IRISH JOURNAL OF MANAGEMENT
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Irish Journal of Management • 41(1) • 2022 • 52-68
DOI: 10.2478/ijm-2022-0002

Irish Journal of **Management**

Determinants of equity financing: a demand-side analysis of Irish indigenous technology-based firms

Research Article

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Abstract: Successful high-technology industries enhance productivity, competition, and consumer choice. To support their innovating activities, these firms need access to finance. Given the uncertain nature of innovation, along with the high associated cost, many firms turn to equity financing. Using novel survey data for 153 indigenous equity and 141 indigenous non-equity financed high-tech firms, we examine what determines how these firms raise equity finance (i.e., independent and corporate venture capital, business angel, government-sponsored) and non-equity finance (i.e., personal investment, family and friend investment, debt finance). We find that debt finance is negatively associated with equity financing in high-tech firms. Moreover, in our sample of high-tech firms, we find that innovating firms, export-oriented firms operating in niche markets, and firms with high levels of human capital have a greater probability of being equity financed.

Keywords: *Equity finance; non-equity finance; high-tech firms; innovation; probit*

INTRODUCTION

It has become something of a stylised fact over the second half of the twentieth century that technology sectors are a panacea for boosting economic growth and productivity (Coad & Reid, 2012; Cowling et al., 2021; Eurostat, 2016b). These firms create jobs, actively innovate, sell their goods and services internationally, and contribute to regional development (Audretsch, 1995; Knockaert et al., 2010). Technology-based firms, however, are those most likely to be financially constrained (North et al., 2013). Equity finance plays a vital role in financing these firms (Bottazzi & Da Rin, 2002; Cumming et al., 2017). While much is known about the supply-side of equity finance (Eckhardt et al., 2006), relatively little is understood about the factors impacting the demand-side, with many recognising the need for research in this area (Grégoire et al., 2011; Howorth, 2001; Rasmussen & Sørheim, 2012; Seghers et al., 2012). This paper undertakes a micro-econometric analysis of Irish technology-based firms with a view to establishing likely demand side determinants of equity financing.

Since the demand-side studies which exist tend to focus on a narrow set of factors in isolation, predominantly human capital (Behrens et al., 2012; Hsu, 2007) or intellectual property (Haeussler et al., 2014; Munari & Toschi, 2015; Zhou et al., 2016), we add to the literature by including a much wider set of determinants. Using novel survey data from 294 Irish technology-based firms across both technology-based manufacturing and knowledge-intensive service sectors, we examine whether the signals arising from the firms' use of non-equity finance (i.e., their use of personal investment, family/friend-connections, and debt finance), along with their innovation activities (measured by their innovation activity, R&D frequency, and patent numbers) impact on their ability to source equity

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financing.[1] Understanding these determinants will help entrepreneurs seeking equity funding improve their chances of obtaining the capital infusions needed to fund their ventures.

This paper makes a number of contributions. First, we adopt a broad definition of equity finance, encompassing private (i.e., independent and corporate venture capital, business angels) and public (i.e., government-sponsored) sources of equity to undertake an in-depth analysis of the determinants of equity financing. We adopt a broad definition of equity finance which includes all sources of external equity finance (e.g., angel, venture capital, corporate venture capital and public equity) accounting for the variety of sources of this finance used by Irish equity-financed technology-based firms in Ireland and the strong evidence of co-investment when public equity sources are raised.

Extant research in this area is largely segmented and predominantly focused on a single source of equity. Specifically, evidence almost exclusively details the attributes of firms financed by (independent) venture capitalists (Audretsch et al., 2012; Colombo & Grilli, 2010; Hoenen et al., 2014; Mann & Sager, 2007). Research on angel finance is restricted to the examination of applications submitted to angels or angel groups (Brush et al., 2012; Mitteness et al., 2012) or interactions between entrepreneurs and angels (Maxwell & Lévesque, 2010). To the best of our knowledge, nobody has, to date, included government-sponsored equity in a demand-side analysis of the determinants of equity financing. Existing work has focused on the role of the public sector in stimulating private sector investment. Referred to as the seeding hypothesis (Leleux & Surlemont, 2003), the premise is that the presence of the public investor should enhance the capacity of a firm to attract private sector investment by lowering information asymmetries which might otherwise preclude private involvement (Buzzacchi et al., 2013; Colombo et al., 2016; Minola et al., 2017). We build on the work of Hart and Lenihan (2006) who, in a study of the impact of Enterprise Ireland's financial assistance on indigenous Irish firms in the period 2000 to 2002, find that public equity complements private equity in Ireland. Through the adoption of a broad definition of equity finance, we provide greater insight into the drivers of equity financing and this, in turn, serves to improve our understanding of potential contributory elements that enhance overall use of this form of entrepreneurial financing. This evidence may be used to cultivate and enhance access to equity funding.

Second, we present novel empirical evidence on the relationship between the firm's non-equity (i.e., personal investment, family/friend-connections, and debt finance) and equity financing. This is, to the best of our knowledge, the first paper to empirically examine how signals based on financial information work in concert with each other to determine equity investment and is a particularly underdeveloped area in the related literature. Moreover, while the effect of innovation on gaining access to equity finance has been more extensively examined in the literature for particular types of equity finance such as venture capital (Mina et al., 2013; Peneder, 2010) rather than business angel financing and public equity, the broader definition of equity finance adopted in this paper enables an assessment of the importance of this signal for gaining access to any form of equity finance.

Third, this work uses a unique database which spans technology-based manufacturing and knowledge-intensive service sectors thus adding to existing sector specific studies (Hoenen et al., 2014; Munari & Toschi, 2015). The sample spans Irish technology-based manufacturing and knowledge-intensive service sectors, building on existing sector-specific studies (Hogan & Hutson, 2005a, 2005b; Hogan et al., 2017; Mac an Bhaird & Lynn, 2015). Finally, we provide novel empirical evidence in the Irish context. In Ireland, between 2003 and 2016, venture capital and private equity funds invested €5 billion in Irish SMEs and, through syndication, attracted a further €3 billion from international investors, with high-tech enterprises accounting for approximately 90% of the funds raised (IVCA, 2016, 2021). In spite of the challenges caused by Covid-19, equity investment into Irish SMEs grew by 13% to €925 million in 2020, compared to €820 million the previous year (IVCA, 2021).

To-date, however, there has been little empirical examination of equity financed firms. Hogan and Hutson (2005b) examine the determinants of venture capital for a sample of 119 Irish software firms. Using the same database, Hogan et al. (2017) revisit the issue of funding for software firms, extending the analysis to the determinants of private-equity and venture capital funding (Hogan et al., 2017, page 243). Focusing only on internal funds and angel finance, Mac an Bhaird and Lynn (2015) investigate financial bootstrapping in eighteen Irish computer software

1 Extensive data for equity finance firms (N=153) was gathered through face-to-face interviews using a structured survey instrument. The latter allowed us to gather data on a complex issue Fowler, F. J. (2014). The problem with survey research. In: SAGE Publications Sage CA: Los Angeles, CA., while also maximising the response rate. A smaller data set was gathered for non-equity financed firms (N=141) online using a shorter version of the structured survey instrument. The reader is referred to the Data and Methodology Section for further details.

companies. This paper, through the adoption of a broad definition of equity finance (encompassing angel, venture capital and government-sponsored funding), builds on these studies to provide greater insight into the demand-side determinants of equity finance. This, in turn, serves to improve our understanding of the determinants of this form of financing. Moreover, our sample spans Irish technology-based manufacturing and knowledge-intensive service sectors, building on existing sector-specific studies (Hogan & Hutson, 2005a, 2005b; Hogan et al., 2017; Mac an Bhaird & Lynn, 2015).

The remainder of this paper is structured as follows. Section 2 briefly reviews the related literature and develops testable hypotheses. The data and methods are discussed in Section 3 with results presented in Section 4. Lastly, Section 5 concludes our paper.

RELATED LITERATURE & HYPOTHESIS DEVELOPMENT

Considered particularly relevant for the investigation of entrepreneurial financing, agency theory (Jensen & Meckling, 1976) provides a framework for exploring the relationship between the providers of equity (supply-side) and the receivers of those funds (demand-side) (Arthurs & Busenitz, 2003; Hsu et al., 2014). In brief, at the pre-investment phase, two mechanisms are employed to mitigate agency issues inherent in entrepreneurial financing: screening and signalling (Spence, 1974; Stiglitz, 2000). External investors, who cannot assess unambiguous information regarding intrinsic quality, screen and filter potential investees based on the presence of attributes assumed to be correlated with desired, but unobservable, qualities (Weiss, 1995). Correspondingly, entrepreneurs face the challenge of credibly informing potential investors of their quality through the communication of observable signals that contain information on unobservable attributes (Courtney et al., 2017). In other words, in attempting to mitigate agency issues, entrepreneurs seeking funding can use signals that partly substitute for incomplete information (Busenitz et al., 2005) and investors tend to rely on these signals in making investment decisions (Higgins & Gulati, 2006). After controlling for firm characteristics such as age, size, and sector, it is likely that other factors such as the firms use of non-equity finance and their level of innovation impact on their ability to signal their quality to equity financers. In this section we explore these signals.

Non-equity financing

During a firm's lifecycle they are likely to use many forms of non-equity financing, including personal investment, family and friend's investment and debt financing.[2] Many authors argue that the entrepreneur's willingness to invest in their own firm acts as a signal of the quality of the firm (Atherton, 2012; Busenitz et al., 2005). Busenitz et al. (2005) argue that personal investment can signal the firm's true value and potential, which helps to lessen agency and information asymmetry issues. Moreover, personal ownership leads to a greater alignment of interests with other investors and signals that the entrepreneur will seek to make decisions that maximise the value of the venture (Jensen & Meckling, 1976). Although empirical investigation is extremely limited, Ahlers et al. (2015) show that retaining equity ownership can be an effective signal for entrepreneurs seeking crowdfunding. Likewise, Downes and Heinkel (1982) provide empirical evidence that entrepreneurial ownership is an effective signal in an IPO context. Based on these considerations, we hypothesise that:

Hypothesis 1: Personal investment in the firm has a positive impact on the likelihood of obtaining equity financing.

Turning to external finance, the entrepreneur's social circle is typically considered an easily accessible form of funding, especially for young firms (Bygrave & Quill, 2007). Family and friend investors (i.e., f-connections) are defined as individuals who use their own money to provide capital to a private business owned and operated by a family member or friend (neighbour, colleague, etc.) (Shane, 2008). Referred to as 'love money' (GEM, 2016), family and friends tend to provide capital on the basis of a personal relationship rather than on the basis of financial rewards (Da Rin & Hellmann, 2020; Sherman, 2012). These investors can also represent a critical conduit for information flows which reduce the transaction costs associated with information search and processing (Mesquita & Lazzarini, 2009). Since those who are closest to the entrepreneur possess the most information on the likely success of the venture. If f-connections are reluctant to invest their own money, it may signal to external investors

2 *Firms also use internal sources of finance such as working capital finance.*

that the enterprise has below average odds of success (Conti et al., 2013; Sorenson, 2018). Empirical research on the role of f-connection funding as a signal for firms seeking external equity investment is extremely sparse. Conti et al. (2013) show that, although not a significant signal for venture capital, family and friends' investment is a significant signal for angel funding. Other researchers highlight the role of f-connection investment in crowdfunding campaigns, with family and friends providing the first donations that precipitate interest from strangers (Agrawal et al., 2011). Thus, we hypothesise that:

Hypothesis 2: F-connection funding has a positive impact on the likelihood of obtaining equity financing.

According to Ross (1977), firms can convey private information through the proportion of debt in their capital structure. Debt is easily observable in financial statements and has costly underpinnings – it entails higher screening and monitoring costs and lenders institute an ongoing governance and control mechanism, making debt a reliable signal (Epure & Guasch, 2020). Epure and Guasch (2020), using data collected through the Kauffman Firm Survey, find a positive relationship between debt and external equity financing. Audretsch and Lehmann (2004), examining high-tech firms listed on the Neur Market, find that the likelihood of obtaining venture capital is inversely related to the extent to which the firm is financed by debt. Thus, it appears that it is excessive debt that acts to reduce the incentive of an equity investor to invest in the firm. Taking these considerations together, we conjecture that obtaining debt can serve to mitigate information asymmetries, not only by demonstrating firm quality (Ross, 1977), but also through the governance it imposes (Epure & Guasch, 2020). Thus:

Hypothesis 3: Debt finance has a positive impact on the likelihood of obtaining equity financing.

Innovation activity

Equity financing is considered a particularly important and appropriate source of funding for innovative firms (Brown et al., 2009; Zhou et al., 2016). Innovation often has desirable side-effects on firm performance and growth and hence can act as a signal of firm quality (Coad & Rao, 2008; Schumpeter, 1950). Authors such as Colombelli et al. (2013), Geroski and Machin (1992), Mansfield (1962), Roper (1997), amongst many others, report a positive relationship between innovation and firm performance. In addition, learning during the innovation process generates absorptive capacity (Van de Ven & Polley, 1992) which confers a competitive advantage (Zahra & George, 2002). Further, the benefits of innovation include economies of scale and scope, pre-emption of limited resources, advantages in further innovation, and the ability to set standards (Rosenbusch et al., 2011). Additionally, innovation activities have also been linked to the probability of survival (Børing, 2015; Cefis & Marsili, 2006). Hellmann and Puri (1998), examining firms located in Silicon Valley, find that firms pursuing an innovation strategy are more likely to obtain venture capital. Likewise, for Austrian firms, Peneder (2010) reports that those with above average levels of innovation are more likely to obtain venture capital. Mina et al. (2013), for a sample of firms in the U.K. and U.S., find that product and process innovations constitute signals for potential equity investors and significantly help firms attract external investment. Based on this:

Hypothesis 4: Innovation activity has a positive impact on the likelihood of obtaining equity financing.

R&D is a critical input into the innovation process (Brown et al., 2009; Hall, 2002), and it can also convey important informational cues to equity investors. Previous research has found a positive association between R&D investment, firm value (Hall & Oriani, 2006; Hughes, 2008) and sales growth (Demirel & Mazzucato, 2012; García-Manjón & Romero-Merino, 2012). According to Noel and Schankerman (2013), there are large, positive technology spill-overs from R&D for software firms. In their analysis of publicly-traded UK firms, Aghion et al. (2004) find that R&D-intensive firms are more likely to raise equity finance, with the use of equity increasing with R&D intensity. Casson et al. (2008) and Wang and Thornhill (2010) also find a positive relationship between R&D and equity financing. Similarly Lahr and Mina (2016), examining UK and US businesses, find that R&D expenditure is a strong predictor of venture capital use. Essentially, because reducing information asymmetries via fuller disclosure is often of limited effectiveness in this arena (e.g., ease of imitation makes firms reluctant to reveal full details of innovative ideas). Given that data pertaining to R&D expenditure is more readily available, it is feasible that this is an effective and observable signal (Hall & Lerner, 2010). This leads to the following hypothesis:

Hypothesis 5: R&D activity has a positive impact on the likelihood of obtaining equity financing.

Commonly used as a proxy for innovative output, patents, can also represent an important quality signal (Hoenig & Henkel, 2015). In short, the knowledge generated through innovative activity exhibits, at least partly, characteristics and properties of a public good – it is non-excludable and non-rival in use (Arrow, 1962). Thus, in order to fully appropriate investments in innovative activity, the associated intellectual property must be guarded by protection mechanisms such as patents, which not only signal the ability to appropriate the returns of innovations but also the actual feasibility of the proposed project (Audretsch et al., 2012). Entrepreneurs may also be attracted to patenting in order to signal commercial value of their innovations (Hall & Ziedonis, 2001). Evidence confirms the importance of patent protection as a signal for external financiers (Audretsch et al., 2012; Conti et al., 2013). Based on a sample of German and British biotechnology firms, Mueller et al. (2009) find that as start-ups file patent applications the likelihood of obtaining venture capital increases. Baum and Silverman (2004) report that biotechnology start-ups in possession of patent applications or grants receive significantly more venture capital funding than those without. With respect to the supply-side, patent protection is an important factor for investors making the decision to invest (Feeney et al., 1999). In short, patents are considered evidence of the development stage of a firm, its defined market niche, and the quality of its management team (Lemley, 2000). Thus, the following hypothesis is proposed:

Hypothesis 6: Patents have a positive impact on the likelihood of obtaining equity financing.

Next, we specify a model which allows us to test the determinants of equity financing.

DATA AND METHODOLOGY

This paper uses primary-source evidence collected from a novel sample of Irish technology-based firms. Firms were identified for inclusion using NACE Rev. 2 codes at two-digit level (Eurostat, 2016a). Within this classification, manufacturing sectors are categorised as high, medium or low technology based on their R&D expenditure/value added whilst knowledge-intensive activities are classified based on the share of tertiary-educated persons in the sector relative to the total employed (Eurostat, 2016a). The sample was further stratified into two groups based on financing, specifically whether the firm had obtained equity finance or not.

We adopt a broad definition to describe an 'equity financed' firm, encompassing venture capital, corporate venture capital, business angel and government-sponsored sources of equity. Thus, to be classified as 'equity-financed' the firm must have obtained, at the time of data collection, equity funds from at least one of these external sources. This allows us to account for the variety of equity finance sources used by Irish and international technology-based firms (see Bellavitis et al., 2017), along with the strong Irish evidence of co-investment when public equity is used (Hart & Lenihan, 2006). It also enables us to build on other studies which focus on narrower definitions of equity finance (Hogan & Hutson, 2005a, 2005b; Hsu, 2007; Ozmel et al., 2013; Patzelt, 2010) and to address the dearth in demand-side evidence using a broad definition of equity financing which has been noted by Howorth (2001), Grégoire et al. (2011), and Rasmussen and Sørheim (2012).

A sample frame of 685 Irish technology-based firms was compiled, composed of 313 equity and 372 non-equity financed firms. Sample selection took place in late 2010 and early 2011, with data collection throughout 2011 and 2012. The status of the firms in the sample was subsequently updated in December 2018 and again in December 2019. The time of sampling and data collection was characterised by challenging market conditions coming out of the downturn. Access to external finance for firms in the aftermath of the financial crisis has been the subject of several studies (Baldock et al., 2015; Block & Sandner, 2009; Mac an Bhaird, 2013; Udell, 2009). While research emphatically suggests that access to debt finance becomes more problematic for innovative firms during crisis episodes (Lee et al., 2015; Udell, 2009), much less evidence exists for how these shock events influence the market for sources of equity financing (Block & Sandner, 2009; Conti et al., 2019). Data provided by the Irish Venture Capital Association shows there was a steady rise in equity investment over the crisis period, from €226 million in 2007 to €310.2 million in 2010. There was a decrease in funds invested in 2011 (€274.4m) and 2012 (€268.9m), before a slight increase in 2013 (€284.9m). The following year, total investment rose by over 40% to €400.7 million, and this was followed by a more marked rise through to 2017. Since the onset of the credit crunch in 2008, in excess of 1,400 Irish SMEs raised equity financing totalling €3.5 billion (IVCA, 2019).

Equity financing, particularly venture capital, is volatile which makes this form of investment susceptible to the uncertainty caused by shock events (Gompers et al., 2008). Interestingly, in their analysis of the effect of the financial crisis on venture capital financing for US Internet start-ups, Block and Sandner (2009) find that while the financial crisis had a negative impact on the amount of funds raised per funding round, this effect is present only where later funding rounds are concerned. For firms obtaining initial financing, no such devaluations could be observed. The authors find that the average amount of funds raised per round decreases by 20% during the crisis, detectable only in later rounds. Conti et al. (2019) find that, on aggregate, funded start-ups received no less financing during the crisis compared to non-crisis times, although venture capitalists do tend to focus investments in their core sectors. Examining the US angel investor market in 2008, Sohl (2009) reports that angel investments declined in terms of dollars but not in terms of deals. For Ireland, Mac an Bhaird (2013), based on data provided by the CSO, reports that, in 2007, firms in ICT sectors (typified by higher dependence on intangible assets) had greater demand for equity finance throughout the crisis period. On the other hand, firms in the construction sector had a greater probability of applying for debt finance. These results indicate that, even when there are significant changes in credit conditions, long established patterns of financing based on asset structure endure.

For data collection, two structured survey instruments were designed, one for distribution to equity financed firms and a refined version for non-equity financed firms. While the non-equity survey data was self-administered online, the equity financed firms were asked the same questions and an extended set of questions in a face-to-face setting. Specifically, the latter survey contained a detailed additional section examining the CEOs experience of sourcing equity finance. In view of the complexity of this survey instrument it was felt that the use of online or postal questionnaires would potentially result in a low response rate and, furthermore, a poor quality of return. The structured survey instrument for equity financed firms included standardised questions and open-ended questions. Fowler (2014), Cohen (2007), amongst others, note that using standardised questions in an interview setting improves interviewer consistency allowing the interviewer to maintain systematic direction in the interview process while offering enough flexibility to respond to the interviewee. The open-ended questions allowed the interviewee the freedom to express their own experiences, feelings and opinions (Merriam & Tisdell, 2015). Ruane (2016) noted that such fieldwork offers a depth of exploration and understanding which can only be gained by engagement in the social world of research subjects. Interviews are particularly appropriate for collecting data on individuals' experiences and perspectives (Page, 2014). Reid (1998) noted that gathering data by speaking to people has the greatest potential to generate insight into the object of analysis. Interviewing our respondents face-to face offered a unique insight into the equity financing process, from the entrepreneur's perspective. The founder-CEOs were guided through the survey, were allowed to take time to consider the questions, were able to express their opinions of and experiences in obtaining financing for their business. Overall, these face-to-face interviews with the equity financed firms ensured and enhanced the quality of the data collected.[3]

A total of 294 firms participated (response rate = 43%), consisting of 153 (52%) equity and 141 (48%) non-equity financed firms. All the founder-CEOs (153) from equity financed firms completed the survey through a face-to-face interview with the researcher. All firms that participated were private limited companies at the time of data collection. Of the 153 equity financed firms, 8 (5.2%) solely received funding from a government-sponsored fund, 4 (2.6%) solely from venture capital and 11 (7.2%) solely from angel finance. There were 24 (15.7%) firms that had obtained venture capital and government-sponsored equity, while 30 (19.6%) had obtained angel funding and government-sponsored equity and 17 (11.1%) who were funded by angel and venture capital funding. Fifty-nine (38.6%) firms had obtained equity from all three sources at some point in their lifecycle.

Table 1 presents definitions and descriptive statistics for each of the explanatory variables. The three source of finance measures (personal funds, f-connections, debt) are binary variables which take the value of '1' if the firm possessed that form of financing and '0' otherwise.[4] We note that 95.9% of the firms in our sample used personal funds, almost one third (32.3%) used f-connections, while 40.8% used debt finance.

3 To ensure consistency across the face-to-face and on-line samples, sample statistics were examined by Sectoral Composition according to NACE Rev. 2 codes – 2 digit, Technological-Intensity according to NACE Rev.2 Classification, Age Profile, and Size Profile. The equity and non-equity samples were closely aligned.

4 For the purposes of this study, 'F-connection Investors' are defined narrowly as family members and/or personal friends of the entrepreneur who provide funding to the firm. Often referred to as 'family, friends and fools', this description typically includes informal investors and angels (Bygrave and Hunt, 2007) Given the scope of this study (i.e., the inclusion of angel financing as a stand-alone source of equity finance), and to mitigate confusion in data collection, it was decided that a narrow definition of f-connections was the most appropriate. Thus, we follow the likes of (Shane, 2008) to define an angel investor as a person who provides capital to a private business owned and operated by someone who is not a friend or family member while f-connection investors are friends or friends who provide their own capital to a business owned and operated by someone with whom they share a close personal relationship (Da Rin and Hellmann, 2020) Defined in this way, we can ensure that angel investors are a distinct subset of private equity finance (Cumming, 2012)

Three innovation measures are included. Respondents were asked whether they engaged in product and/or process innovation and to self-appraise their firm's frequency of innovation with the following response categories: continuously, regularly, rarely, or never. Most stated that their firm undertakes both product (68.7%) and process (60.5%) innovation on a continuous basis. Over half (55.8%) rate innovation activities as continuous. Firms were asked to quantify their frequency of R&D on a six-point scale from weekly to yearly. Almost half undertake R&D daily, with over a quarter (26.9%) describing R&D as a weekly task. Patent activity is captured with a dummy variable. Of the 294 technology-based firms, a total of 88 (29.9%) hold at least one patent.

Our control variables include measures of firm demographics, market and product characteristics, and human capital. These factors were identified from the literature as potential determinants of equity (Block et al., 2014; Hsu et al., 2014; Zhou et al., 2016). Firms in our sample are on average 8 years old (standard deviation=5.6) and have on average 25 full time employees (standard deviation=54.8). These firms operate across both technology-based manufacturing and knowledge-intensive service sectors, with the vast majority (84%) in the latter sectors. This profile is consistent with data provided by the Central Statistics Office (CSO, 2013) and also equates reasonably well with figures provided by Eurostat (2013). The variable Incubator provides a proxy for third-party certification and the role of the assistance and network of incubator firms in accessing equity finance. Of the 294 firms, 44 (15%) were based in an incubation centre.

Examining characteristics of the firm's market, we approximate competitive pressure by a count of the number of major rivals the firm faces in the main market for its product (Power & Reid, 2015). Although, on average, respondents faced competition from approximately 22 rivals (standard deviation=116.29) this number is driven up by five firms, all non-equity financed, claiming to have one thousand rivals. Most firms in our sample (83%) export, generating, on average, 54% (standard deviation=39.7%) of turnover through exporting. In general respondents' state that they differentiate their product(s), with over two thirds indicating that they offer a different or very different product to their rivals.

To capture the impact of human capital four variables are included. Founder-CEO education, a common proxy for general human capital (Teixeira & Tavares-Lehmann, 2014). This is classified using the National Framework of Qualifications (NFQ), a ten-level system which gives an academic or vocational value to qualifications. Over half (54.8%) of the entrepreneurs in our sample are educated up to degree level; just over a third (37.8%) to Masters; with 22 (7.4%) holding a Ph.D. The next two variables focus on specific human capital, proxied through experience (Dimov & Shepherd, 2005). First, founder-CEO industry-specific experience is measured by years' experience working in the industrial sector of the firm, irrespective of their function (Carpentier & Suret, 2015). Respondents have, on average, 18 (standard deviation=7.6) years of industry experience. Second, FoundIntExp captures experience working abroad in a technology-based sector, prior to their role in the current firm (Patzelt, 2010). Almost three-quarters (71.4%) of the founder-CEOs have international experience. To control for organisational human capital, WorkQual measures the percentage of employees who possess a third-level degree or equivalent. In almost half (48.6%) of firms, every employee possesses a third-level or equivalent qualification.

METHOD

To identify the determinants of equity financing, the dependent variable, EquityFinanced, a binary variable indicating whether the firm has obtained equity finance or not, is explained by the financing, innovating, and control variables using a probit estimation of the form:

$$Y_i = W_i\beta + X_i\phi + Z_i\alpha + u_i$$

where Y_i takes a value of '1' if firm i is equity financed and '0' otherwise; W_i captures the non-equity financing-related variables (i.e., personal, f-connections and debt); X_i captures the innovation-related variables (i.e., innovation activity, R&D frequency, patent), $Z_i\alpha$ is a set of control variables capturing firm-specific, market/product, and human capital attributes; the vectors β, ϕ and α include the estimated parameter coefficients; and $u \sim N(0, 1)$. The model is estimated using maximum likelihood with robust standard errors.

Table 1: Definition and Descriptive Statistics

Variable	Definition	All Firms (N = 294)	Equity (N = 153)	Non-Equity (N = 141)
		Number (percentage)[a] / Mean (std. dev.)[b]		
	Financing			
PersInvest	='1' if firm used founder personal funding; ='0' otherwise	282 (95.9%)	148 (96.7%)	134 (95%)
FConnections	='1' if firm received f-connection funding; ='0' otherwise	95 (32.3%)	57 (37.3%)	38 (27%)
Debt	='1' if firm obtained debt financing; ='0' otherwise	120 (40.8%)	49 (32%)	71 (50.4%)
	Firm-specific			
Size	Number of full-time equivalent employees in 2011	25.3 (55.7)	28.7 (65.8)	21.6 (41.9)
Age	Elapsed years from foundation to exit; to Dec. 2016 otherwise	7.70 (5.58)	6.64 (3.70)	8.84 (6.91)
ServiceFirm	='1' knowledge-intensive service firm (NACE 58-63, 66, 69-75, 78, 79, 82); ='0' otherwise	247 (84%)	130 (85%)	117 (83%)
Incubator	='1' if located in an incubation centre; ='0' otherwise	44 (15%)	29 (19%)	15 (10%)
	Market & Product			
Rivalry	Number of major rivals the firm faces in its main market	22.15 (116.19)	4.60 (5.17)	41.2 (165.9)
Exports	Export sales as a percentage of total sales for the last fiscal year	53.96 (39.68)	68.18 (35.52)	38.52 (38.27)
ProdDiff	='1' (very similar); ='2' (similar); ='3' (different); ='4' (very different)	2.08 (0.79)	2.22 (0.75)	1.94 (0.81)
	Human Capital			
FoundEdu	='1' (up to Degree); ='2' (Masters); ='3' (Ph.D.)	1.53 (0.63)	1.68 (0.65)	1.36 (0.58)
WorkQual	Percentage of employees who possess a third level or equivalent qualification	85.51 (20.76)	90.75 (13.47)	79.82 (25.34)
FoundIndExp	Number of years' experience working in the firm's industrial sector	18.54 (7.60)	18.69 (7.02)	18.38 (8.21)
FoundIntExp	='1' if experience working abroad prior to current role; ='0' otherwise	210 (71.4%)	123 (80.4%)	87 (61.7%)
	Innovation			
Innovation	Sum of product and process innovation, where 2 is the lowest and 8 the highest	6.97 (1.34)	7.37 (0.97)	6.45 (1.55)
R&D	='1' (longer); ='2' (weekly); ='3' (daily)	2.25 (0.82)	2.46 (0.73)	2.01 (0.85)
Patent	='1' patent holder; ='0' otherwise	89 (30.3%)	62 (40.5%)	27 (19.1%)

Note: [a] Number (percentage) reported for dummy variables; [b] Mean (standard deviation) reported for ordinal and scale variables

RESULTS

Here we outline the results of econometric analysis, the aim of which is to ascertain the determinants of equity financing (where an 'equity financed' firm is defined as having obtained one or more sources of external equity finance – venture capital, angel and/or government-sponsored equity). The probit results are presented in Table 2, with robust standard errors in Column I, marginal effects in Column II, and elasticities calculated at mean values presented in Column III. Our model is statistically significant (Wald Chi-square=80.39; $p<0.000$). In considering these results, we are interested in the direction and significance of the coefficients.

Looking first at the sources of finance, we find no evidence to support H1, that personal investment increased the likelihood of securing equity investment. Consistent with H2, the positive and significant coefficient on FConnections financing indicates that having obtained funding from family and friends has a positive impact on the likelihood that a firm is equity financed. Looking at the marginal effect (Column II), having obtained f-connection funding increases the probability that the firm will be equity financed by approximately 7%. This finding is in line with Agrawal et al. (2011) and Conti et al. (2013), who highlight the role of family and friends' investment as an effective signal in supporting access to equity finance. The negative and significant coefficient on Debt indicates that equity financing is inversely related to debt financing, contradicting H3. The marginal effect (Column II) is -0.104 indicating that equity financed firms are approximately 10% less likely to utilise debt. This finding is consistent with evidence pointing to a lack of debt for technology-based firms (Giudici & Paleari, 2000; Hall, 2002; North et al., 2013). Conversely, it may also indicate that those successfully obtaining equity finance have less need to seek debt.

Turning to innovation effects, the positive and significant coefficient on Innovation suggests that innovation has a positive impact on the likelihood of securing equity finance, thus confirming H4. From Column II, the probability of being equity financed rises by 4.7% when the frequency of innovation increases by one unit. The effect is significant (p-value<0.05), and the coefficient has a very high elasticity (2.1), being the second largest observed. R&D activity is also positive but not significant providing no support for H5. We find no support for H6, that patents are a positive signal for obtaining equity finance.

Turning to the other factors considered, we note that firm-specific variables (i.e., age, size, service/manufacturing firm, incubator) have no significant impact on the probability of being equity financed. Market, Product, and Human Capital factors, on the other hand, did impact this probability. Rivalry is negative and significant, indicating that it is those technology-based firms who face lower levels of competition in their main market that are more likely to be equity financed. A 1% increase in number of rivals, ceteris paribus, is associated with a decrease in the probability of the firm being equity financed by approximately 1.6% (Column II). The coefficient has a high elasticity (2.3), the largest observed in the estimation (Column III). Thus, occupying a market niche is a determining factor in accessing equity financing, consistent with supply-side research. Petty and Gruber (2011), Kollmann and Kuckertz (2010) and Carpentier and Suret (2015) show that equity investors mostly disregard potential investees operating in markets deemed too crowded or saturated. Results also indicate a positive and significant relationship between exporting (Exports) and equity finance. The greater the proportion of turnover generated by exporting the greater the likelihood that the firm will be equity financed. The coefficient has a relatively high elasticity (0.647) (Column III). Although no other study, to the best of our knowledge, provides comparable empirical evidence, it is somewhat in line with extant research. In his analysis of the impact of venture capital on firm growth, Peneder (2010) reports that venture capital backed firms have a stronger orientation towards international markets. According to Riding et al. (2012), Canadian SMEs pursuing an export strategy are more likely to seek equity financing. In their study of French and Canadian SMEs, St-Pierre et al. (2011) find that venture capital backed firms are more likely to export. ProdDiff, is also a significant determinant of equity financing. This finding is consistent with supply-side evidence highlighting the importance of the product offering in investment appraisal (see Lumme et al., 2013; Petty & Gruber, 2011).

Overall results corroborate the signalling role of human capital. The positive and significant coefficient on FoundEdu indicates that firms run by highly educated individuals are more likely to be equity financed. Indeed, in terms of magnitude, the coefficient is the second largest observed in the probit (Column I). The coefficient also has a high elasticity (1.029) (Column III). Corroborating this, Gimmon and Levie (2010), Zarutskie (2010), and Unger et al. (2011) highlight the role of entrepreneurial education in attracting equity finance. Founder-CEO international experience is also a positive and significant determinant of equity. Its marginal effect (Column II) suggests that those firms with a founder-CEO who has experience working overseas are approximately 7% more likely to be equity financed. The finding is consistent with Patzelt (2010), who highlights the positive relationship between

Table 2: Probit Results

	I	II	III
	Probit	**Marginal Effects**	**Elasticities**
	(Std. Error)	**(Std. Error)**	**(Std. Error)**
Financing			
Personal Investment	0.614*	0.107*	0.906
	(0.465)	(0.0611)	(0.586)
FConnections	0.306*	0.0770	0.152
	(0.192)	(0.0570)	(0.0960)
Debt	-0.455**	-0.104**	-0.286**
	(0.182)	(0.0498)	(0.129)
Innovation			
Innovation	0.201***	0.0478**	2.148**
	(0.0787)	(0.0222)	(0.862)
R&D	0.135	0.0321	0.465
	(0.121)	(0.0300)	(0.429)
Patent	0.106	0.0257	0.0492
	(0.210)	(0.0497)	(0.0931)
Firm-Specific			
Size	0.00136	0.000324	0.0529
	(0.00167)	(0.000423)	(0.0702)
Age	-0.0283	-0.00676	-0.335
	(0.0208)	(0.00516)	(0.243)
ServiceFirm	-0.256	-0.0665	-0.331
	(0.256)	(0.0856)	(0.366)
Incubator	0.317	0.0839	0.0728
	(0.270)	(0.0748)	(0.0612)
Market & Product			
Rivalry	-0.0693***	-0.0165***	-2.361**
	(0.0182)	(0.00159)	(1.054)
Exports	0.00780***	0.00186**	0.647***
	(0.00236)	(0.000853)	(0.221)
ProdDiff	-0.239*	-0.0570**	-0.765
	(0.141)	(0.0282)	(0.523)
Human Capital			
FoundEdu	0.438***	0.104**	1.029***
	(0.154)	(0.0468)	(0.387)
FoundIndExp	0.0159	0.00378	0.452
	(0.0126)	(0.00326)	(0.367)
FoundIntExp	0.328*	0.0727*	0.360
	(0.204)	(0.0434)	(0.233)
WorkQual	0.00981**	0.00234*	1.290*
	(0.00518)	(0.00133)	(0.707)
Constant	-3.321***		
	(0.985)		
Observations	294		
Log Likelihood	-138.469		
Wald Chi-square (17)	80.39		
Pseudo R^2	0.3197		
Prob > Chi^2	0.0000		

Notes: *significant at p-value < 0.1; ** significant at p-value < 0.05; ***significant at p-value < 0.01

international experience and venture capital. Turning to organisational human capital, employee education is a positive and significant determinant of equity. The high and positive elasticity for employee education (Column II), shows that a 1% increase in the proportion of qualified employees, ceteris paribus, is associated with a very small (0.2%) increase in the probability of the firm being equity financed. In terms of magnitude, this is the third largest elasticity observed, suggesting that organisational human capital is an important driver of equity finance. Although, to the best of our knowledge, no other study provides empirical evidence linking organisational human capital to the use of equity financing, this finding is in line with work emphasising the crucial role of firm-level, or organisational, human capital (Chowdhury et al., 2014; Millán et al., 2014).

CONCLUSION

This paper analysed the determinants of equity financing in Irish technology-based firms from a demand-side perspective. Specifically, we drew on both agency and signalling (Spence, 1974) literature to examine the factors effective in obtaining equity finance, with a particular emphasis on the role of non-equity sources of financing and innovation activity. Several interesting findings emerge from our analysis.

Firstly, results reveal that the firm's use of non-equity financing plays a significant role for external equity. We note that investment from family and friends has a positive effect on the likelihood of obtaining equity financing. Our findings echo those of Conti et al. (2013) who show how the signal from founder, family and friends' investment (as a signal of commitment) has a positive and significant impact on angel funding. Conversely, debt negatively impacts on equity financing. This is consistent with the findings of Audretsch and Lehmann (2004) and, more generally, with those reporting a lack of debt for technology-based firms (Coleman & Robb, 2012; Colombo & Grilli, 2007). Secondly, we find that innovation activity has a positive impact on the likelihood that the firm will be equity financed, highlighting the importance of equity capital for innovation.

Thirdly our analysis identifies several additional determining factors for equity financing. Findings support supply-side evidence that equity investors are attracted to unique product offerings targeting markets that are not too crowded while also being export oriented (Carpentier & Suret, 2015; Petty & Gruber, 2011; Shepherd et al., 2003). This is consistent with existing evidence (Hall, 2010; Mina et al., 2013). Technology-based firms led by founder-CEOs with higher levels of educational attainment and international experience are more likely to be equity financed. Moreover, organisational human capital, contained within employees, also has a positive impact on equity.

This analysis heeds the call to pay attention to the effects of multiple signals (Connelly et al., 2011; Plummer et al., 2016), rather than only examining signals in isolation. The unique evidence provided details the role of a multifaceted array of factors as signals to equity investors. Additionally, by focusing on the characteristics of those firms that are equity financed, this research offers important insight into the criteria applied by equity investors in selecting portfolio firms. This avoids noted issues, including biases in self-reporting and accuracy of recall (Shepherd & Zacharakis, 1999), in supply-side research into investment criteria. Indeed, empirical results show that equity investors possess only limited understanding of their own decision process, which raises concerns regarding the validity of self-reported data (see Shepherd & Zacharakis, 1999; Zacharakis & Meyer, 1998). By relying on data gathered from those who have successfully obtained equity investment, this research overcomes such shortcomings and provides a unique portrayal of the drivers of equity financing.

For entrepreneurs, the results offer guidance as to the different attributes that they can rely on to signal to potential external equity investors. Specifically, these findings highlight the factors that entrepreneurs should emphasise in their applications for external equity investment and can act as a guide in selecting appropriate signals so that they can differentiate their applications for equity funding. This can, ultimately, improve their chances of successfully obtaining equity funding. Provided with a more detailed understanding of the criteria equity investors apply in their decision making, entrepreneurs can attempt to optimise their profile and make a clear and concise presentation of their venture's quality. Overall, these findings can aid entrepreneurs in improving the attractiveness or investment readiness of their ventures. Entrepreneurs typically have a limited amount of time and, in most cases, one opportunity to pitch to an investor (Hsu et al., 2014). Knowing how to present their investment opportunity effectively to potential equity investors is an important aspect of being investor ready (Mason & Kwok, 2010).

Interestingly, from a policy perspective, these results highlight the complementary relationship between f-connection funding and equity financing while also showing that there is a lower likelihood of these firms using debt. This not only serves to emphasise the role of equity as a source of entrepreneurial finance for technology-

based firms but also reveals a role for policymakers in promoting personal financial networks in facilitating access to equity finance. Specifically, adopting programs to support founder and f-connection investments and educating entrepreneurs on how to leverage such investments as a signal to potential equity investors should enhance subsequent access to equity capital. This could include, for example, the provision of training and information on the benefits of assorted financing options and the role of diverse personal financial networks in facilitating access to equity financing. Although not specifically examined in each wave of the Department of Finance SME Credit Demand Survey, where the data is available it shows that only approximately 1% of Irish SMEs are approaching f-connections for funding. Findings herein suggest that financing instruments should not be seen in isolation but rather as a set of interacting policies. To encourage investments from these sources, policymakers could focus on the tax incentives for private (personal) investors. For instance, the Start-up Relief for Entrepreneurs (SURE) scheme, which provides a refund of income tax paid to non-PAYE taxpayers could be extended through an increase in the limit of this scheme or by granting tax SURE relief upfront to assist cash flow rather than retrospectively. Furthermore, the Employment and Investment Incentive Scheme (EIIS), the main tax scheme through which equity capital injections are likely to be accessed by SMEs, could be expanded. More generally, initiatives that facilitate the development of financing know-how and capabilities, such as training in the preparation of financial documentation for applications to equity investors, improving the understanding of entrepreneurs of different financing sources, and how to produce effective business plans would be beneficial in supporting entrepreneurs in successfully accessing equity finance.

In conclusion, while the results presented herein provide a valuable insight into the equity financing of technology-based firms, there are limitations to this research. First, the analysis assumes that the factors determining equity financing are constant throughout the lifecycle. Examining how these factors change over the lifecycle (i.e., stages of development) would provide empirical evidence of the determinants of external equity finance as firms grow. Second, while paper presents a general view of the determinants of equity finance, an investigation of how these determinants apply across the distinct sources of equity financing would enhance our understanding of the demand-side drivers of equity finance. Although we have data on non-equity financed firms, we do not have data and it is hard to directly identify or observe firms which applied for equity finance but did not receive this finance. A future avenue of research would be to examine the effect of this sample selection bias. Despite this the findings of detailed study are compelling and useful for policymakers, entrepreneurs, finance providers and other related practitioners.

ACKNOWLEDGEMENTS

This research has been undertaken with the generous support of the Irish Research Council for Humanities and Social Sciences (IRCHSS) who funded Jane Power's PhD through their Postgraduate Scholarship Scheme. We would like to thank the many firms who gave generously of their time enabling us to collect the high quality data.

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