International Review of Entrepreneurship, Article #1685, 20(4): pp. 477-494.

From IT Investment Opportunity to Realising Investment at Scale

Marc Cowling[1]
Oxford Brookes Business School, Oxford Brookes University, United Kingdom

Weixi Liu
School of Management, University of Bath, United Kingdom

Tim Vorley
Oxford Brookes Business School, Oxford Brookes University, United Kingdom

Abstract. Investing in information technology allows firms to enhance their capabilities and performance and in doing so grow and create value. Yet we still lack a detailed understanding about how this process occurs. In this paper we are able to trace out the pathway from identifying an opportunity to invest in ICT, through the decision to realise an investment or not, and if it does progress at what scale. Using a large bespoke UK business survey about investment decision-making, our initial results show that 72% of firms had an ICT investment opportunity but, of those who had an opportunity, only 70% took advantage of their opportunity. Of those that did the scale of investment was between £50,000 and £100,000 on average. ICT opportunities, investments, and scale of investment were increasing in firm size but negatively related to firm age. Investment scale rose as the ability to secure equity funding increased. In this respect, smaller firms may be at a relative disadvantage in terms of their ability to take advantage of ICT opportunities and this is problematic as they are also less likely to identify opportunities *per se*.

Keywords: ICT, investment appraisal, capital budgeting.

Acknowledgements: This work is supported by the Ministry of Economy, Finance and European Funds of the Andalusian Regional Government (Junta de Andalucía-Consejería de Economía, Hacienda y Fondos Europeos) through Andalusia ERDF 2014-20 Operational Programme (Programa Operativo FEDER Andalucía 2014-20) under University of Huelva research project UHU-1265299.

1. Introduction

The 4th Industrial Revolution has been driven forward by great leaps forward in information and communication technologies (ICTs, Moavenzadeh, 2015). The use and application of ICT has fundamentally changed the way firms do business,

1. Corresponding author: Marc Cowling, Oxford Brookes Business School, Oxford Brookes University, Headington Campus, Headington Rd, Headington, Oxford OX3 0BP, United Kingdom. Telephone: +44(0) 1865 485858. Email: mcowling@brookes.ac.uk

and enhanced their capabilities and the general level of competitiveness (Bagnoli, Dal Mas and Massaro, 2019; Caputo, Riso, Romano and Maalaoui, 2022). Nowhere have these technology-driven transformations been more evident than in the entrepreneurial sector of the economy where large numbers of SMEs have embraced ICT as enablers of growth and value creation (Nambisan, 2017). Yet as with all revolutions there are winners and losers and the Covid-19 pandemic has highlighted how firms' ability to embrace and harness ICT to address new ways of doing business has led to even greater variation in business performance, particularly amongst resource constrained SMEs.

Whilst theory and evidence building in the field of entrepreneurship on this issue of embracing ICT is not fully formed, but has certainly expanded during the Covid-19 pandemic, it is also the case that established theories in other fields may usefully be brought to bear on many of the key gaps in our knowledge. For example, corporate finance and economics both have well developed theories on the how, and why, firms make investment decisions. Entrepreneurship, in contrast, spends a lot of time considering opportunity and, as most entrepreneurial firms are small and young, whether there are internal and external resource constraints that inhibit and constrain entrepreneurial firms from realising their opportunities. However, neither discipline really get into detailed conversations about whether or not firms actually have an investment opportunity in the first place.

It is the intention in this paper to try to reconcile these two streams of literature around a common theme – ICT adoption and investment – and examine the entire process in full. Using a large bespoke UK business survey about investment decision-making, collected by CATI interviewing in 2018, and with a final sample of 1,501 businesses, we are able to initially trace out who has an opportunity for productive investment in ICT. Conditional upon having an opportunity we are also able to establish what types of firms turn this opportunity into a reality by formally making an investment. The final piece of the causal pathway is that we are able to put a cash figure on the investments in ICT that are realised. In this respect we hope to add significant new knowledge and understanding of the "who invests in ICT?". We have access to a bespoke new financing decisions and investment survey containing the responses from 1,501 UK businesses spread across the business population and including all size, age and industry classes. This unique survey allows us to explore new research questions and identify the entire causal process from identifying an opportunity, through to realisation and the cash scale of investment.

Our evidence shows that 72% of businesses have identified an opportunity to invest in ICT, but only 70% actually invested in their ICT opportunity. The typical scale of ICT investment was in the region of £50,000 - £100,000 and it appears that ICT is a large and significant investment for many firms. Our key findings from our econometric analysis are that firm size is positively associated with opportunity, actual investment, and investment scale. In contrast, younger

firms were more likely to invest in ICT given an opportunity. On investment scale, we find that exporting firms invested more in ICT as did firms that were able to secure external equity. Overall, our findings suggest that not all SMEs are able to embrace ICT but there is certainly a desire from the early-stage entrepreneurial firms to commit to ICT investments that is less evident in older established firms. Capital markets also play an important role in facilitating ICT investment and we find as firms are able to access more sources of external finance, their ability to invest at scale increases significantly.

The rest of the paper is organised as follows: In Section 2 we identify and summarise key literatures relating to opportunity identification and investment. Section 3 discusses our data set and presents key univariate statistics. In Section 4 we conduct our core modelling of the three steps in the investment process and discuss key findings. We conclude in Section 5 with a discussion of what the implications of our key findings are for investment.

2. Literature Review

In this section, we first review the general literature on the evaluation and implementation of capital asset investment opportunities, followed by studies that specifically look at investment in ICT projects.

2.1. The Identification and Realisation of Investment Opportunities

It is widely accepted in financial economic theories, that corporations evaluate potential investment opportunities by examining the risk-adjusted return of the project (Brealey, Myers and Allen, 2020). Here the Capital Asset Pricing Model (CAPM), and more recent capital market theories, such as the Arbitrage Pricing Theory, determine the required rate of return from the project, which is often used jointly with investment appraisal techniques such as discounted cash flow models to compare the expected return and the cost of the investment. Under the CAPM, assuming perfect capital market with costless diversification, the only risk that matters is the systematic risk, market-wide variability in returns that cannot be eliminated through diversification; and the required rate of return is defined as the compensation for the systematic risk associated with the asset.

Earlier research following this stream of theories contends that firm size, managerial knowledge and organisational change are three main causes for varying capital budgeting practices by smaller companies (Sangster, 1993). For example, firm size is commonly seen as a proxy for diversification costs (Aron, 1988), and thus larger firms are likely to have a lower cost of capital through a more diversified investment portfolio. However, the assumptions of both perfect capital market and managerial rationality in decision-making are less likely to

hold for small businesses. Graham and Harvey (2001) in their seminal study of corporate finance practice in the US, find that smaller companies are significantly less likely to use capital budgeting techniques. Small businesses usually have more volatile projects and with limited financial management capability, their investment appraisal can be based on ad hoc decision rules (McDonald, 2000), and subject to behavioural biases such as heuristic and anchoring (Graham and Harvey, 2001). Smaller firms usually lack the resources for, and experience in, investment evaluation, and are found to believe firm profit is unrelated to capital budgeting (Lazaridis, 2004).

SMEs, compared to large firms, also lack the resource, be it physical, financial or human, to appraise investment projects using sophisticated capital budgeting techniques. As a result, they have to rely on some non-sophisticated but less resource-demanding techniques or even rules of thumb (Peel, 1999; Arnold and Hatzopoulos, 2000; Lazaridis, 2004; Danielson and Scott, 2006; Harjoto and Paglia, 2012), which may lead to distorted investment decisions. Accordingly, a stream of recent research has adopted a resource-based view to complement traditional corporate finance theories. Penrose (1959: 136-137), in her widely acknowledged and seminal work, stated that: "*In entering any new field, a firm must consider not only the rate of return it might expect on its new investment, but also whether or not its resources are likely to be sufficient for the maintenance of the rate of investment that will be required to keep up with competitors' innovations and expansion in its existing fields, as well as in the new one*." Here resources refer to both firm level and wider human capital and firms with access to those resources see a wider range of investment opportunities than firms' with less versatile resources (Kor and Mahoney, 2000).

Whereas the identification of investment opportunities is explained from a finance and resource-based perspective, the decision to actually pursue an investment opportunity is usually a finance one. Since external finance is not costless, firms with financing needs will primarily look into internal sources of funds and only turn to external sources when internally generated funds cannot satisfy the firm's capital requirement (Myers, 1984; Myers and Majluf, 1984). When external finance is required, debt is preferred to equity. Empirical evidence on SMEs is generally consistent with the pecking order hypothesis (Michaelas, Chittenden and Poutziouris, 1999; Revest and Sapio, 2012) with commercial (high street) bank loans being the most common source of external funding (Colombo and Grilli, 2007; De Bettignies and Brander, 2007). However, credit rationing, particularly in the context of the small business sector, has been well-documented in theoretical and empirical studies (Berger and Udell, 1992 and 1998; Hall and Lerner, 2010). The issue of 'unfair' credit rationing, that is not based on firm quality (Stiglitz and Weiss, 1981), has been the focus of a large volume of literature (Cowling and Mitchell, 2003; Fraser, 2009), and has been used to justify government intervention such as loan guarantee programmes (Cowling and Clay, 1994; Riding, 1997; Cowling, 2010; Cowling and Siepel,

2013). Therefore, SMEs' decision to realise investment opportunities and the scale of investment are likely to be constrained by internal funds, or free cash flow, available, which are positively related to firm size, age, and performance in general.

2.2. ICT Investment Decision-Making

Information and communication technologies continuously produce great opportunities but are usually associated with significant uncertainties as well (Larsen, 2003; Ritchie and Brindley, 2005). SMEs are flexible organisations that can easily adapt to new technology innovations, such as ICT. However, SMEs' adoption of ICT is inevitably hindered by their small size, lack of required knowledge and skills, and slack in committing to provide these resources (Boekhoudt and Van der Stappen, 2004; Lucchetti and Sterlacchini, 2004; Lumpkin and Dess, 2004; Ritchie and Brindley, 2005). Consistent with both the resource-based view and the financial constraints literature, ICT adoption is positively related to firm size (Lucchetti and Sterlacchini, 2004; Jeon, Han and Lee, 2006; Ghobakhloo, Arias-Aranda and Benitez-Amado, 2011; Bordonaba-Juste, Lucia-Palacios and Polo-Redondo, 2012) and earnings performance (Millán, Lyalkov, Burke, Millán and Van Stel, 2021). Although an earlier study found younger firms are more likely to adopt computer or e-business technologies (Lai, 1994), more recent studies generally showed insignificant effect of firm age on ICT adoption (Chatterjee, Grewal and Sambamurthy, 2002; Li, Lai and Wang, 2010; Ifinedo, 2011). Lucchetti and Sterlacchini (2004), using a sample of Italian SMEs, found the adoption of ICT is also determined by the nature of business and function of the ICT, where larger SMEs with better educated employees are more likely to adopt production-related ICTs whilst exporting business have higher preference over market-oriented ICTs. Harindranath, Dyerson and Barnes (2008) reveal that UK SMEs were generally open to ICTs, but their high cost and complexity are the main barriers to ICT adoption.

Whilst the generic finance and management theories can partly explain the identification and realisation of ICT investment opportunities, they usually fail to account for the enormous uncertainties, such as real options within an ICT project (Arya, Fellingham and Glover, 1998). Unlike the standard corporate resource allocation approaches, the real options approach acknowledges the value of flexibility in taking actions in investment decision-making (Dixit and Pindyck, 1994). Therefore, the real options approach is recognised as a superior capital budgeting method for analysing the strategic investment decision under uncertainties, compared to discounted cash flow models (Amram and Kulatilaka 1999; Luehrman, 1998). Typical real options in ICT investments include the options to defer (wait), stage, expand or contract, switch and abandon a project (Angelou and Economides, 2005).

Following the financial option pricing models (Black and Scholes, 1973; Merton, 1973), and the binomial process (Cox, Ross and Rubinstein, 1979), the value of real option can be expressed as a function of project cash flows, investment cost, time horizon, cost of capital and the volatility of the value of project assets (McDonald and Siegel, 1986). Because of the high uncertainties within ICT projects, failure in considering the value of real options may cause firms to reject an otherwise value-adding project. Accordingly, the decision to invest in an ICT opportunity depends on the firm's perception of the strategic value of managerial flexibility, which in turn is heterogeneous across firms of different characteristics such as size, age and sector.

3. Data and Sample Characteristics

The source of our data is a large representative investment decision-making survey of UK businesses conducted by a professional survey house for the UK Department for Business, Energy and Industrial Strategy in late 2018. We have a total of 1,501 responses. The sample is weighted according to the size and industry structure of the UK business population using the Office for National Statistics –Business Population Statistics register. The survey was designed explicitly to capture evidence on how firms go about the full investment process from whether or not they had investment opportunities, if so, what were they? Then whether in the presence of an opportunity they acted upon it, and finally how much cash did they invest. The variable descriptions for our key variables of interest are presented in Appendix A - Table A1.

From Table 1 below we observe that 71.9% of the UK business population have had an ICT investment opportunity available to them within the last three years. Of those that did have an opportunity available, 70.0% actually made an investment. In its totality, 50.3% of the UK business population have made an investment in ICT in the last three years. On average, the cash amount associated with these investments is in the range of £50,000 - £75,000. In this sense, this represents a significant loan for the majority of smaller firms.

Table 1. ICT opportunity, investment, and scale of investment

	ICT Opportunity		**ICT Investment || Opportunity**		**Average Investment Size £000s**
	No	Yes	No	Yes	
	28.10	71.90	30.00	70.00	50-75
Firm Size					
Micro	29.99	70.01	32.08	67.92	50-75
Small	25.59	74.41	27.44	72.56	100-500
Medium	12.56	87.44	13.81	86.19	500-1m
Large	5.34	94.66	6.77	93.23	2m-5m
Firm Age					

<4 years	41.99	58.01	43.69	56.31	75-100
4-5 years	35.61	64.39	39.15	60.85	75-100
5-10 years	27.83	72.17	30.69	69.31	75-100
10-15 years	26.92	73.08	35.00	65.00	75-100
15+ years	22.83	77.17	19.89	80.11	100-500
Industry					
A – Agriculture, Forestry and Fishing	42.95	57.05	37.25	62.75	100-500
BDE – Mining and Quarrying, Public Utilities	0.00	100.00	0.00	100.00	100-500
C – Manufacturing	28.17	71.83	28.38	71.62	100-500
F – Construction	34.63	65.37	39.05	60.95	75-100
G – Wholesale and Retail Trade	25.39	74.61	24.17	75.83	100-500
H – Transport and Storage	37.91	62.09	29.10	70.90	500-1m
I – Accommodation and Food Service	44.17	55.83	52.02	47.98	100-500
J – Information and Communication	28.68	71.32	36.09	63.91	75-100
K – Financial and Insurance	14.79	85.21	17.36	82.64	75-100
L – Real Estate	23.29	76.71	33.66	66.34	75-100
M – Professional, Scientific and Technical	15.18	84.82	18.62	81.38	75-100
N – Administrative and Support Services	29.78	70.22	34.84	65.16	75-100
P – Education	19.12	80.88	10.57	89.43	50-75
Q – Human Health and Social Work	32.49	67.51	19.73	80.27	75-100
R – Arts, Entertainment and Recreation	34.63	65.37	46.06	53.94	75-100
S – Other Services	29.82	70.18	30.80	69.20	50-75
Financing Investment					
Own Funds	26.19	73.81	14.00	86.00	50-75
+ Debt	76.33	23.67	87.55	12.45	75-100
+ Equity	99.47	0.53	99.03	0.97	100-500
+ Debt + Equity	98.01	1.99	99.42	0.58	500-1m
Attitude to Risk					
Loving	26.41	73.59	29.73	70.27	100-500
Neutral	34.54	65.46	29.91	70.09	75-100
Averse	30.78	69.22	32.11	67.89	75-100

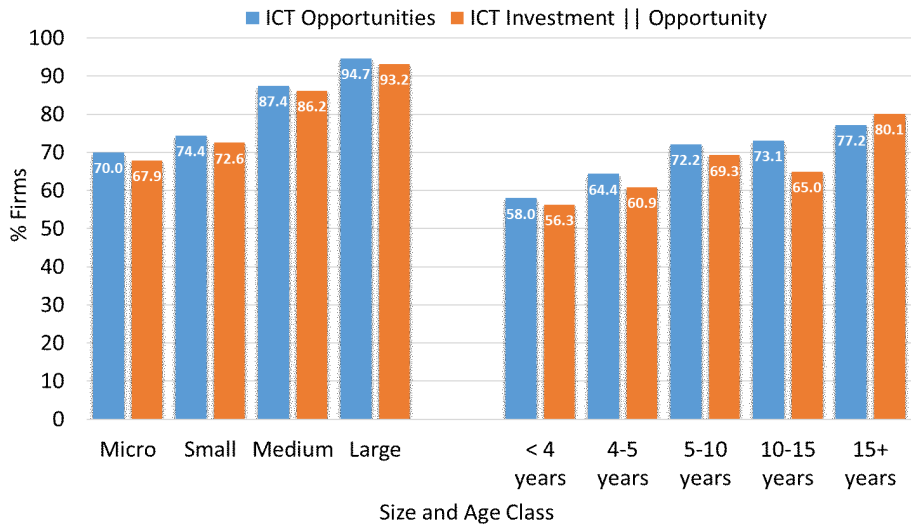
Source: Author´s calculations and UK Department for Business, Energy and Industrial Strategy

We observe that there was an increasing presence of ICT investment opportunities as we move upwards through the firm size-class distribution from micro firms through to large firms (Figure 1). The largest leap is between small firms and medium-sized firms where opportunities increase from 74.4% to 87.4%. The same positive firm size relationship was apparent in respect of turning an ICT investment opportunity. As expected, the scale of ICT investment made increased through the firm size bands from £50,000 – 75,000 for micro firms to £2m - £5m for large firms (Table 1).

Firm age was found to be an area of differentiation on all three measures of investment activity (Figure 1). On the presence of opportunities, the general pattern shows that the larger a firm is, the more likely it is to have an ICT opportunity. This pattern was not clear-cut in terms of acting upon an opportunity,

which was highest for very old established firms at 80.1%, and fairly high for firms between 5 and 10 years old at 69.3%. New firms were the least likely to act on an ICT opportunity. On the scale of investment, through all ages up to 15 years the average investment was in the bounds of £75,000 - £100,000. For the very oldest firms this average investment size rose to £100,000 - £1/2m. In this sense, the firm age patterns are not as clear-cut as for firm size.

Figure 1. ICT opportunities and investments by firm size and age class



Source: UK Department for Business, Energy and Industrial Strategy

Industry sector was central to understanding ICT investment. Sectors with high shares of firms with an ICT investment opportunity include Mining and Utilities where all firms had opportunities, professional and scientific services, 84.8%, and education, 80.9%. This compares to only 57.1% in agriculture and 55.8% in hospitality sectors. On actual investment in the presence of opportunities, all mining sector firms made an investment in their ICT opportunity, as did 89.4% of firms in the education sector. Sectors where fewer opportunities were realised include hospitality, 48.0%, and arts and cultural sectors, 53.9%. On investment scale, the transport industries made the largest investments on average at £500,000 - £1m and the educational and other service sectors the lowest average scale of investments at £50,000 - £75,000.

Risk is central to all core theories of investment and we find clear differences in terms of firms' appetite for risk. We find that risk-loving firms had more ICT opportunities on average, and were more likely to take advantage of them than their risk-averse counterparts. Further, the average investment scale for risk-loving firms was larger at £100,000 - £500,000 compared to £75,000 - £100,000 for risk-neutral and risk-averse firms. As ICT investments are technology driven, we would expect that they are, on average, riskier than traditional types of

investments. This suggests that attitudes to risk are an important feature in the firms' decision-making process. Our evidence is broadly supportive of this as risk-averse firms are less likely to invest in an ICT opportunity when one is present.

Finally, as capital is essential for new investments, we find that debt has lower usage amongst firms making ICT investments but equity has higher usage, although in general debt dominates equity by a factor of 7/1. It was also true that average ICT investments involving equity were much larger at £100,000 - £500,000, compared to £75,000 - £100,000 for investments using debt. Investments using both debt and equity were between £500,000 and £1m on average. This suggests that debt is used to finance modest ICT investments, but those of a more serious scale are more likely to be supported by raising equity capital, or a combination of the two. This is consistent with technology investments being at the high risk – high return end of the investment spectrum.

4. Results

In this section, we initially model the existence of an ICT opportunity to the firm. The second stage modelling relates to the decision to invest or not conditional upon an opportunity being present. The final stage modelling establishes the scale of the investment made by those firms who had an ICT opportunity and made an investment in that opportunity. As the first two stages of the modelling and binary decisions (did you have an ICT opportunity? Coded 1 for yes and 0 for no. And, conditional upon a positive response, did you invest in that opportunity? Coded 1 for yes and 0 for no) we model these two decisions using a binary sample selection model initially as it may be that there is a non-randomness in those firms that identified an ICT investment opportunity and those that actually made an investment. The third stage was estimated by ordered probit as our investments size-class variable is coded in hierarchical bands. We also allow for selection into this third stage modelling. All models have a weight applied to them according to firm size and sector distribution from the UK Office for National Statistics Business Population Estimates.

The selection-based approach allows us to test whether or not each step of the three-stage process was non-random in the sense that only firms that were most likely to invest in an opportunity actively sought out potential opportunities, and equally whether firms that pursued an opportunity did so because they had the resources to invest at scale. As each of the first two decisions are binary (0,1) responses we use the special form of the selection type model and derive the inverse Mill's ratio which then enters the following equation. If these terms were significant, then this is evidence that the next step in the decision-making process of the firm around investment is non-random.

4.1. ICT Investment Opportunity

From Table 2 Model 1 we find that firm size is a key variable in terms of firms having an ICT investment opportunity available to them. Whilst micro and small firms have the same probability of identifying an opportunity as we move to larger firm size bands the level of opportunity increases significantly. This suggests that larger sized firms are more capable of identifying opportunities in the ICT space and this may relate to the internal resources available to them. We also find that firms between the ages of 4 and 5 are the least likely to identify an ICT investment opportunity.

This is a very specific period in the life cycle of firms' when they transition from being in danger of not surviving to a more stable phase in their lives and this result may reflect the fact that firms may pause for breath and consolidate their position.

While we observe that only one broad industry sector was different, it was a key sector for the economy. Here we find that firms in professional, scientific and technical services were more likely, than firms in any other sector, to identify an ICT investment opportunity. An example of a firm in this sector would be one that conducts Covid-19 lateral flow testing. It appears that the high use of sophisticated technologies is conducive and indeed critical for business operations and viability. Other non-results, that are equally important, are that exporting and attitude to risk did not differentiate between firms in respect of ICT opportunity identification, nor indeed did geography play a role.

Table 2. Regression models

	[1] IT Investment Opportunity				**[2] Invested in IT Opportunity**				**[3] Investment Scale £ || Invested**		
	Coeff.	**Z stat**	**Pr>z**	**dy/Dx**	**Coeff.**	**Z stat**	**Pr>z**	**dy/Dx**	**Coeff.**	**Z stat**	**Pr>z**
Firm Size											
Micro	(ref.)				(ref.)				(ref.)		
Small	0.116	0.850	0.397	0.037	0.1391	0.990	0.320	0.046	0.606	2.800	0.005
Medium	0.663	3.430	0.001	0.169	0.5680	3.020	0.003	0.154	1.635	5.920	0.000
Large	1.064	2.790	0.005	0.220	0.8892	2.850	0.004	0.215	2.707	6.470	0.000
Firm Age											
<4 years	(ref.)				(ref.)				(ref.)		
4-5 years	-0.533	-2.260	0.024	-0.054	-0.7316	-2.900	0.004	0.039	0.010	0.030	0.976
5-10 years	-0.375	-1.580	0.113	0.071	-0.6108	-2.370	0.018	0.106	-1.090	-2.280	0.023
10-15 years	-0.149	-0.850	0.394	0.046	-0.2914	-1.560	0.119	0.036	-0.065	-0.270	0.784
15+ years	-0.230	-1.190	0.234	0.117	-0.5222	-2.630	0.009	0.202	-0.228	-0.750	0.452
Industry											
A – Agriculture, Forestry and Fishing	(ref.)				(ref.)				(ref.)		
BDE – Mining and Quarrying, Public Utilities	(ref.)				(ref.)				2.263	2.840	0.004
C – Manufacturing	0.382	1.090	0.276	0.111	0.2149	0.540	0.590	0.078	0.885	1.390	0.166
F – Construction	0.249	0.670	0.503	0.076	0.0242	0.060	0.954	0.008	0.753	1.150	0.252
G – Wholesale and Retail Trade	0.442	1.290	0.195	0.128	0.3569	0.910	0.361	0.121	1.003	1.440	0.149

H – Transport and Storage	-0.034	-0.070	0.942	-0.011	0.0646	0.120	0.903	0.039	1.736	2.190	0.028
I – Accommodation and Food Service	-0.027	-0.070	0.947	-0.009	-0.3754	-0.840	0.399	-0.126	0.397	0.510	0.609
J – Information and Communication	0.363	0.960	0.336	0.106	0.0091	0.020	0.983	0.019	0.861	1.420	0.157
K – Financial and Insurance	0.829	1.520	0.128	0.193	0.5652	0.970	0.330	0.172	0.292	0.430	0.667
L – Real Estate	0.311	0.630	0.527	0.091	-0.1682	-0.320	0.751	-0.046	-0.735	-1.190	0.234
M – Professional, Scientific and Technical	0.780	2.270	0.023	0.209	0.5104	1.300	0.192	0.172	0.886	1.400	0.162
N – Administrative and Support Services	0.340	0.920	0.356	0.101	0.1376	0.340	0.735	0.057	0.610	0.930	0.350
P – Education	0.812	1.300	0.192	0.191	1.0358	1.530	0.127	0.241	1.292	1.350	0.179
Q – Human Health and Social Work	0.189	0.390	0.698	0.058	0.5167	0.880	0.378	0.160	1.888	2.320	0.020
R – Arts, Entertainment and Recreation	0.179	0.280	0.781	0.055	-0.2977	-0.390	0.695	-0.075	5.920	6.450	0.000
S – Other Services	0.521	1.160	0.246	0.141	0.3427	0.710	0.479	0.119	-0.245	-0.340	0.731
Financing Investment											
Own Funds											
+ Debt	-0.018	-0.110	0.913	-0.006	-0.1993	-1.230	0.218	-0.020	-0.119	-0.560	0.574
+ Equity	0.094	0.220	0.829	0.030	-0.1640	-0.350	0.725	-0.004	0.431	0.970	0.332
+ Debt + Equity	-0.289	-0.430	0.671	-0.102	0.2015	0.350	0.725	0.028	5.747	9.570	0.000
Attitude to Risk											
Loving	(ref.)				(ref.)				(ref.)		
Neutral	-0.323	-1.550	0.122	-0.113	-0.0606	-0.260	0.791	-0.021	-0.307	-0.720	0.475
Averse	-0.125	-0.660	0.512	-0.042	-0.1566	-0.780	0.434	-0.057	-0.381	-1.050	0.294
Constant	0.674	1.570	0.115		0.6581	1.380	0.166				
Plus Region	Yes				Yes				Yes		
N Obs	751				679				241		
Pr> Chi Sq	0.0207				0.0203				0.00001		
Pseudo R2	0.0796				0.0842				0.1377		
Cutpoints											
1									-1.839		
2									-1.215		
3									-0.263		
4									0.004		
5									0.373		
6									1.478		
7									2.031		
8									2.484		
9									3.035		

Source: Author´s calculations and UK Department for Business, Energy and Industrial Strategy

4.2. Investing or Not in an ICT Opportunity

From Appendix Table A2, we note that the selection term from the presence of an ICT opportunity is not significant (z-stat=1.58, Pr>Z=0.115), thus we are able to default to the full set of variables specified in the opportunity model plus

dummy variables capturing use of equity and use of debt (Table 2 Model 2). We find that the firm size effect in terms of making an actual investment in your identified ICT opportunity mirrors that observed for the opportunity itself. Again, we find no difference between micro and small firms and an increasing probability that medium and large firms will act on their opportunity. In this sense, the firm size story is consistent in that medium and large firms have more ICT opportunities and are more likely to realise them when they do have them.

The firm age effect in this case is different and the general relationship between firm age class and acting on an opportunity is negative. Young firms in the very early phases of their life-cycles' up to the age of 3 are more likely to invest in ICT opportunities. Once firms have passed this start-up stage, they are consistently less likely to invest in their ICT opportunities. In a broader sense, this suggests that young firms see ICT as providing them with a competitive advantage in a tech savvy consumer environment. It may be the case that the Covid-19 pandemic and economic lockdowns have accelerated this process of consumer engagement supported by sophisticated ICT adoption and new ways of doing business by firms. No other variables were found to be significant including risk attitude, debt and equity use, or region. In this sense, given the presence of an opportunity to invest in ICT, the decision to proceed with that investment opportunity is fundamentally related to how large a firm is and whether or not it is in the early stages of its life cycle.

4.3. Scale of ICT Investment

The second selection term which relates to making an actual ICT investment given an opportunity is not statistically significant (z-stat=0.38, Pr>z=0.703) in the size of investment model (Appendix Table A2). This allows us to use the full set of variables in the final model. We observe that the magnitude in cash terms of investment in ICT opportunities are positively related to firm size as expected. Larger firms make larger ICT investments (Table 2 Model 3). We also find that firm age is important with 4-5 years old firms making the largest investments and the very oldest firms making the smallest investments. This group of 4-5 years old firms face fewer opportunities to invest in ICT, but when they do invest, they do so at scale.

Industry sectors were also found to be important, with firms in administrative services, education and health making smaller scale investments than firms in other industry sectors. We also find significant variation in other factors. Risk-averse firms made smaller-scale investments' which is consistent with their more cautious approach to doing business. We also find that the types of finance that firms use to fund investment matters in terms of scale of investment. Here debt users make larger investments than firms that self-fund their new investment activities, and equity users make even larger investments. These findings are

consistent with a pecking order approach to financing investment in that firms first exhaust their internal cash reserves, and only then resort to external debt, and if their funding requirements are particularly large, they bring in equity, a form of finance that has a natural bias towards innovation driven investments.

5. Conclusions

We set out to trace out the causal process by which some firms identified an opportunity to invest in ICT, and conditional upon an opportunity being present, making the choice of whether or not to invest in it. The final element in the causal chain of events was the scale of the total ICT investment given the firm had decided to proceed. The basic evidence shows us that 72% of firms had identified an opportunity to invest in ICT and this suggests that there is a high general level of awareness amongst the UK business population. Of those who had an opportunity, 70% realised their opportunity with an investment. At the population level, 50% of UK firms had invested in ICT over the last three years. This represents a significant investment in technology and ICT capability. The average level of investment was between £50,000 and £75,000 that suggests that it is non-trivial and represents a significant commitment.

From our econometric modelling of the three elements in the process from opportunity identification to the decision to invest in that opportunity and finally at what funding scale, we find that firm size and age were key. The larger a firm is the more likely it is to identify an ICT opportunity, more likely to invest in that opportunity, and more likely to invest at scale. In contrast, firm age played quite different roles across the three elements in the process. Firms that had just passed the survival phase of their lives identified fewer opportunities but when they did invest did so at significant scale. Older firms had more opportunities, but were less likely to act on them and, if they did, they invested at much smaller scale. More generally, action in the presence of an ICT opportunity diminished as firms grew older. Overall, it seems that the most dynamic group of firms in the context of ICT is start-up and early-stage firms who are able to identify opportunities and act upon them. This suggests that many newer firms started their lives with an ICT intensive business model and appear to be more in tune with shifting consumer preferences and ways of doing business.

Finally, the way in which firms seek to fund their investment is important, particularly given the well-documented preferences and financing behaviours for self-funding when possible. In its totality, equity is a minor source of funding for investment, but our evidence clearly shows that technology driven ICT investment equity allows firms the ability to invest at significant scale in a way that self-funding and debt cannot match. Further, if the UK wants to support its exporters in the post-Brexit world, then supporting their ICT investment activities

may make them more competitive internationally. There may well be a case for specific support for smaller exporters to enhance their ICT capabilities.

So what are the wider lessons and issues that our study can inform? On the firm side, our evidence suggests that small firms appear to have a particular problem in terms of identifying new potential opportunities for productive investment in IT. However, young firms do not have this problem and are more than capable of finding new opportunities and realising them. In this sense, small is not beautiful but youth is. For the UK economy it suggests a rebalancing of innovation support with young firms being a specific point of focus whilst paying less attention to SMEs per se who appear to be less proactive and growth orientated, at least in respect of upgrading and investing in IT. If IT is crucial to modern business, then many UK SMEs will be left behind and operating in a technology vacuum. Efforts to promote and address this IT deficit might help engage more laggard SMEs.

On the finance and capital market side, again we reinforce the view that when firms have the ability to self-fund their investments they will. There are clear benefits from doing this in terms of a lower cost of capital, but this relies on firms generating enough free cash to finance all their new investments. Where this self-funding preference falls down is when the cash size of an opportunity the firm wishes to pursue is bigger than their cash pile. This scenario is very likely to be one present in the UK business population in the aftermath of the Covid-19 pandemic. On this, we find that a willingness and ability to secure outside equity to fund new IT investments is critical to being able to invest at large scale. In contrast, debt does not facilitate this in the same way. In this respect, the availability of venture capital through early-stage government backed hybrid funds would appear to be the appropriate policy response, but its wider use would require a cultural shift from the SME population to a more positive view on taking on external equity.

Finally, we observe that attitudes to risk were not important in any of the three IT investment related decisions. Risk-loving firms did not seek out more opportunities, be more likely to pursue an IT opportunity, nor invest more when they did. As most of the theories of financing investment and opportunity identification place risk at the heart of them, this is perhaps a strange finding. However, we believe that the nature of IT investments may be more readily associated with uncertainty than risk as the distribution of potential outcomes is unknown or uncertain prior to making the investment decision. Only when the risk distribution is quantifiable and known can the firm make a choice about whether it can tolerate that level of risk. In this sense, more attention needs to be paid to the level of uncertainty inherent in a potential investment and this is central to technology and innovation investment decision-making.

References:

Amram, M. and Kulatilaka, N. (1999), "Uncertainty: The new rules for strategy", *Journal of Business Strategy*, 20(3): p 25-29.

Angelou, G.N. and Economides, A.A. (2005), "Flexible ICT investments analysis using real options", *International Journal of Technology, Policy and Management*, 5(2): p 146-166.

Arnold, G.C. and Hatzopoulos, P.D. (2000), "The theory-practice gap in capital budgeting: Evidence from the United Kingdom", *Journal of Business Finance & Accounting*, 27(5-6): p 603-626.

Aron, D.J. (1988), "Ability, moral hazard, firm size, and diversification", *The Rand Journal of Economics*, 19(1): p 72-87.

Arya, A., Fellingham, J.C., and Glover, J.C. (1998), "Capital budgeting: Some exceptions to the net present value rule", *Issues in Accounting Education*, 13(3): p 499-508.

Bagnoli, C., Dal Mas, F., and Massaro, M. (2019), "The 4th industrial revolution: Business models and evidence from the field", *International Journal of E-Services and Mobile Applications (IJESMA)*, 11(3): p 34-47.

Berger, A.N. and Udell, G.F. (1992), "Some evidence on the empirical significance of credit rationing", *Journal of Political Economy*, 100(5): p 1047-1077.

Berger, A.N. and Udell, G.F. (1998), "The economics of small business finance: The roles of private equity and debt markets in the financial growth cycle", *Journal of Banking & Finance*, 22(6-8): p 613-673.

Black, F. and Scholes, M. (1973), "The pricing of options and corporate liabilities", *Journal of Political Economy*, 81(3): p 637-654.

Boekhoudt, P. and Van der Stappen, P. (2004), "The ASpect project case: A model for SME adoption of ICT innovation", In: *ICEC '04: Proceedings of the 6th International Conference on Electronic Commerce*, March 2004, p 201-206.

Bordonaba-Juste, V., Lucia-Palacios, L., and Polo-Redondo, Y. (2012), "The influence of organizational factors on e-business use: Analysis of firm size", *Marketing Intelligence & Planning*, 30(2): p 212-229.

Brealey, R., Myers, S., and Allen, F. (2020), *Principles of Corporate Finance*, New York: McGraw Hill.

Caputo, F., Riso, T., Romano, M., and Maalaoui, A. (2022), "Digital platforms and international performance of Italian SMEs: An exploitation-based overview", *International Marketing Review*, 39(3): p 568-585.

Chatterjee, D., Grewal, R., and Sambamurthy, V. (2002), "Shaping up for e-commerce: Institutional enablers of the organizational assimilation of web technologies", *MIS Quarterly*, 26(2): p 65-89.

Colombo, M.G. and Grilli, L. (2007), "Funding gaps? Access to bank loans by high-tech start-ups", *Small Business Economics*, 29(1): p 25-46.

Cowling, M. (2010), "The role of loan guarantee schemes in alleviating credit rationing in the UK", *Journal of Financial Stability*, 6(1): p 36-44.

Cowling, M. and Clay, N. (1994), "An assessment of the Loan Guarantee Scheme", *Journal of Small Business and Enterprise Development*, 1(3): p 7-13.

Cowling, M. and Mitchell, P. (2003), "Is the Small Firms Loan Guarantee scheme hazardous for banks or helpful to small business?", *Small Business Economics*, 21(1): p 63-71.

Cowling, M. and Siepel, J. (2013), "Public intervention in UK small firm credit markets: Value-for-money or waste of scarce resources?", *Technovation*, 33(8): p 265-275.

Cox, J. C., Ross, S.A., and Rubinstein, M. (1979), "Option pricing: A simplified approach", *Journal of Financial Economics*, 7(3): p 229-263.

Danielson, M.G. and Scott, J.A. (2006), "The capital budgeting decisions of small businesses", *Journal of Applied Finance*, 16(2): p 45-56.

De Bettignies, J.E. and Brander, J.A. (2007), "Financing entrepreneurship: Bank finance versus venture capital", *Journal of Business Venturing*, 22(6): p 808-832.

Dixit, A. and Pindyck, R. (1994), *Investment under Uncertainty*, Princeton NJ: Princeton University Press.

Fraser, S. (2009), "Is there ethnic discrimination in the UK market for small business credit?", *International Small Business Journal*, 27(5): p 583-607.

Ghobakhloo, M., Arias-Aranda, D. and Benitez-Amado, J. (2011), "Adoption of e-commerce applications in SMEs", *Industrial Management & Data Systems*, 111(8): p 1238-1269.

Graham, J.R. and Harvey, C.R. (2001), "The theory and practice of corporate finance: Evidence from the field", *Journal of Financial Economics*, 60(2-3): p 187-243.

Hall, B.H. and Lerner, J. (2010), "The financing of R&D and innovation", In: Hall, B.H. and Rosenberg, N. (Eds.), *Handbook of the Economics of Innovation. Volume 1*, North-Holland: Elsevier, p. 609-639.

Harindranath, G., Dyerson, R. and Barnes, D. (2008), "ICT adoption and use in UK SMEs: A failure of initiatives?", *Electronic Journal of Information Systems Evaluation*, 11(2): p 91-96.

Harjoto, M.A. and Paglia, J.K. (2012), "Cost of capital and capital budgeting for privately-held firms: Evidence from business owners survey", *Journal of Accounting and Finance*, 12(5): p 71-85.

Ifinedo, P. (2011), "Internet/e-business technologies acceptance in Canada's SMEs: An exploratory investigation", *Internet Research*, 21(3): p 255-281.

Jeon, B.N., Han, K.S., and Lee, M.J. (2006), "Determining factors for the adoption of e-business: The case of SMEs in Korea", *Applied Economics*, 38(16): p 1905-1916.

Kor, Y.Y. and Mahoney, J.T. (2000), "Penrose's resource-based approach: The process and product of research creativity", *Journal of Management Studies*, 37(1): p 109-139.

Lai, V.S. (1994), "A survey of rural small business computer use: Success factors and decision support", *Information and Management*, 26(6): p 297-304.

Larsen, K.R. (2003), "A taxonomy of antecedents of information systems success: Variable analysis studies", *Journal of Management Information Systems*, 20(2): p 169-246.

Lazaridis, I.T. (2004), "Capital budgeting practices: A survey in the firms in Cyprus", *Journal of Small Business Management*, 42(4): p 427-433.

Li, D., Lai, F., and Wang, J.E. (2010), "E-business assimilation in China's international trade firms: The technology-organization-environment framework", *Journal of Global Information Management*, 18(1): p 39-65.

Lucchetti, R. and Sterlacchini, A. (2004), "The adoption of ICT among SMEs: Evidence from an Italian survey", *Small Business Economics*, 23(2): p 151-168.

Luehrman, T.A. (1998), "Strategy as a portfolio of real options", *Harvard Business Review*, 76: p 89-101.

Lumpkin, G.T. and Dess, G.G. (2004), "E-business strategies and internet business models: How the internet adds value", *Organizational Dynamics*, 33(2): p 161-173.

McDonald, R.L. (2000), "Real options and rules of thumb in capital budgeting", In: Brenan, M.J. and Trigeorgis, L. (Eds.), *Project Flexibility, Agency, and Competition: New Developments in the Theory and Application of Real Options*, New York: Oxford University Press, p. 13-33.

McDonald, R. and Siegel, D. (1986), "The value of waiting to invest", *The Quarterly Journal of Economics*, 101(4): p 707-727.

Merton, R.C. (1973), "Theory of rational option pricing", *The Bell Journal of Economics and Management Science*, 4(1): p 141-183.

Michaelas, N., Chittenden, F., and Poutziouris, P. (1999), "Financial policy and capital structure choice in UK SMEs: Empirical evidence from company panel data", *Small Business Economics*, 12(2): p 113-130.

Millán, J.M., Lyalkov, S., Burke, A., Millán, A., and Van Stel, A. (2021), " 'Digital divide' among European entrepreneurs: Which types benefit most from ICT implementation?", *Journal of Business Research*, 125: p 533-547.

Moavenzadeh, J. (2015), "The 4th industrial revolution: Reshaping the future of production", Paper presented at the World Economic Forum, DHL Global Engineering & Manufacturing Summit, Amsterdam.

Myers, S.C. (1984), "The capital structure puzzle", *The Journal of Finance*, 39(3): p 574-592.

Myers, S.C. and Majluf, N.S. (1984), "Corporate financing and investment decisions when firms have information that investors do not have", *Journal of Financial Economics*, 13(2): p 187-221.

Nambisan, S. (2017), "Digital entrepreneurship: Toward a digital technology perspective of entrepreneurship", *Entrepreneurship Theory and Practice*, 41(6): p 1029-1055.

Peel, M. (1999), "Planning, business objectives and capital budgeting in Japanese, German and domestic SMEs: Some evidence from the UK manufacturing sector", *Journal of Small Business and Enterprise Development*, 6(4): p 350-365.

Penrose, E.T. (1959), *The Theory of the Growth of the Firm*. New York: John Wiley.

Revest, V. and Sapio, A. (2012), "Financing technology-based small firms in Europe: What do we know?", *Small Business Economics*, 39(1): p 179-205.

Riding, A. (1997), "On the care and nurture of loan guarantee programs", In: Halpern, P. (Ed.), *Financing Growth in Canada*, Calgary: University of Calgary Press, p 637-672.

Ritchie, B. and Brindley, C. (2005), "ICT adoption by SMEs: Implications for relationships and management", *New Technology, Work and Employment*, 20(3): p 205-217.

Sangster, A. (1993), "Capital investment appraisal techniques: A survey of current usage", *Journal of Business Finance & Accounting*, 20(3): p 307-332.

Stiglitz, J.E. and Weiss, A. (1981), "Credit rationing in markets with imperfect information", *American Economic Review*, 71(3): p 393-410.

Appendix

Table A1. Variable descriptions

IT investment opportunity	Coded 1 if the firm had an IT investment opportunity and 0 otherwise
Actual Investment in IT opportunity	If had IT investment opportunities: Coded 1 if firm undertook an IT investment and 0 otherwise
Cash Amount of IT investment	Real £ amount of total IT investment
Own Funds	Coded 1 if firm uses own funds only, 2 if uses own funds + debt, 3 if firm uses own funds and equity, and 4 if firm uses own funds, debt, and equity.
+ Debt Use	
+ Equity Use	
+ Debt + Equity Use	
Attitude to Risk	I am willing to take risks when considering investments made by the business: 1= Agree, 2= Neither Agree Nor Disagree, and 3=Disagree

Table A2. Selection term statistics

	Coefficient	**S.E**	**Z-stat**	**Pr>z**
Imr_IT_Opportunity	-2.3317	2.0948	-1.11	0.266
Imr_IT_Actual_Investment	-1.2564	2.0914	-0.60	0.548

Source: Author´s calculations and UK Department for Business, Energy and Industrial Strategy