	0.027	0.022	0.019	0.025	0.025	0.031	0.009	0.011

CHAPTER 6

AN ECONOMETRIC ANALYSIS OF IRISH HOUSEHOLD EXPENDITURE ON PREPARED MEALS

6.1 Introduction

In this chapter, Irish households' expenditure on prepared meals for home consumption is analysed using the 1987 and 1994 Irish Household Budget Survey datasets. The chapter aims to analyse the factors influencing households' choices to purchase these foods and how these factors differ between the two years. Tobit, double-hurdle and infrequency of purchase models, developed in Chapter 2, are applied to the data and the most appropriate modelling technique is chosen using relevant specification testing procedures.

As discussed in Chapter 1, Section 1.2.3, prepared meals form a small component of the overall prepared consumer foods sector but the sector as a whole is the fastest growing food sector in Ireland. The factors identified as contributing to the growth of the sector are discussed in Chapter 1, and have led to the emergence of a 'cash-rich, time-poor' consumer who view convenience as one of the most important attributes of the food products they consume (McCarthy and Pitts, 1999).

In Chapters 4 and 5, the negative effects of various socio-economic household characteristics on meat expenditure decisions were largely explained through strong convenience preferences of certain household groups. The main aim of this chapter is to identify differences in the pattern of expenditure on prepared meals of these household groups to confirm these convenience preferences.

6.2 Specification

The dependent variable in this analysis is household expenditure on prepared meals (see Chapter 3, Section 3.4.1 for a detailed description of this variable). As discussed in Chapter 3, information on the value of household expenditure only is collected and so quantity and quality effects cannot be separately identified. The dependent variable is assumed to be expressible as a linear combination of the vector of explanatory variables consisting of income and the various socio-economic characteristics, assumed to underpin tastes and preferences, listed in Table 6.1 (see Chapter 3, Section 3.4.2, for a detailed description of these variables).

Tobit, double-hurdle and infrequency of purchase models are applied to the prepared meals expenditure equation in both years as detailed in Chapter 2, Sections 2.2, 2.3 and 2.4 respectively. All explanatory variables are included as regressors in the tobit model, however, as discussed in Chapter 4, Section 4.2.2, and Chapter 5, Section 5.2, theory provides no guidance as to which explanatory variables to include in the first and second hurdles of the double-hurdle and infrequency of purchase models. Including the same set of regressors in each hurdle makes it difficult to identify the parameters of the model correctly. As with aggregate and disaggregate meat expenditure, exclusion restrictions must be imposed (Jones, 1992, Yen *et al.*, 1996). Economic factors, namely income and income squared, are excluded from the first equations of the double-hurdle and infrequency of purchase models and a probit model is also estimated for each prepared meals expenditure category in each year (see Appendix 6A). However, since none of the parameters are found to be statistically insignificant in both years, all socio-economic variables are included in the first equations of each model (see Table 6.2). The variance equation, as before, is specified as a function of the continuous variables of the model (Yen and Su, 1995, Jensen and Yen, 1996, Su and Yen, 1996).

6.3 Estimation

The tobit, double-hurdle and infrequency of purchase models, with specification adjustments for heteroscedasticity and non-normality, are estimated for household expenditure on prepared meals for each year by maximising the log of the relevant likelihood function, as detailed in Chapter 2, Section 2.6, using the Maxlik procedure in Gauss version 3.5 (for examples of the procedures used see Chapter 4, Appendix 4B). Likelihood ratio tests reject the restricted model of homoscedasticity in favour of the alternative variance specification (see Appendix 6B). Variables statistically insignificant in the variance equation are excluded with the final variance specification for the double-hurdle model including income only (see Table 6.4) and that for the tobit and infrequency of purchase model including both income and age (see Tables 6.3 and 6.5). The increase in the value of the log-likelihood (see Appendix 6C) and the significance of the θ parameter provides a justification for the use of the IHS specification (see Tables 6.3, 6.4 and 6.5). Likelihood ratio tests reject the tobit specification in favour of the two alternative models (see Appendix 6D). Finally, Vuong's (1989) non-nested test of model specification, detailed in Chapter 2, Section 2.7, is used to determine between the double-hurdle and infrequency of purchase models, with the double-hurdle model the appropriate choice in both years (see Appendix 6E).

Maximum likelihood estimates for the tobit, double-hurdle and infrequency of purchase models are presented in Tables 6.3, 6.4 and 6.5 respectively. In this analysis the application of Vuong's test for correct model specification is crucial due to the differences in the results obtained from the double-hurdle and infrequency of purchase models. In 1987 female-headed households, married households and households owning a freezer are significant in the participation equation of the double-hurdle model, but are insignificant in the purchase equation of the infrequency of purchase model. On the other hand, households of a professional social status are significant in the purchase equation of the infrequency of purchase model but insignificant in the participation equation of the double-hurdle model. In 1994, all working households are significant in the purchase equation but insignificant in the participation equation. The urban variable is significant in the participation equation but insignificant in the purchase equation. Differences can also be found in the expenditure equations of the models. For example, in 1987, children and gender are insignificant in the double-hurdle model but significant in the infrequency of purchase model, while single adult households are significant in the double-hurdle model but insignificant in the infrequency of purchase model. In 1994, opposite signs are observed for the effect of single adult households in the two models. This emphasises the importance of accurately testing for the correct model specification.

6.4 Empirical Results

The results discussed in this section are based on the most appropriate model specification, the double-hurdle model, adjusted for heteroscedasticity and non-normality. As already noted, the maximum likelihood estimates for the double-hurdle model of household expenditure on prepared meals are presented in Table 6.4. The marginal effects of the explanatory variables on the various components of the dependent variable and their associated standard errors are calculated as detailed in Chapter 2, Section 2.8. The marginal effects and associated standard errors for the double-hurdle model of Irish households' expenditure on prepared meals in 1987 and 1994 are presented in Table 6.6. These marginal effects are used to calculate elasticities for the continuous variables of the model, calculated at the sample means, and discrete effects for the categorical variables. These are presented in Table 6.7. The significance levels of these elasticities and discrete effects are based on the significance levels of their underlying marginal effects.

6.4.1 Income

Parameter Values

Income squared is included in the analysis to capture the possibility of a non-linear relationship between income and expenditure on prepared meals. In 1987 and 1994, income has a positive and significant effect, while income squared has a negative and significant effect on household expenditure on prepared meals (see Table 6.4). This implies that as household income increases, expenditure on prepared meals also increases. However, the magnitude of the increase will decline as income reaches higher levels.

Elasticity Estimates

Income elasticity estimates for the IHS heteroscedastic double-hurdle model are positive and significant for prepared meals in each year, at 0.380 in 1987 and 0.352 in 1994. Furthermore, the effects on the probability of participation and the conditional level of expenditure are also positive and significant. Evaluating the value of the 1994 unconditional income elasticity at the 1987 sample mean, adjusted for changes in the money value of income over time, reveals that between the two years the income elasticity has declined by 0.03 per cent (see Table 6.8). Furthermore, the difference in income elasticities between the two years is significant at the 1 per cent level.

This indicates that the responsiveness of household expenditure on prepared meals to changes in income is declining over time. Between 1987 and 1994, the constant money value of average per capita weekly household income levels increased from £93.62 to £95.06 respectively. The non-linear relationship found between household expenditure on prepared meals and income, coupled with the observed decline in income elasticities provides evidence that as income levels increase, it declines in importance as an explanatory factor in the decision to purchase prepared meals and how much to spend on them. In Chapter 1, Section 1.2.3, increasing consumer affluence is given as a characteristic driving the demand for prepared meals, however, at constant income levels the responsiveness of households' expenditure on prepared meals to changes in income has declined. The result observed in this analysis suggests that prepared meals follow the same pattern as other food expenditures, exhibiting a declining income elasticity as income levels increase.

6.4.2 Age

The effect of the age of the head of household on household expenditure on prepared meals is negative and significant in both years. This negative result is evident in the effect on the probability of purchase, the conditional level of expenditure and the unconditional level of expenditure. This result implies that the older the head of household, the less likely they are to purchase prepared meals. Of households that do participate in this market, the older the head of household the less, on average, that is spent on these food items.

Consistent with the literature outlined in Chapter 1, Section 1.2.3, this result suggests that younger headed households have a preference for a convenient lifestyle and so relative to older households purchase more prepared meals. However, between 1987 and 1994 the unconditional age elasticity has declined by just under a third. This implies that expenditure on prepared meals is less sensitive to the age of the head of household in 1994 compared with 1987, evidence that the preferences of old and young households with regard to expenditure on prepared meals are converging.

6.4.3 All-Working

The first discrete variable captures the difference between households where all adult members work and households where at least one adult member is without a job. The variable is negative and significant in 1987 but has an insignificant effect on overall expenditure on prepared meals in 1994. While the effect on the probability of participation is negative and significant in both years, the effect on the conditional level of expenditure is negative and significant in 1987 only.

This result is surprising as one would expect all working households to have a greater desire for time-saving, and therefore to spend more on convenience foods, since no adult member remains in the home engaged in home duties. Examination of the 1994 Household Budget Survey shows that the average per capita weekly expenditure of all-working households on food consumed away from home was £10.29, compared with other households who spent on average £4.49 weekly. This suggests that all-working household members could be substituting the more convenient alternative of eating out of home for any type of home-cooking alternatives.

6.4.4 Urban

The urban variable has a positive effect on prepared meals expenditure. The discrete effects show that households living in urban areas spent 17 per cent more on prepared meals than households living in rural areas in both 1987 and 1994. In both years urban households were 10 per cent more likely to participate in this market than rural households. Of all households that purchase these foods, urban households spent 7-8 per cent more.

As with the meat expenditure analyses in Chapters 4 and 5, this significant difference between urban and rural households could be identifying a difference in the choices urban and rural dwellers make with regard to home-cooking due to differences in the types of lifestyles they lead. For example, urban dwellers may face greater time constraints in commuting to and from work due to traffic congestion, and so have less time to prepare meals in the home. As a result, urban households are more 'time-poor' than their rural counterparts and so spend more on prepared meals. Another explanation may be that urban households have greater availability and choice of prepared meals on offer to them compared with rural households and so will be more likely to purchase these products and spend more on them.

6.4.5 Children

The presence of children in a household has a positive and significant effect on expenditure on prepared meals in both years. In 1987, the unconditional effect is 0.74 implying that overall households with children spent on average 74 per cent more on prepared meals than households without. In 1994, this effect has declined but remains substantial at 33 per cent. In 1994, the effect on the probability of participation is positive and significant while the effect on the conditional level of expenditure is negative and significant. This implies that households with children in 1994 were 40 per cent more likely to participate in the prepared meals market, but of all participating households, households with children spent 8 per cent less than households without.

From this result it can be suggested that while children demand more prepared meals, on an adult equivalent basis, they consume less per head due to the fact that they require smaller portions.

As outlined in Chapter 1, Section 1.2.3, the literature on the changing pattern of food demand suggests that increasingly consumers are adopting an individualistic lifestyle (Food Product Development Centre, 1997, Meat and Livestock Commission, 1997, Senauer *et al.*, 1998). This implies that the role of the family meal-eating occasion is declining as individual household members increasingly satisfy their own preferences and prepare and consume their own meals. Senauer *et al.* (1998) reveal that two-thirds of children in the U.S. prepared at least one meal a week without supervision in 1990. The effect of households with children on prepared meals found in this analysis could also be reflecting this pattern as households with children are more likely to purchase prepared meals, which children themselves could easily prepare.

6.4.6 Gender

Gender has a positive effect on household expenditure on prepared meals in both 1987 and 1994. In 1987, the unconditional effect of this variable is 11 per cent while in 1994 it has risen to 16 per cent. Furthermore, the effect on the conditional level of expenditure in both years is insignificant implying that the overall positive result is driven by the greater likelihood of participation of female-headed households in this food market than male-headed households in both years.

As outlined in Chapter 3, Section 3.1.2 and referred to in Chapter 5, Section 5.4.2, female-headed households cannot be considered traditional family-type households compared with male-headed households. Controlling for other factors, female-headed households are more likely to purchase prepared meals than male-headed households. In Chapter 5, Section 5.4.2 it was proposed that female-headed households were healthier than male-headed households. However, prepared meals are often perceived as less healthy than meals containing fresh homemade products. Therefore the most likely explanation for the positive effect of gender on this food category is that female-headed households have a greater desire for convenience than male-headed households.

The characteristics of female-headed households who participate in the prepared meals market and those who do not leads to the identification of two distinct female-headed household groups. Eighty-three per cent of participating female-headed households live in urban areas, 54 per cent have children, 43 per cent are single and 17 per cent are married. Their average age is 46 compared with the average age of non-participating female-headed households of 61. It can therefore be concluded that participating female-headed households are young, are more likely to live in urban areas and a large percentage of them have children. On the other hand, older female-headed households, 72 per cent of whom live alone are not participating in the market.

6.4.7 Education

While in 1987, the education level of the head of household is insignificant in explaining overall household expenditure on prepared meals, in 1994 educated-heads of household spent 12 per cent more on prepared meals than the base category. The difference in the effect of this variable over time is also evident in its effect on the probability of participation and the conditional level of purchase in each year. In 1987, education has an insignificant effect on the decision to participate in the prepared meals expenditure market, however, conditional on purchase, educated households spent 4 per cent less than the base category. In 1994, however, educated households were 11 per cent more likely to purchase prepared meals but conditional on purchase did not spend a significantly different amount than the base category.

The negative result observed in 1987 could be explained by the fact that educated households are more health conscious than the base category and perceive prepared meals to be unhealthy. However, the positive result observed in 1994 could illustrate a change in consumers' perception of this food category in relation to its perceived healthiness with educated households more likely to purchase these products than other households.

6.4.8 Social Status

Similar to the effect of education on prepared meals expenditure, the social status of the head of household is insignificant in explaining household expenditure on prepared consumer foods in 1987 but has a significant and positive effect on expenditure in 1994. In 1994, heads of household of a professional social status spent 10 per cent more overall on prepared meals than the base category, manual and agricultural workers, and farmers, while heads of household of an intermediate social status spent 6 per cent more than the base.

The positive effect of social status on prepared meals expenditure, as proposed in Chapters 4 and 5, could be attributed to the fact that professional households and households of an intermediate social status, face greater time constraints than other households and so have a greater preference for time-saving in meal preparation. As a result they are more likely to purchase prepared meals than other household groups. This possible time-saving preference can also be seen in the expenditure of these groups on food consumed away from home. The 1994 data set shows that professional households spend on average £22.48 weekly on food consumed away from home compared with the intermediate social group who spend on average £13.28 and the base category who spend on average £7.45.

6.4.9 Marital Status

Single adult

In both 1987 and 1994, the overall effect of single adult households is insignificant. However, examination of the breakdown of this effect into the effect on the probability of participation and the level of expenditure conditional on participation reveals some interesting findings. While single adult households are less likely to purchase prepared meals, those that do spend on average 14 per cent and 12 per cent more than the base category in 1987 and 1994 respectively.

The opposite results observed on the probability of participation and the conditional level of expenditure suggests that there are two opposing forces at work. Separating single adult households into participating and non-participating groups reveals that the average age of participating single adult households is 47 while the average age of non-participating single adult households is 62. While age is controlled for in the analysis, this observation provides some insight into the factors driving the expenditure decisions of single-adult households. The negative effect on the probability of participation could be attributed to the fact that many single-adult households are pensioners, living alone and so have more time to prepare home cooked meals. Therefore they do not require or demand the added value of convenience the purchase of prepared meals offers. On the other hand, of all participating households, single adult households spend more on prepared meals than other households, suggesting that they have a greater desire for convenience in the preparation of meals in the home. This could be explained by the fact that firstly, there is less incentive to prepare a home cooked meal when cooking for one and secondly, prepared meals are often conveniently packaged for one compared with other home-cooking alternatives.

Married couples

The discrete effect of this variable reveals that married couples spend more on prepared consumer foods than the base category in both 1987 and 1994. However, the magnitude of this effect has declined from 0.213 to 0.093 between the two years. In 1987, a positive effect is observed on both the probability of participation and the conditional level of expenditure. In 1994, however, the positive result is motivated by the fact that households containing a married couple are more likely to participate in the prepared meals market, but conditional on participation, spend on average less. This implies that while married couples are more likely to buy these products than other households, compared to other participating households they spend less.

The positive relationship between married households and meat expenditure revealed in Chapters 4 and 5, leads to the deduction that married households have a greater preference for home-cooked meals than other household. The results of this analysis, however, suggest that certain married households have a greater desire for convenience and therefore a greater likelihood of participation in the prepared meals market than other household groups. However, compared with other participating households married households spend less on prepared meals. This suggests that while convenience is of some importance to this household group relative to other households, they still have a greater preference for home-cooked meals than other participating households.

6.4.10 Household Appliances

In Chapter 1, Section 1.2.3, the growth in demand for prepared consumer foods was partly attributed to increased microwave and freezer ownership (Meat and Livestock Commission, 1997). For this reason household ownership of these appliances is included in this analysis. While these appliances are often not necessary for the consumption of prepared meals they can add to the convenience attribute of these products in terms of cooking and storage. Ownership of a microwave in particular is important as many prepared meal products can only be cooked using a microwave. As a result households without a microwave are automatically excluded from the consumption of certain prepared meal products.[32] In 1987, 6 per cent of surveyed households owned a microwave while 15 per cent owned a freezer. By 1994 these figures had risen to 46 per cent and 22 per cent respectively.

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[32] The Household Budget Survey does not break the prepared meals category into microwavable and non-microwavable and so this sample selection problem cannot be incorporated into the analysis.

Microwave

In 1987, household ownership of a microwave is insignificant in explaining overall expenditure on prepared meals. However, of all participating households, those that own a microwave spent 4 per cent more than those that do not. In 1994, households in possession of a microwave spent 24 per cent more overall on prepared meals than households without. They were 20 per cent more likely to participate in the market and conditional on participation, spent 4 per cent more. The fact that the overall effect of microwave ownership is insignificant in 1987 but positive and significant in 1994 could be attributed to the small sample of microwave owners in the 1987 dataset.

Ownership of a freezer

In 1987, households in possession of a freezer spent 11 per cent less overall on prepared meals than households without. This overall result is attributable to the negative effect of this variable on the probability of purchase, that is, households with a freezer are less likely to participate in the prepared meals market. This result could indicate that households with a freezer are less likely to participate in the market in the week surveyed due to the fact that they can store the goods for a longer period of time than households without a freezer. This suggests that this variable is reflecting an infrequency of purchase problem rather than non-participation as captured by the double-hurdle model. Yen and Huang (1996) identify that often survey data does not contain detailed enough information to correctly identify different sources of zero observations and the probability of consumption can also reflect the probability of purchase. This implies that infrequency of purchase can also be important within a double-hurdle framework. Using this reasoning, the result for the ownership of a freezer variable can therefore be interpreted in an infrequency of purchase context. In 1994, ownership of a freezer is insignificant in explaining expenditure on prepared meals.

6.5 Summary and Conclusions

This chapter applied tobit, double-hurdle and infrequency of purchase methodologies to Irish households' expenditure on prepared meals in 1987 and 1994. The double-hurdle model was found to be the most appropriate modelling technique based on relevant specification testing procedures.

The observed decline in the estimated income elasticities accompanied by the significant non-linear relationship between income and expenditure on prepared meals, identified in Section 6.4.1, provides evidence that the effect of income on prepared meals expenditure follows the same pattern as other food items. That is, as income increases, the influence it has on food expenditure decisions declines in importance. As with meat and disaggregated meat expenditure, understanding other factors shaping expenditure decisions becomes increasingly important with increasing income levels.

In this chapter, differences in the pattern of expenditure on prepared meals of different household groups are explained through differences in their preferences for convenience. Younger households, urban households, households with children, female-headed households and educated households of a professional social status, all have a greater preference for convenience than other households as illustrated in their expenditure patterns on prepared meals. All-working households purchase and spend less than other households on prepared meals, however average weekly household expenditure of this household group on food consumed out of home is substantially higher than other households. This suggests that all-working households substitute eating out of home for all types of home cooking. Mixed results are observed for the marital status variable. While the presence of a large number of older single adult households leads to a negative effect on the probability of this household group participating in the prepared meals market, younger urban dwelling single adult households exhibit a greater preference for convenience than other participating households by spending more on prepared meals. Similarly, while married couples are more likely to participate in the prepared meals market, compared to households with two or more unmarried adults, they spend less, suggesting that while they have some level of preference for convenience compared to other households, it is not as strong as for other household groups.

This chapter identified distinct relationships between the socio-economic characteristics of household groups and their preferences for convenience by analysing prepared meals expenditure patterns. In Chapter 7, these results are compared with those of Chapters 4 and 5 in an attempt to ascertain the types of household choosing prepared meals over home-cooked meat meal centres.

6A Tables

TABLE 6.1 EXPLANATORY VARIABLES IN EXPENDITURE EQUATIONS

Income
$Income^2$
Age
All-working
Urban
Children
Gender
Education
Social Status
Marital Status
Ownership of a Microwave
Ownership of a Freezer

TABLE 6.2 EXPLANATORY VARIABLES IN PROBIT PARTICIPATION/PURCHASE EQUATIONS

Age
All-working
Urban
Children
Gender
Education
Social Status
Marital Status
Ownership of a Microwave
Ownership of a Freezer

TABLE 6.3 MAXIMUM LIKELIHOOD ESTIMATES OF IHS HETEROSCEDASTIC TOBIT MODEL

	1987		1994	
	Expenditure	**Hetero**	**Expenditure**	**Hetero**
Constant	0.040***	-2.483***	0.064***	-1.340***
	(0.009)	(0.052)	(0.024)	(0.050)
Income	0.057***	0.175***	0.186***	0.108***
	(0.009)	(0.027)	(0.017)	(0.017)
$Income^2$	-0.004***		-0.024***	
	(0.003)		(0.004)	
Age	-0.023***	0.059***	-0.048***	0.046***
	(0.001)	(0.010)	(0.003)	(0.008)
All Working	-0.006**		-0.019**	
	(0.004)		(0.009)	
Urban	0.017***		0.053***	
	(0.003)		(0.008)	
Children	0.082***		0.076***	
	(0.005)		(0.010)	
Gender	0.012***		0.058***	
	(0.005)		(0.010)	
Education	-0.007***		0.008	
	(0.003)		(0.008)	
Social1	-0.003		0.007	
	(0.004)		(0.010)	
Social2	0.001		0.006	
	(0.003)		(0.009)	
Single	-0.047***		-0.079***	
	(0.006)		(0.014)	
Married	-0.004		-0.009	
	(0.003)		(0.009)	
Microwave	0.006		0.048***	
	(0.005)		(0.008)	
Freezer	-0.004		0.003	
	(0.003)		(0.008)	
IHS	3.450***		1.292***	
	(0.180)		(0.056)	
Log Likelihood	-424.51		-2387.11	

*** significant at 1% level, ** significant at 5% level, * significant at 10% level
Standard errors are given in parentheses.

TABLE 6.4 **MAXIMUM LIKELIHOOD ESTIMATES OF IHS HETEROSCEDASTIC DOUBLE-HURDLE MODEL**

	1987			**1994**		
	Part.	**Exp.**	**Hetero.**	**Part.**	**Exp.**	**Hetero.**
Constant	1.085*** (0.159)	0.046*** (0.007)	-2.499*** (0.034)	0.579*** (0.143)	0.134*** (0.017)	-1.540*** (0.035)
Income		0.034*** (0.006)	0.090*** (0.023)		0.094*** (0.011)	0.058*** (0.017)
Income^2		-0.011** (0.002)			-0.011*** (0.002)	
Age	-0.329*** (0.022)	-0.002** (0.001)		-0.219*** (0.020)	-0.008*** (0.002)	
All Working	-0.031 (0.091)	-0.011** (0.003)		-0.100 (0.080)	-0.001 (0.006)	
Urban	0.082 (0.072)	0.013*** (0.002)		0.124** (0.062)	0.030*** (0.005)	
Children	1.603*** (0.094)	-0.004 (0.003)		1.015*** (0.098)	-0.031*** (0.007)	
Gender	0.246*** (0.091)	-0.001 (0.004)		0.420*** (0.073)	-0.002 (0.007)	
Education	0.095 (0.083)	-0.007*** (0.002)		0.232*** (0.073)	0.006 (0.006)	
Social1	0.086 (0.090)	-0.002 (0.003)		0.258*** (0.080)	-0.003 (0.007)	
Social2	0.035 (0.078)	0.002 (0.002)		0.132* (0.074)	0.000 (0.006)	
Single	-0.621*** (0.098)	0.023*** (0.005)		-0.479*** (0.088)	0.047*** (0.010)	
Married	0.213*** (0.085)	0.101*** (0.003)		0.371*** (0.082)	-0.017*** (0.006)	
Microwave	0.050 (0.141)	0.006 (0.004)		0.418*** (0.060)	0.015*** (0.005)	
Freezer	-0.182* (0.098)	-0.001 (0.003)		0.114 (0.074)	-0.006 (0.005)	
IHS		5.039*** (0.247)			2.084*** (0.092)	
Log Likelihood		-169.22			-2102.26	

*** significant at 1% level, ** significant at 5% level, * significant at 10% level
Standard errors are given in parentheses.

TABLE 6.5 MAXIMUM LIKELIHOOD ESTIMATES OF IHS HETEROSCEDASTIC INFREQUENCY OF PURCHASE MODEL

	1987			1994		
	Part.	**Exp.**	**Hetero.**	**Part.**	**Exp.**	**Hetero.**
Constant	1.302***	0.032***	-2.524***	0.778***	0.091***	-1.569***
	(0.150)	(0.005)	(0.069)	(0.128)	(0.013)	(0.069)
Income		0.027***	0.082***		0.080***	0.055***
		(0.005)	(0.025)		(0.009)	(0.017)
Income^2		-0.007***			-0.009***	
		(0.002)			(0.002)	
Age	-0.271***	-0.007***	-0.045***	-0.182***	-0.016***	-0.042***
	(0.021)	(0.001)	(0.012)	(0.018)	(0.002)	(0.011)
All Working	-0.074	-0.007***		-0.137**	-0.004	
	(0.072)	(0.002)		(0.063)	(0.005)	
Urban	-0.022	0.011***		0.030	0.028***	
	(0.058)	(0.002)		(0.050)	(0.004)	
Children	1.063***	0.031***		0.753***	0.022***	
	(0.070)	(0.003)		(0.066)	(0.005)	
Gender	0.108	0.005*		0.322***	0.018***	
	(0.076)	(0.003)		(0.058)	(0.005)	
Education	0.048	-0.005***		0.157***	0.009**	
	(0.067)	(0.002)		(0.058)	(0.005)	
Social1	0.133*	-0.002		0.178***	0.004	
	(0.075)	(0.002)		(0.064)	(0.005)	
Social2	0.029	0.002		0.127**	0.004	
	(0.061)	(0.002)		(0.059)	(0.005)	
Single	-0.542***	-0.005		-0.421***	-0.013*	
	(0.082)	(0.004)		(0.069)	(0.007)	
Married	0.063	0.006***		0.280***	-0.007	
	(0.068)	(0.002)		(0.063)	(0.005)	
Microwave	0.062	0.004		0.280***	0.026***	
	(0.130)	(0.003)		(0.048)	(0.004)	
Freezer	-0.088	-0.002		0.087	-0.002	
	(0.082)	(0.002)		(0.060)	(0.004)	
IHS		6.340***			2.602***	
		(0.355)			(0.130)	
Log Likelihood		-199.46			-2120.11	

*** significant at 1% level, ** significant at 5% level, * significant at 10% level
Standard errors are given in parentheses.

TABLE 6.6 MARGINAL EFFECTS FOR IHS HETEROSCEDASTIC DOUBLE-HURDLE MODEL

	1987			1994		
	Prob.	**Cond.**	**Uncond.**	**Prob.**	**Cond.**	**Uncond.**
Continuous						
Income$^{\theta}$	0.066***	0.032***	0.025***	0.050***	0.067***	0.056***
	(0.007)	(0.003)	(0.002)	(0.015)	(0.020)	(0.006)
Age	-0.093***	-0.001**	-0.011***	-0.064***	-0.006***	-0.024***
	(0.006)	(0.001)	(0.001)	(0.005)	(0.002)	(0.002)
Discrete						
All Working	-0.034*	-0.008***	-0.008***	-0.027*	-0.001	-0.009
	(0.024)	(0.002)	(0.003)	(0.020)	(0.005)	(0.007)
Urban	0.052***	0.009***	0.011***	0.059***	0.023***	0.032***
	(0.019)	(0.002)	(0.002)	(0.016)	(0.004)	(0.006)
Children	0.424***	-0.003	0.047***	0.239***	-0.024***	0.061***
	(0.021)	(0.002)	(0.003)	(0.018)	(0.006)	(0.007)
Gender	0.064***	-0.001	0.007***	0.108***	-0.002	0.033***
	(0.022)	(0.003)	(0.003)	(0.017)	(0.005)	(0.007)
Education	0.010	-0.005***	-0.001	0.066***	0.004	0.023***
	(0.021)	(0.002)	(0.003)	(0.019)	(0.004)	(0.006)
Social1	0.018	-0.002	0.001	0.065***	-0.003	0.019***
	(0.024)	(0.002)	(0.003)	(0.021)	(0.005)	(0.007)
Social2	0.015	0.002	0.003	0.034**	-0.000	0.011**
	(0.021)	(0.002)	(0.003)	(0.019)	(0.005)	(0.006)
Single	-0.114***	0.016***	-0.004	-0.084***	0.037***	-0.004
	(0.028)	(0.004)	(0.004)	(0.024)	(0.008)	(0.009)
Married	0.081***	0.007***	0.013***	0.082***	-0.014***	0.018***
	(0.022)	(0.002)	(0.013)	(0.019)	(0.005)	(0.007)
Microwave	0.027	0.004*	0.005	0.123***	0.012***	0.046***
	(0.036)	(0.003)	(0.004)	(0.015)	(0.004)	(0.006)
Freezer	-0.052**	-0.001	-0.006**	0.025*	-0.005	0.005
	(0.025)	(0.002)	(0.003)	(0.019)	(0.004)	(0.007)

*** significant at 1% level, ** significant at 5% level, * significant at 10% level
Standard errors are given in parentheses.
$^{\theta}$The marginal effect of income is calculated including income^2.

TABLE 6.7 ELASTICITY ESTIMATES AND DISCRETE EFFECTS FOR IHS HETEROSCEDASTIC DOUBLE-HURDLE MODEL

	1987			1994		
	Prob.	**Cond.**	**Uncond.**	**Prob.**	**Cond.**	**Uncond.**
Elasticities						
Income$^{\theta}$	0.114***	0.266***	0.380***	0.099***	0.253***	0.352***
Age	-0.851***	-0.055**	-0.906***	-0.552***	-0.096***	-0.648***
Discrete Effects						
All Working	-0.063*	-0.066***	-0.130***	-0.046*	-0.002	-0.048
Urban	0.096***	0.078***	0.174***	0.100***	0.073***	0.173***
Children	0.767***	-0.024	0.743***	0.405***	-0.078***	0.328***
Gender	0.113***	-0.007	0.106***	0.170***	-0.006	0.165***
Education	0.017	-0.042***	-0.025	0.109***	0.014	0.123***
Social 1	0.033	-0.014	0.018	0.105***	-0.009	0.096***
Social 2	0.028	0.016	0.044	0.057**	-0.001	0.056**
Single	-0.253***	0.143***	-0.109	-0.163***	0.121***	-0.042
Married	0.150***	0.063***	0.213***	0.136***	-0.043***	0.093***
Microwave	0.050	0.037*	0.088	0.205***	0.038***	0.243***
Freezer	-0.099**	-0.008	-0.107***	0.041*	-0.014	0.026

*** significant at 1% level, ** significant at 5% level, * significant at 10% level
Significance levels are based on significance levels of the underlying marginal effects.
$^{\theta}$The marginal effect of income is calculated including income^2.

TABLE 6.8 UNCONDITIONAL INCOME ELASTICITY ESTIMATES EVALUATED AT 1987 SAMPLE MEANS FOR IHS HETEROSCEDASTIC DOUBLE-HURDLE MODEL

	1987		1994♣
Unconditional Income Elasticity$^{\theta}$	0.380***		0.347***
Difference $z = 2.326$ Stat = 7.21❑		0.033***	

*** significant at 1% level, ** significant at 5% level, * significant at 10% level
Significance levels are based on significance of underlying marginal effects.
$^{\theta}$The marginal effect of income is calculated including income^2.
♣Evaluated at 1987 mean adjusted to 1994 market prices using the Consumer Price Index (Central Statistics Office, 1988, 1995).
❑ See Chapter 4, Table 4.10 for details of testing procedure.

6B Appendices

Appendix 6A **PROBIT MODELS OF THE DECISION TO PARTICIPATE/PURCHASE PREPARED MEALS**

Variable	1987	1994
One	0.559***	0.260***
	(0.102)	(0.094)
Age	-0.241***	-0.164***
	(0.013)	(0.012)
All Working	-0.095**	-0.053
	(0.047)	(0.042)
Urban	0.159***	0.140***
	(0.038)	(0.037)
Children	0.962***	0.482***
	(0.043)	(0.040)
Gender	0.059	0.218***
	(0.051)	(0.043)
Education	-0.049	0.165***
	(0.042)	(0.041)
Social1	0.081	0.244***
	(0.050)	(0.047)
Social2	0.058	0.134***
	(0.045)	(0.043)
Single	-0.565***	-0.459***
	(0.063)	(0.053)
Married	-0.039	0.054
	(0.044)	(0.042)
Microwave	0.043	0.329***
	(0.071)	(0.035)
Freezer	-0.043	0.105***
	(0.048)	(0.042)
Log Likelihood	-3642.00	-4118.26

*** significant at 1% level, ** significant at 5% level, * significant at 10% level
Standard errors are written in parentheses.
Estimated using the Maxlik procedure in Gauss version 3.5.

Appendix 6B LIKELIHOOD RATIO TESTS OF HOMOSCEDASTICITY RESTRICTION

H_0=Homoscedastic Error Structure H_1=Heteroscedastic Error Specification		
Tobit Model		
	1987	**1994**
Test Statistic	47.86	277.49
Critical Value $\chi^2_{2,0.01} = 9.21$	Reject null hypothesis	Reject null hypothesis
Double Hurdle Model		
	1987	**1994**
Test Statistic	32.56	305.19
Critical Value $\chi^2_{2,0.01} = 9.21$	Reject null hypothesis	Reject null hypothesis
Infrequency of Purchase Model		
	1987	**1994**
Test Statistic	29.05	121.73
Critical Value $\chi^2_{2,0.01} = 9.21$	Reject null hypothesis	Reject null hypothesis

Appendix 6C LOG LIKELIHOOD VALUES OF STANDARD HETEROSCEDASTIC MODELS V'S IHS HETEROSCEDASTIC MODELS

Tobit Model		
	1987	**1994**
Standard Hetero. model	-1834.10	-4089.36
IHS Hetero model	-424.51	-2387.11
Double Hurdle Model		
	1987	**1994**
Standard Hetero. model	-1637.49	-3915.56
IHS Hetero. model	-169.21	-2101.02
Infrequency of Purchase Model		
	1987	**1994**
Standard Hetero. model	-1652.16	-3857.56
IHS Hetero. model	-199.46	-2120.11

Appendix 6D LIKELIHOOD RATIO TESTS OF TOBIT SPECIFICATION

	1987	1994
	H_0=Tobit Specification **H_1=Double Hurdle Specification**	
Test Statistic	510.58	569.69
Critical Value $\chi^2_{13,0.01} = 27.69$	Reject null hypothesis	Reject null hypothesis

	1987	1994
	H_0=Tobit Specification **H_1=Infrequency of Purchase Specification**	
Test Statistic	450.10	534.00
Critical Value $\chi^2_{13,0.01} = 27.69$	Reject null hypothesis	Reject null hypothesis

Appendix 6E VUONG'S TEST FOR MODEL SPECIFICATION

	1987	1994
	H_0=IFP and DH Models are equivalent❖	
Test Statistic	4.437	7.361
Critical Value z = 2.326	Reject null in favour of DH model	Reject null in favour of DH Model

DH: Double Hurdle Model, IFP: Infrequency of Purchase Model, H_0: Null Hypothesis

❖ See Chapter 2, Section 2.7.

CHAPTER 7

SUMMARY AND POLICY IMPLICATIONS

7.1 Overview

The market for food has experienced change in terms of the way in which both economic and demographic factors affect the environment in which the sector operates (Smallwood *et al.*, 1986). In Chapter 1 of this thesis, the changing pattern of food consumption is outlined and the importance of two sectors of the industry, meat and prepared meals, to the Irish food sector is emphasised. A number of factors are identified as influencing the demand for these food items with the main implication being a decline in the importance of price and income factors. Simultaneously, socio-economic factors increasingly determine the demand for food as they are assumed to underpin consumers' tastes and preferences. Specifically, convenience and health have become significant preferences of many household groups. Using this information, both industry and policy makers can be better informed as to what influences their consumers. In this thesis, expenditure patterns of Irish households in 1987/8 and 1994/5 are analysed in an attempt to explain the factors influencing household expenditure on meat and prepared meals.

In Chapter 2, the econometric methodology specific to modelling household expenditure using micro survey data, in the presence of zero observations on the dependent variable, is discussed in detail. This entails a description of the three relevant models, the tobit, double-hurdle and infrequency of purchase models, the estimation procedures applied, relevant specification issues and the interpretation of parameters.

In Chapter 3, aspects of the 1987/8 and 1994/5 Irish Household Budget Survey datasets are introduced. The sample and variables used in the analyses of the thesis are described with specific attention paid to describing the chosen dependent and independent variables and how they relate to each other.

In Chapters 4, 5 and 6, Irish households' expenditure patterns on aggregate meat, disaggregated meat categories and prepared meals are analysed using the methodologies outlined in Chapter 2 and the data described in Chapter 3. In Section 7.2, the results of these analyses are summarised and compared.

7.2 Summary of Results

7.2.1 Economic Factors

Income and income squared are the only economic factors included in these models (see Chapter 3, Section 3.4.1 for a discussion on price related issues). The effects of these factors are similar for all expenditure categories. Firstly, in each expenditure equation, the inclusion of income squared captures a significant non-linear relationship between income and expenditure. This means that at higher income levels, the effect of income on expenditure declines in magnitude.

The second feature of the income effect is that it is small in magnitude compared to income elasticities estimated in other studies (Boyle, 1996). This issue is addressed in Chapter 5, Section 5.4, and is mainly attributed to the fact that in cross-sectional analyses, socio-economic effects are also taken into account reducing the magnitude of the estimated elasticity.

The final and most significant finding is that the magnitude of the income elasticity estimate has declined for all expenditure categories, even for similar income levels. This result is consistent with the literature emphasising the decline in the importance of economic factors in food consumption/expenditure decisions.

The main implication of these findings is that in order to encourage increased participation and expenditure in aggregate and disaggregated meat markets and in the market for prepared meals, the industry needs to identify other factors influencing expenditure decisions.

7.2.2 Socio-economic factors

In Chapters 4 and 5, convenience and perceived healthiness were the main explanations given for the observed differences in household expenditure patterns on aggregate and disaggregated meat categories. In Chapter 6, households' preferences for convenience are explored further by analysing their expenditure decisions regarding prepared meals. This section summarises the way in which households' socio-economic characteristics relate to their demand for these attributes.

Convenience

The preference for convenience among certain household groups, can be identified based on their aggregate and disaggregated meat expenditure patterns and can be re-enforced by analysing their preferences for prepared meals, a more convenient alternative. Younger households, all-working households, urban households, female-headed households, educated households, professional households and single adult households all exhibit expenditure patterns suggestive of a greater desire for convenience compared with other households. For younger households, all-working households, urban households, educated households and professional households this can be attributed to time constraints imposed by the lifestyles which they lead, relative to other households. For female-headed and single adult households it can be attributed to the fact that these household groups are not typical family households in a traditional sense, and so purchase convenient alternatives to better suit non-family oriented eating habits. Households with children and married households do not exhibit stronger preferences for convenience compared with other household groups. While these households consume convenient food products, the deduction can be made that they have a greater preference for traditional meal centres compared with other households.

Examination of the effect of both the education level and the social status of the head of household on disaggregated meat expenditure categories reveals another dimension to the analysis. The results suggest that, despite their preference for convenience, both educated and professional households possess a 'snob' or 'bourgeoisie' preference for traditional cuts of meat, which they will choose over other cuts of meat when they do decide to cook in the home.

Health

In Chapter 4, it is noted that explaining differences in household meat expenditure patterns with attitudes and preferences regarding health issues is difficult due to the diversity of products the aggregate meat category entails. Furthermore, in Chapter 5 it is concluded that it is difficult to deduce the different degrees of health consciousness of different household groups based on their meat expenditure patterns, without specific attitudinal data on individual households. Nevertheless certain deductions regarding the health consciousness of different household groups are made. For example, it is proposed that younger headed households, female-headed households and educated households exhibit meat expenditure behaviour suggestive of a greater level of health consciousness compared with other households. This is evidenced by a negative relationship between these variables and the aggregate meat expenditure category. However, on examination of disaggregated meat expenditure patterns, this hypothesis only holds true for female-headed households who exhibit preferences for white over red meats compared with male-headed households. The results for age and education are better explained through convenience and 'snob' preferences as outlined in the previous section.

7.3 Data Problems

In this thesis it is assumed that socio-economic factors underpin the tastes and preferences of the consumer. It is therefore individual tastes and preferences that determine household expenditure patterns and which, therefore, must be understood in order to influence consumer behaviour. This thesis attempts to accomplish this as accurately as possible. However, certain issues are excluded that could potentially strengthen the analysis and expand its possibilities.

Firstly, in Chapter 1, the two most important attributes of food, from the perspective of the consumer, were identified as convenience and perceived healthiness. The dataset used in this thesis does not provide enough information on households to model attitudes and preferences directly in the analysis. In this thesis, the observed expenditure patterns on meat and prepared meals are used to make deductions about the preference for these attributes of different household groups. Attitudinal data would allow analyses, such as this, to accurately determine household preferences instead of relying on speculative deductions.

An important aspect of food demand, excluded from this analysis and addressed in Chapter 3, Section 3.4.1, is the issue of quality and the degree to which it impacts on the demand for food. The lack of price and quantity data in the Irish Household Budget Survey dataset makes it impossible to incorporate this important issue into expenditure analyses.[33]

Finally, in this thesis, the economic agent concerned is the household. However, households can be made up of a number of individuals with different tastes and preferences. The socio-economic characteristics of households, in the majority of cases refer to the head of household as defined in Chapter 3, Section 3.4.2. However, food expenditure decisions are made for the entire household. One possibility is to analyse

[33] Analysing household demand for quality would also allow more meaningful deductions to be made about households' levels of health consciousness.

single adult households in isolation (Burton *et al.*, 1996), however, as revealed in this thesis, the expenditure patterns and preferences of single-adult households differ from other household groups. For this reason, analysing this household group in isolation would not reflect the expenditure decisions or tastes and preferences of the true population.

7.4 Implications and Conclusions

Despite the problems discussed in Section 7.3, this research is the first of its kind to model household food expenditure patterns at a micro level. Sophisticated econometric techniques were applied to the latest survey data available in an attempt to calculate the most accurate income elasticities to date in the country and to examine the impact of socio-economic factors on food expenditure decisions for the first time. The main implication of the results observed in the analyses conducted in this thesis is that economic incentives alone may not be as effective in maintaining or stimulating demand for food products as campaigns marketing the attributes of food that changing lifestyles demand. In the case of meat, examples may include identifying ways in which meat can be conveniently prepared or providing information about the nutritional value of meat. For prepared meals, focusing on quality and nutritional aspects could encourage consumption.

In the late 1990s and early 2000s, lifestyles across Europe and more specifically in Ireland have been converging. An increase in the proportion of the Irish population of working age, an increase in third level graduates, an explosion of population in urban areas, and government incentives aimed at expanding labour supply increasing the number of all-working households in Ireland, will all shape the food market of the future. It is therefore increasingly important for the food industry to identify the attributes of food products desired by this type of consumer who forms an increasing proportion of the Irish and European population.

7.5 Future Research

The first recommendation for future research is to extend the methodologies applied in this thesis to incorporate recent developments in the econometric literature. One such extension could be to apply an integrated approach to modelling household expenditure, integrating both double-hurdle and infrequency of purchase approaches (Kimhi, 1999). Another possibility is to extend the linear functional form typically used in these kinds of analyses to incorporate more sophisticated elements of consumer demand theory e.g. an Almost Ideal Demand System Approach (see Moro and Sckokai (2000) for an example of a demand system incorporating socio-economic variables).

It is difficult to make inferences about Irish households' future expenditure patterns based on data from 1987/8 and 1994/5. The second recommendation with regard to future research is therefore the extension of this research to incorporate the 2000 Household Budget Survey dataset, which will become available at the end of 2001. This will allow crucial developments in the food sector to be incorporated into the analysis. With food scares like the BSE crisis and Foot and Mouth disease, consumers' perceptions of the food industry and particularly the meat industry have changed. Due to increased health concerns and awareness about food safety and animal welfare issues, the structure of preferences and the way in which expenditure decisions are made are likely to differ substantially in 2000 compared with the year 1994. Analysing preferences in the year 2000 would also contribute substantially to the analysis of prepared meals as the economic boom in Ireland since 1994 is likely to have altered Irish consumers' preferences for food. Recent trends in Ireland such as increasing incomes, increasing female participation in the labour force, rural to urban migration *etc.* will contribute to the factors significant in determining the consumption of convenience food items.

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