

Drivers of External Equity Funding in Small High-Tech Ventures

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Financing is one of the major issues affecting the success and survival of entrepreneurial ventures. Theory suggests that due to information asymmetry between owners and investors or lenders, there is a “pecking order” of financing preferences, whereby retained earnings is preferred to debt, and outside equity is seen as a last resort. In high-tech ventures, however, outside equity financing is more commonly used than debt, but the reasons for this are not yet well-understood. We develop hypotheses to examine this theory-practice gap, which we test using a sample of private high-tech firms of various ages. We find that the greater the owner’s perception of information asymmetries in debt markets, the larger the proportion of external equity in the firm’s capital structure. As our sample firms age, their use of external equity relative to other sources of finance diminishes. We also find a positive relationship between the use of external equity and the firm’s initial investment. Lastly, we show that the greater the perception amongst founders that obtaining external equity sends a positive signal, the greater its use. We discuss the implications of these findings and offer suggestion for future research and practice.

Introduction

Securing funding to establish, manage, and grow an entrepreneurial venture through its development lifecycle is one of the biggest challenges that a young firm’s management faces, and one that can directly influence its success and very survival. Theories from corporate finance, such as the Stage or Financial Life Cycle Model and Pecking Order Theory are commonly employed to analyze such new venture finance. Financial life cycle models suggest that the financing needs and choices available to the firm will parallel the stages in its development, with equity financing used predominantly in later stages (Weston and Brigham 1970). Information theory suggests that information asymmetries between owners and providers of finance affect

the firm's choice of funding. In order to minimize the costs associated with information asymmetry, Pecking Order Theory (Myers and Majluf 1984) suggests that firms use retained earnings in preference to debt, and that new equity is issued only as a last resort.

However, there is theoretical support for a greater use of equity in small high-tech¹ firms, particularly in the early stages of their development when there is a sizeable likelihood of failure (Audretsch and Lehmann 2004; Bank of England 1996 and 2001; Carpenter and Petersen 2002; Berger and Udell 1998; Denis 2004; Gompers and Lerner 2001). The use of equity in preference to debt for high-risk high-potential ventures can be explained by the fact the lenders share in losses but do not benefit if the firm performs well, whereas equity holders participate in gains if the firm is successful. A second explanation relates to information asymmetries in debt markets – which are particularly acute for high-tech firms. Empirical evidence from market-based economies with strong private equity markets, such as the US and the UK, shows that external equity is the preferred source of funding for high-tech ventures at start-up (Colman and Robb 2012; Roberts 1990 and 1991; Brewer and Genay 1994; Moore 1994). However, in bank-based financial systems, debt is more common (Revest and Sapio, 2012).

There are still significant gaps in our knowledge of the funding of private high-tech firms. *First*, there is little evidence about how private high-tech firms' financing evolves beyond the start-up stage. *Second*, there is limited empirical evidence on how

¹ A high technology-based firm is defined as one which emphasises research and development or which places a major emphasis on exploiting new technical knowledge (Cooper, 1971: 5).

demand-side factors – the preferences and perceptions of founders – affect financing patterns in high-tech ventures (Ang et al. 2010; Cressy and Olofsson 1997). While the use of equity over debt in high-tech firms can be explained with reference to theories relating to venture risk and information asymmetries in debt markets, there is little direct evidence to support these explanations (Minola, Cassia, and Criaco 2013).

We address these gaps by applying as our conceptual lens, the highly influential financial growth paradigm of Berger and Udell (1998), which integrates the life cycle model (Weston and Brigham 1970) with the pecking order theory (Myers and Majluf 1984). In this paradigm, firms are depicted on a size/age/information continuum, whereby small, young and information-opaque firms are more dependent on owners' funds. As firms age and develop, information asymmetries diminish and firms have access to a more diverse range of funding sources. We draw on this paradigm and its underlying theories to develop several hypotheses about the principal drivers of the amount of external equity as a proportion of total financing used by high-tech firms. We test these hypotheses in the high-tech context using data on Irish software development firms. Our analysis focuses on factors that drive the percentage of external equity in a firm's total financing. To our knowledge, this is the first study to test these hypotheses using demand-side information based on data provided by founders – thus representing a substantial contribution to the literature.

Theoretical and Hypotheses Development

Two theories, drawn from the corporate finance literature, dominate the analysis of SME financing: the Stage Model or Life Cycle Theory of Weston and Brigham (1970), and the Pecking Order Theory of Myers and Majluf (1984).

According to life cycle theory, stages in the development of the firm are paralleled by changes in its financing needs as well as a diversification in funding options available to the firm. Pecking order theory predicts that in order to avoid problems associated with information asymmetries, firms prefer to finance projects from retained earnings first, followed by debt and lastly external equity. In their seminal paper, Berger and Udell (1998) combined information asymmetry and lifecycle theory to explain the capital structure of SMEs. Information asymmetries give rise to moral hazard and adverse selection (Stiglitz and Weiss 1981), and banks use collateral agreements, loan guarantees and covenants to minimise risk as well as to reduce moral hazard, raising the cost of capital for younger firms. As a result, many new firms eschew debt financing (Stanworth and Grey 1991). As firms develop, retained earnings typically replace owners' funds. With age, firms establish a record of accomplishment and generate more information, reducing information asymmetries with potential providers of finance. They also accumulate assets that can be used as collateral in securing debt finance.

Berger and Udell (1998) recognise the heterogeneous nature of the SME sector with respect to information asymmetries, particularly that high-tech small firms are likely to face greater information asymmetries in financial markets.² They also recognise that many small firms do not achieve or even aspire to progress linearly along the growth continuum to the final stage – access to the public finance market via an IPO. Because our sample firms comprise firms of various ages and stages of

² The notion that high-tech small firms face greater information asymmetries in financial markets than other SMEs is well-understood (Bank of England 2001; Carpenter and Petersen 2002; Cassar 2004; Himmelberg and Petersen, 1994).

development – from start-up to mature firms – we are able to examine the use of external equity over the life cycle of high-tech small firms. Despite being one of the most influential papers on small business finance, the model has rarely been fully tested. While only a few studies have looked at the relationship between age, size and financing, only one has examined the role of information asymmetries in a multivariate model (Gregory, Rutherford, Oswald, and Gardiner 2005). Gregory et al (2005) used a binary information index that distinguished between firms for which complete business accounts were available and those for which records were incomplete, to test the impact of information transparency on the types of funding used by firms. This measure, however, was found to provide little explanatory power, and the authors advised caution in drawing strong conclusions from their findings. In addition, their study did not distinguish between VC and bank finance. Thus, all these issues remain in need of examination.

We can observe from this introductory discussion that there are a number of competing arguments that challenge the ability of traditional theories to explain funding preferences. As a means to conceptually frame a firm's expected financing preferences, we present Berger and Udell's (1998) growth cycle model (adapted for high-tech firms) in Figure 1. In the remainder of this section, we develop hypotheses to test the drivers for equity use depicted in this model.

Insert Figure 1 about here

Information asymmetry and external equity funding

High-tech small firms face serious information asymmetries in debt markets, relative to the general population of SMEs (Bank of England 1996 and 2001; Berger

and Udell 1998; European Commission 2003). Much of the value of high-tech companies derives from intangible real assets created by the investment of human capital in research and development. This is particularly true of software development, which is a labor-intensive rather than a capital-intensive activity. Because of the high level of human capital involved, the potential for information asymmetries between founders and financiers is much greater; that is, banks do not understand high-technology businesses (Oakey 1984; Deakins and Hussain 1993; Bank of England 1996; European Commission 2001). Several studies demonstrate that 'relationship lending' is the key to solving the information problem in small company financing (Petersen and Rajan 1994; Ennew and Binks 1997; Berger and Udell 1998). Over time, relationship lending increases the information flow between the customers and banks, easing information asymmetries and the potential for credit rationing. However, Carpenter and Petersen (2002) suggest that the relationship-lending model may not work as well for companies operating in rapidly changing environment. They note that young high-tech small firms 'may have to make major investments in a time frame that is too brief to develop a close relationship with a lender' (Carpenter and Petersen, 2002 pp. 28-29).

High levels of information asymmetries are associated with moral hazard, whereby founders 'gamble with the banks money', substituting high-risk for low-risk projects once debt financing has been secured. The financial contracting literature demonstrates how insider investors or venture capitalists structure contracts in order to overcome information asymmetries and moral hazard problems inherent in high-tech investment projects (Aghion and Bolton 1992; Hart 2001; Winton and Yerramilli

2008). The empirical evidence on how venture capitalists operate supports this perspective (Amit, Brander, and Zott 1998; Gompers and Lerner 2001). Their ongoing relationship with the company allows venture capitalists to closely monitor and advise managers, and by ensuring that the owner-managers' interests are aligned with their own (Sahlman 1990), reducing moral hazard. Indeed empirical evidence indicates that venture capitalists often exercise their right to replace the original founder as CEO (Lerner 1994; Hellmann and Puri 2000). Information asymmetries are less likely because venture capital companies usually have in-depth knowledge of markets and technologies in specific fields (Ruhnka and Young 1991; Gupta and Sapienza 1991; Norton and Tenenbaum 1993; Lindholm-Dahlstrand and Cetindamar, 2000).

High levels of intangible or firm-specific assets in high-tech companies will provide poor or no collateral value (Carpenter and Petersen 2002). Banks use collateral agreements, loan guarantees and covenants to minimise risk and reduce moral hazard when lending under conditions of asymmetric information. Five studies report a positive relationship between fixed assets and long-term debt levels in SMEs (Van der Wijst and Thurik 1993; Chittenden et al. 1996; Jordan et al. 1998; Michaelas et al. 1999). In addition, collateral constraints are more likely to affect companies in the early years when the owner-manager lacks a record of accomplishment with debt holders. Collateral guarantees are not a feature of private equity contacts, making it a potentially more attractive source of funding to cash poor high-tech founders with intangible or firm-specific assets.

For these reasons, banks tend to avoid lending to high-tech small firms, even after start-up. Equity financing, with its superior ability to ameliorate information

asymmetries, is likely preferable for high-tech small firms. Thus, we advance the following hypothesis for the relationship between information asymmetry and equity:

H1: There is a positive relationship between information asymmetry in debt markets and the proportion of external equity in the firm's capital structure, such that high-tech ventures with higher levels of information asymmetry will have a greater proportion of external equity in their capital structure.

Risk and external equity funding

High-tech small firms are considered high-risk, as products are often untried and are commonly subject to rapid obsolescence (Cooper 1971; Myers 1999). In addition, high-tech companies tend to be less diversified than SMEs in general. The less diversified the product and customer base, the greater the company's exposure to variability in future income, and the riskier the company. Young high-tech companies tend to focus on developing a single product, which is often designed to meet the specific needs of one or a small number of customers (European Commission 2000). Debt contracts are not seen as suitable for financing high-risk high-return investments, because debt holders do not participate in the gains generated when the company is successful, but they share in the losses if the company fails (Stiglitz 1985). It is not surprising, therefore, that a European Commission (2001) review found that the prevailing view of European bankers was that 'good practice for commercial banks is simply to avoid lending to new technology-based companies' (p. 47).

In contrast, equity holders benefit commensurate with the extent of the firm's success. From the perspective of the angel or VC investor, risk is beneficial because it is associated with a small probability of a spectacular payoff (Fluck et al. 1998). From the owners' perspective, the greater the risk that they perceive in the venture, the less

likely it is that they will be prepared to risk their own savings – so they will have a preference for external equity.

In our second hypothesis, we therefore predict that risk will be positively associated with higher equity use in high-tech small firms.

H2: There is a positive relationship between venture risk and the proportion of external equity in the firm's capital structure, such that high-tech ventures with higher levels of risk will have a greater proportion of external equity in their capital structure.

Age and external equity funding

As firms age and grow, they have greater access to other sources of funding such as internal revenues, debt, and external equity (Berger and Udell 1998). Because the high-tech start-up lacks a record of accomplishment and its products are often new and untried, its business will be essentially opaque to outsiders. Berger and Udell (1998) suggest that the adverse selection problem is particularly serious for technology firms with high development costs, because the potential for moral hazard rises as the proportion of external to owner's finance increases. Without collateral, these firms will find it difficult to secure bank financing. It is for this reason that they and others conclude that high-growth high-risk firms tend to obtain equity before debt (Audretsch and Lehmann 2004; Bank of England 1996 and 2001; Carpenter and Petersen 2002; Denis 2004; Gompers and Lerner 2001). Empirical support for this 'abnormal' pecking order in economies with strong private equity markets, such as the US (Colman and Robb 2012; Roberts 1990 and 1991; Brewer and Genay 1994) and the UK (Moore 1994), shows that the use of debt at start-up is uncommon.

The evidence from bank-based economies, however, shows a greater recourse to debt at start-up (Colombo and Grilli 2007; Scellato and Ughetto 2009 (Italy); Honjo, Kato and Okamuro, 2014 (Japan); Müller and Zimmerman 2009 (Germany); Bozkaya and van Pottelsberghe de la Potterie 2008 (Belgium); and Lindelof and Lofsten, 2002 (Sweden)). Exceptions are Guidici and Paleari (2000) for Italian internet firms and Hutson and Hogan (2005) for software firms in Ireland, which find that equity is dominant.

Few studies focus on the financing of privately held high-tech small firms in the commercialization stage (and beyond), and this is largely due to a lack of publicly available data. For venture capital-backed firms, external equity increases over time because venture capital funding is usually advanced in stages or rounds (Sahlman 1990 and Bergemann and Hege 1998). There is, however, limited empirical evidence that high-tech small firms continue to depend largely on external equity after start-up – and that evidence comes from studies of capital structure at IPO. Carpenter and Peterson (2002) in the US and Audretsch and Lehmann (2004) in Germany show that high-tech IPOs were more likely to be funded by venture capitalists than banks prior to listing, and Hyytinen and Pajarinen (2002) find a negative relationship between technology intensity and debt in a sample of Finish firms.

An important, yet to be addressed question on this topic is, what happens to the capital structure in high-tech small firms that remain private and independent? Do such firms continue to rely on external equity, or do they increasingly rely on other sources of finance such as debt or retained earnings? In Berger and Udell's (1998) growth cycle model, the ultimate aim is that the firm is sold or taken public in order to

allow both investors and founders to ‘cash-out’. However, not all high-tech small firms will aspire to or reach this stage. If the firm does not complete a successful exit, or if ‘exit’ was never intended by the founders, then it is unlikely to continue to attract VC or angel funding. External equity investors will be less inclined to invest or continue to invest if there is little likelihood of high returns. Thus, as high-tech ventures age, we expect them to have greater access to other sources of funding including internal revenues and debt. Therefore, we hypothesize an inverse relationship between age and private equity usage in small high-tech firms.

H3: There is an inverse relationship between age and the proportion of external equity employed in the firm’s capital structure, such that as high-tech firms age, they will have a lower proportion of external equity in their capital structure.

Initial investment requirement and external equity funding

High-tech small firms differ from the general population of SMEs because of the high levels of R&D required. R&D projects typically ‘require large fixed costs which are independent of the size of the market for the innovation’ (Symeonidis 1996:17). As a result, high-tech small firms in their early stages usually require greater amounts of capital than the general population of SMEs, because of the high costs associated with R&D and commercialization (Geroski 1995; Minola and Giorgino 2011; Minola et al. 2013). Empirical support for a positive relationship between the investment requirement and equity financing is provided in Schäfer, Werwatz, and Zimmermann (2004), Ueda (2004), and Minola et al. (2013). Using Kauffman Foundation data on US firms, Minola et al. (2013) found that high-tech firms with a greater a capex to start-up capital ratio are more likely to obtain external equity.

Founders of start-up firms will typically have access to a limited pool of their own savings and those of family and friends.

Given the evidence on the near-absence of debt financing for high-tech start-ups, the greater the initial investment requirement, the more likely it is that firms will need to seek outside equity. If the outside equity is venture capital, the size of the investment will be substantial; VCs prefer to make relatively large investments in firms because their evaluation and monitoring costs tend to be fixed, and because they are under pressure to raise large pools of funds (Gompers 1995; Gompers and Lerner 2001). The size of angel investors' contributions is less well understood, but there is agreement that angels invest less than VCs (Freear, Sohl, and Wetzel 1995; Mason and Harrison 2000). Nevertheless, like their venture capital-backed counterparts, firms that attract angel finance do so because they have higher start-up costs than the general population of SMEs. Therefore, we hypothesize a positive relationship between initial investment size and private equity usage in high-tech small firms:

H4: There is a positive relationship between the size of the firm's initial investment and the proportion of external equity in the firm's capital structure, such that high-tech ventures with larger initial investments will have a greater proportion of external equity in their capital structure.

The signalling value of equity and external equity funding

At the heart of the POH is the asymmetry of information between the company's management and 'uninformed' outside investors. This information asymmetry implies that a new share issue will trigger a reduction in the stock price, because investors assume that managers will issue stock only if they perceive it to be overvalued. Obtaining external equity has a different signalling function in high-tech private firms. Venture capitalists can potentially help entrepreneurs raise additional funds by

certifying the quality of a start-up, particularly companies going public in an IPO. This is because venture capitalists are repeat players in the IPO market and need to demonstrate success to secure new funds. Megginson and Weiss (1991) find that venture-backed IPOs exhibit lower under-pricing than non-VC backed IPOs, confirming the certification theory. This issue is reinforced by the active role played by venture capitalists in monitoring, mentoring and providing strategic advice to the investee company (Gorman and Sahlman 1989; Denis 2004). Thus, based on these arguments, we offer the following hypothesis for the relationship between signalling and equity use:

H5: There is a positive relationship between the firm's perception of the signalling value of equity and the proportion of external equity in the firm's capital structure, such that high-tech ventures with a higher perception of signalling value will have a greater proportion of external equity in their capital structure.

Research Methods

Research context

Ireland sits in a unique position between the bank-based systems of Europe and the market-based systems of the UK and the US. Although classed as a bank-based financial system, Ireland has a well-developed venture capital industry – influenced by its geographic proximity and historical links to the UK, as well as its close cultural ties to the US via the Irish diaspora. Ireland is the location of choice for the EU headquarters of many large US information technology firms, including Google, Apple, Intel LinkedIn, and AirB&B. The investment portfolios of Irish venture capitalists are dominated by software firms – making Ireland an interesting laboratory to examine the financing of high-tech firms. The amount invested by VCs

peaked just before the ‘Dotcom’ bust in 2001 at approximately half a billion euro annually, and since then they have invested more than a quarter of a billion euro on average annually (IVCA, 2012).

The survey

A small number of studies (Graham and Harvey 2001; Poutziouris et al. 1999; Norton 1990) have used surveys to investigate which theories best explain the capital structure choices and preferences of larger firms corporations. Graham and Harvey (2001) and Norton (1990) surveyed Chief Financial Officers of large firms. We surveyed unlisted Irish software development firms; specifically, we addressed our survey instrument to the founders of these firms, as founders have considerable influence on the financing decisions of small firms (Ang 1991; Berger and Udell 1998). We sent this survey to the entire population of independent software product firms in Ireland in 2001, using a database compiled specifically for this study. The survey design was based on self-administered questionnaires using the tailored design method (Dillman 1976 and 2000). It was administered by mail and e-mail, addressed to founders/CEOs by name. The number of valid responses was 117 out of a population of 257, which provided us with an excellent response rate of just under 46 percent. Of the 117 firms that responded, 102 provided detailed information on funding, and it is these 102 firms that comprise our sample, which represents almost 40% of the population of interest.

Data on financing sources

The survey requested details of financing sources, separated into internal (savings, consulting revenues and retained earnings) and external (bank debt, venture

capital, private investors and government grants). Due to the well-known difficulty of getting firms to report actual financial data, we requested this information in percentage form only.

In Table 1, we provide summary information on the sources of finance used to support current investment projects. The average figures for the full sample show an almost 50/50 divide between internal and external sources: 51.6 internal and 48.4 external. A mere 4 percent of financing was sourced from banks. The remaining 46 percent of outside finance constituted venture capital (26.7 percent), angel finance (10.5 percent) and government grants (6.2 percent). Internal finance comprised savings of the founder, family and friends (13.8 percent) and retained profits (16.8 percent). The most important source of internal finance was revenue generated by consulting activities (19.2 percent).

Insert Table 1 about here

In column [2] of Table 1, we report the number of firms with no funding from each source. In columns [3], [4], [5] and [6] we divide the sample into quartiles; for example, Q1 (column [3]) provides the number of firms which have between 0 and 24 percent of their capital structure comprising each of the funding sources, and Q4 (column [6]) shows the number of firms that have between 75 and 100 percent of their capital structure in each funding source. Fourteen percent of our sample firms use no internal funding at all, and 22 percent use no external funding. Regarding bank debt, 71 percent do not borrow, no firms had more than half of their funding requirements satisfied by debt, and only 5 percent had a debt-to-assets ratio of between 25 and 50 percent (Q2, column 4). In contrast, of the 42 firms that secured venture capital, 32

were highly dependent on this source – using it to fund 50 percent or more of their current investment requirements. Focusing on external equity, 43 percent of our sample firms did not use external equity at all, whereas for 26 percent – more than a quarter – of our firms, external equity comprised more than three-quarters of their funding requirement. Given our sample firms’ very low reliance on bank debt, the findings in Table 1 suggest that the financing decision for high-tech small firms centres on whether to fund internally (through retained earnings, consulting revenues or savings) or to seek equity externally, in the form of angel finance or venture capital.

Variables and Measures

The dependent variable in our analysis is *external equity*. To control for potential confounding effects, we include several control variables. Our control variables include measures for the size of the firm (*size*), founders’ education level (*degree, postgraduate degree*), founders’ prior experience (*management experience, start-up experience*), and the founders’ preference for retaining equity control (*control preference*). To examine our five hypotheses, we use the independent variables *information asymmetry, venture risk, age, initial investment, and equity signal*.

External equity. The dependent variable *external equity* is the percentage of total equity financing obtained from external sources: private equity and venture capital. In Figure 2, we present a histogram of *external equity* on a decile basis. Forty-three of our 102 firms (42 percent) did not use external equity. If employed, external equity in most cases comprised a substantial amount of the financial requirement of the firms; it accounted for more than 40 percent of funding in 44 out of 59 (83 percent) of firms that secured this source of funding.

Firm size. Both theoretically (Myers, 1984; Berger and Udell 1998; Fluck et al. 1998) and empirically (Berger and Udell 1998; Fluck et al. 1998), size may exert an independent effect on the firm's financing choice. We control for firm size by including the variable *size*, measured as the number of employees at the time of the survey, in our models. Prior research suggests that number of employees is the most stable measure of scale in studies of small firm finance (Fluck, et al. 1998).

Founders' background. The small firm's ability to secure funding is linked to the background of its founders (Ang et al. 2010; Colombo and Grilli, 2007; Åstebro and Bernhardt 2003; Cooper et al. 1994; Fluck et al. 1998; Bates 1990). Thus, the founders' stock of 'human capital,' as measured by levels of educational attainment, prior work experience, and previous start-up experience, can serve to certify their collective capabilities to potential investors. Our measures for founders' education level include *degree* and *post-graduate degree*. We measure *degree* as a dichotomous variable that takes a value of one if the founder has a university degree, and zero otherwise. Similarly, *postgraduate degree* takes a value of one if the founder has a postgraduate university degree, and zero otherwise. Our measures for founders' experience are *management experience* and *start-up experience*.

We measure *management experience* as the number of years of prior high-tech sector management experience; midpoints are derived from management experience ranges. We measure *start-up experience* as a dichotomous variable that takes a value of one for founders who have previously been involved in starting a business, and zero otherwise.

Control preference. Most prior research explains the preference for debt over outside equity in small firms in terms of the founder's desire to maintain independence and control (Cosh and Hughes 1994; Chittenden et al. 1996; Poutziouris et al. 1998; Jordan et al. 1998; Bolton 1971). Thus, we measure the founder's willingness to cede control of their business to outsiders by asking them the extent to which they wish to 'Retain a majority stake hold (50% or more) in the business for founder(s)'. This measure is new, and it is based on Kaplan and Stromberg's (2003) finding that in order to acquire VC funding, owner-managers must relinquish a substantial equity stake – typically 50 percent. Founders were asked to reply on a 5-point Likert scale, where -2 represents 'not at all' and $+2$ represents 'to a large extent'.

Information asymmetry. We measure founders' experience of information asymmetries in debt markets by asking them the extent to which they agree with the statement that 'banks understand their businesses' (-2 'not at all' to $+2$ 'to a large extent'). The statement is drawn from a study of the bank-client relationship in the UK (Binks et al. 1992), with the permission of the authors.

Venture risk. The main feature determining the firm's likelihood of encountering financial distress is its business risk, which is usually defined as the variability of expected future cash flows from the firm's operations. Venture risk is distinguished from financial risk, the main source of which is the use of debt.

We measure the founders' perception of their venture's risk by asking them the extent they agree with the statement 'Even with adequate financing, the company has a 50 percent chance of failing' (-2 strongly disagree to +2 strongly agree).³

Age. We measure the age of the venture as the firm's age in months. This measurement approach is consistent with that of prior research (for example see Fluck et al.1998).

Initial Investment. The initial investment requirement of the firm – also known as 'start-up cost' – has been used in several studies (Schäfer, Werwatz, and Zimmermann 2004; Ueda 2004; Minola et al. 2013). We measured initial investment by asking our founders to provide information on start-up costs (in ranges); the variable *initial investment* is the midpoint of these range categories.

Equity signal. We measured perception of signalling value of equity by asking the founders the extent to which they agree with the statement 'Raising equity sends a favourable signal to lenders, investors, creditors and customers about the firm's future prospects' (-2 'not at all' to +2 'to a large extent'). We derive this measure from a study of the financial decision-making in small private and public limited firms in the UK by Poutziouris et al. (1999), with the permission of the authors.

We provide an overview of these measures of the dependent, control, and independent variables used in our analysis in Table 2.

Insert Table 2 about here

³ Fluck et al (1998) used a survey item to measure business risk, which asked respondents whether or not they viewed the business situation as being stable. The respondents were asked whether they thought their firms would "continue to operate pretty much as [they] have." The authors were using secondary data supplied by Reynolds, P. and S. White (1993), "Wisconsin's Entrepreneurial Climate Study," Marquette University Center for the Study of Entrepreneurship.

Model and Analytical Procedures

Our dependent variable, the percentage of external equity in the firm's capital structure, is a ratio – by definition falling between 0 and 100 percent. We therefore use a double-censored Tobit model rather than the standard OLS approach:

$$y_i^* = \beta x_i + u_i \quad (1)$$

where y_i^* is the latent variable potential proportion of external equity in the capital structure of firm i , and x_i is a vector of explanatory variables for firm i . u_i is a random disturbance term with $E(u_i) = 0$, and y_i^* is as follows:

$$y_i = \begin{cases} 0 & \text{if } y_i^* \leq 0 \\ y_i^* & \text{if } 0 < y_i^* < 100 \\ 100 & \text{if } y_i^* \geq 100 \end{cases} \quad (2)$$

Equation (1) is estimated using maximum likelihood, with heteroskedasticity-robust (Huber-White) standard errors.

Results

Summary statistics

In Table 3 we present the descriptive statistics for the dependent and independent variables used in our analysis. We include the mean, median, maximum and minimum values, and skewness for the five continuous variables. We also provide summary information for our survey findings on the four Likert scale variables and the three dummy variables. The mean size by number of employees is 25, and the average firm age is 68 months, which is about 5½ years. The skewness statistics show that

none of the variables exhibit excessive skewness. In general, founders feel that banks do not understand their businesses, that raising external equity sends a positive signal, and that most founders view their businesses as highly risky. The vast majority of the sample firms' founders have a primary degree, and over 40 percent have a higher degree. Lastly, a rather high 45 percent of the founders have prior start-up experience.

Insert Table 3 about here

Table 4 presents a Spearman rank correlation matrix for the full set of variables. Column 1 shows the correlations between the independent variables and the dependent variable *external equity*. *Information asymmetry*, *venture risk*, *age*, *initial investment* and *equity signal* all have signs consistent with their hypothesised relation to *external equity*. Of the control variables, *size* and *degree* are significant and positively related to *external equity* as expected, but *postgraduate degree*, *management experience* and *start-up experience* are not significant on a univariate basis. While there are some significant correlations amongst the independent variables, none are of a sufficient magnitude to cause concern regarding multicollinearity.

Insert Table 4 about here

Multivariate analysis

We present the results of our analysis models in Table 5. In this table, we present the findings for seven model specifications. Model [1] includes the control variables only, and in models [2] to [6], we sequentially test hypotheses 1 to 5 by including respectively *information asymmetry*, *venture risk*, *age*, *initial investment*, and *equity signal*. Our final specification in model [7] includes all the variables.

Insert Table 5 about here

We find *information asymmetry* (model [2]) – which measures the extent to which founders believe that banks understand their business – is inversely related to the proportion of outside equity in the firms’ capital structure, and is highly significant ($p = 0.01$). This finding supports *H1* – that more external equity is used when founders perceive greater information asymmetries in bank lending.

We find that *venture risk* (model [3]) has the expected positive sign, but is not significant at standard levels ($p = 0.14$). It is, however, significant at the 10 percent level ($p = 0.10$) in the fully specified model [7]. We therefore conclude weak support for *H2*. Recall that *venture risk* is measured as the extent to which founders agree with the statement ‘even with adequate finance, the company has a 50 percent chance of failing’. It is clear that when the founders’ perception is that the venture’s risk is high, firms are more likely to seek and obtain external equity. Reinforcing founders’ preference to seek external funding for riskier projects, on the supply side venture capitalists and angel investors also have a preference for high-risk investment projects which by definition offer the possibility of very high returns (Fluck et al. 1998).

In model [4], we include age. It has the predicted negative sign, but is significant only at the 10 percent level ($p = 0.10$). Thus, we conclude weak support for *H3*: there is a lesser use of external equity relative to other sources of finance as the firm ages, and a greater use of external equity amongst younger firms. We find that *Initial investment* (model [5]) is positive and highly significant ($p = 0.00$). This finding offers strong support for *H4*; large initial investments are related to higher levels of external equity. This finding confirms that a positive demand-side

motivation on the part of founders – to seek external funding when the investment requirement is high – is likely to be accompanied by the supply-side factor that venture capitalists tend to avoid small-scale projects (Gompers and Lerner 2001).

Lastly, we find that *equity signal* (model [6]) is highly significant ($p = 0.00$) and positive, providing strong support for *H5*. The founders of our sample firms view the ability to secure external equity as an important signal to outsiders about the potential of their firms. This finding is consistent with the predictions of certification theory (Megginson and Weiss 1991).

Of the control variables, *size* is weakly significant in only two of our models. *Degree* is significant at the 5 percent or better in the majority of specifications, showing that firms whose founders have a primary degree use a greater proportion of external equity in their capital structure. *Postgraduate degree*, however, is not significant. These results are somewhat in line with those of Coleman and Robb (2012), who found a positive relationship between equity finance and level of education – for both primary and graduate degrees. The other two human capital variables – management experience and start-up experience – are not significant. In contrast, *control preference* is highly significant and negative, confirming that founders who wish to maintain majority control of the firm are much less likely to seek external equity funding and bear the loss of control that comes with angel or venture capital finance.

Limitations

This study is subject to a number of limitations. It is based on the analysis of a cross-section of surviving high-tech small firms. Survivorship bias is an unavoidable

pitfall of this mode of research, where firms of different ages are included in a survey-based study. Nevertheless, the aim of our study is to examine the financing of high-tech small firms post start-up. Methodologically, one would have more confidence in the results from a panel data study that surveys the same firms at different intervals over time, but such a database for privately held-firms and would be very costly to construct.⁴ Longitudinal data would allow the researcher to observe changes in firm capital structure and owner characteristics and preferences over time. One advantage of this would be that if all founders were surveyed at the time of formation, then one could determine whether the preference to maintain majority control was related to the use of external finance ex-ante – which of course was not possible in this study.

Discussion and conclusions

We find that equity dominates debt financing for private high-tech small firms. This is consistent with prior results for economies with strong private equity markets, such as the US (Colman and Robb 2012; Roberts 1990 and 1991; Brewer and Genay 1994) and the UK (Moore 1994). While in apparent contradiction to the pecking order theory, we argue that these findings are consistent with the rationale of Myers and Majluf's (1984) theory of capital structure, because the pecking order theory suggests that firms will prefer sources of finance associated with the lowest level of information asymmetry.

Our work sheds light on a facet of financing decisions in high-tech small firms that has received little prior academic attention.

⁴ Research programs such as the Kaufman Firm Survey (KFS), and University of Michigan, Panel Study of Entrepreneurial Dynamics (PSED) have been set up to address this data constraint.

For high-tech small firms, this source is private equity provided by venture capital firms or business angels; such sources of finance are designed to overcome many of the information asymmetry problems that firms face in debt markets.

The preference for equity is clearly not just about funding constraints in debt markets. It is also about owners' preferences and perceptions. Researchers and policymakers usually point to the differences in private equity markets between Europe and the US as the main barrier to the formation of high-tech ventures. Our findings suggest that perceived asymmetries in debt markets compound the problem, so that even well established high-tech small firms may be unable to secure debt financing. We also find that our high-tech firm founders' perceptions on the signalling value of equity informs their financing choice.

Our sample firm founders are much less concerned about maintaining control than has been found for SME owner-managers in studies of the general population (Cressy 1995), and we find that founders with a greater willingness to relinquish control have use more external equity.

Our findings have important policy implications. Many high-tech small firm founders are open to sharing equity, and are therefore likely to respond positively to policy measures that make equity more readily available. Further, governments might do more to channel finance to established high-tech small firms, so that they may augment internal innovation in breakthrough technologies. Acting to boost the performance of established high-tech small firms might prove more fruitful than a policy that focuses exclusively on early stage funding. In Ireland, the development of a venture capital market focused on the information technology sector has facilitated the

funding of innovative firms, and illustrates the success of a focused innovation finance programme. Ireland's weakness, in common with other European countries, is that it does not have an efficient public equity market like NASDAQ. At the firm level, access to equity is critical for entrepreneurs to fund the commercialisation of R&D, which in turn promotes national competitive advantage and economic growth.

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Table 1
Sources of Finance

	[1]	[2]	[3]	[4]	[5]	[6]					
	Average	Number of firms in each category of percent financing source									
		Zero		By quartile							
				Q1		Q2		Q3		Q4	
Savings	13.8	56	57.1	27	27.6	3	3.1	5	5.1	7	7.1
Consulting revenues	19.2	48	50.0	19	19.8	11	11.5	8	8.3	10	10.4
Retained profits	16.8	59	60.8	17	17.5	5	5.2	5	5.2	11	11.3
Total internal	51.4	14	14.0	23	23.0	6	6.0	19	19.0	38	38.0
Bank	3.9	71	71.7	23	23.2	5	5.1	0	0.0	0	0.0
Grants	6.2	58	58.6	34	34.3	5	5.1	2	2.0	0	0.0
VC	26.7	58	58.0	2	2.0	8	8.0	15	15.0	17	17.0
Angel	10.5	71	71.0	16	16.0	4	4.0	4	4.0	5	5.0
Corporate	0.6	99	99.0	0	0.0	0	0.0	1	1.0	0	0.0
Total external equity	37.8	43	43.0	5	5.0	9	9.0	17	17.0	26	26.0
Total external	48.6	22	22.0	12	12.0	16	16.0	13	13.0	37	37.0

Notes. This table summarises the sources of financing used by our sample firms. ‘Average’ refers to the overall mean percentage of financing from each source. We also report the number of firms that have no funding from each particular source of finance (‘zero’), and then the number of firms in each quartile. Q1 comprises firms whose total financing comprises between 1 and 24 percent of the particular source; Q2 is firms with between 25 to 49 percent of their total financing; Q3 is 50 to 74 percent, and Q4 75 to 100 percent.

Table 2
Variable Definitions

Variable	Description
External equity	External equity (venture capital + private equity) as percentage of total financing
<i>Independent variables</i>	
Information asymmetry	The extent to which founders agree with the statement ‘Banks understand my business’; -2 strongly disagree to +2 strongly agree.
Venture risk	The extent to which founders agree with the statement “even with adequate finance, the company has a 50 percent chance of failing”; -2 strongly disagree to +2 strongly agree.
Age	Firm age in months.
Initial investment	Amount of initial financial investment: mid points derived from start-up cost range categories.
Equity signal	The extent to which founders agree with the statement ‘Raising equity sends a favourable signal to lenders, investors, creditors and customers about the firm’s future prospects’; -2 not at all to +2 to a large extent.
<i>Control Variables</i>	
Size	Firm size in employees
Degree	Founder has an undergraduate degree; yes = 1, no = 0.
Postgraduate degree	Founder has postgraduate or PhD degree; yes = 1, no = 0.
Management experience	Number of years of management experience the founder had in the software sector prior to start-up: mid points derived from management experience ranges.
Start-up experience	Founder was previously involved in starting a business; yes = 1, no = 0.
Control preference	The extent to which founders expressed a preference ‘to maintain 50% or more of the shares of the business in the hands of the founders’; -2 not at all to +2 to a large extent.

Table 3
Descriptive statistics – dependent and explanatory variables

Continuous variables					
	Mean	Median	Max	Min	Skewness
External equity %	37.7	28	100	0	0.31
Size (number of employees)	25.0	14	200	0	2.85
Age (months)	67.7	49	312	5	1.69
Initial investment	240,441.2	75,000	1,000,000	25,000	1.46
Management experience (years)	4.5	4	10	0	0.23
Likert scale variables					
	-2	-1	0	1	2
Control preference	9 (8.8%)	23 (22.5%)	35 (34.3%)	20 (19.6%)	15 (14.7%)
Venture risk	11 (10.8%)	26 (25.5%)	12 (11.8%)	38 (37.3%)	15 (14.7%)
Information asymmetry	23 (22.5%)	36 (35.3%)	34 (33.3%)	8 (7.8%)	1 (1.0%)
Equity signal	3 (2.9%)	6 (5.9%)	22 (21.6%)	46 (45.1%)	25 (24.5%)
Dummy variables					
	Yes	No	% Yes		
Degree	88	14	86.3		
Postgraduate degree	43	59	42.2		
Start-up experience	46	56	45.1		

Notes. This table provides summary statistics for the dependent and independent variables to be used in the multivariate analysis. Panel A presents the mean, median, maximum and minimum values, and skewness statistics, for the continuous variables. Panel B presents summary information for the Likert scale variables. Survey participants were asked to respond on a 5-point scale; for the variables *control* and *equity signal* -2 represents 'not at all' and +2 'to a large extent'; and for risk and bank asymmetry -2 represents 'strongly disagree' and +2 'strongly agree.' Panel C provides summary information for our dummy variables; 'yes' refers to dummy = 1, where the main founder has a degree, a postgraduate degree, and start-up experience. Please see Table 2 for a full description of the variables.

Table 4
Spearman Rank Correlation Matrix

	1	2	3	4	5	6	7	8	9	10	11	12
1 External equity	1.00											
2 Size	0.23 (0.02)	1.00										
3 Degree	0.26 (0.01)	0.19 <i>(0.06)</i>	1.00									
4 Postgraduate degree	-0.01 <i>(0.95)</i>	0.01 <i>(0.95)</i>	0.34 (0.00)	1.00								
5 Management experience	-0.01 <i>(0.91)</i>	0.01 <i>(0.90)</i>	-0.06 <i>(0.53)</i>	-0.24 (0.01)	1.00							
6 Start-up experience	-0.04 <i>(0.69)</i>	-0.06 <i>(0.53)</i>	-0.01 <i>(0.93)</i>	-0.01 <i>(0.89)</i>	-0.11 <i>(0.30)</i>	1.00						
7 Control preference	-0.27 (0.01)	-0.15 <i>(0.12)</i>	-0.16 <i>(0.11)</i>	0.06 <i>(0.53)</i>	-0.05 <i>(0.66)</i>	-0.01 <i>(0.93)</i>	1.00					
8 Information asymmetry	-0.25 (0.01)	0.02 <i>(0.85)</i>	-0.10 <i>(0.31)</i>	0.07 <i>(0.49)</i>	-0.06 <i>(0.54)</i>	-0.21 (0.03)	0.07 <i>(0.48)</i>	1.00				
9 Venture risk	0.21 (0.04)	-0.09 <i>(0.38)</i>	0.18 <i>(0.08)</i>	0.06 <i>(0.58)</i>	0.03 <i>(0.76)</i>	-0.11 <i>(0.29)</i>	-0.13 <i>(0.19)</i>	0.00 <i>(0.99)</i>	1.00			
10 Age	-0.20 (0.04)	0.40 (0.00)	-0.21 (0.03)	0.07 <i>(0.50)</i>	-0.23 (0.02)	-0.09 <i>(0.40)</i>	0.30 (0.00)	0.16 <i>(0.11)</i>	-0.13 <i>(0.21)</i>	1.00		
11 Initial investment	0.33 (0.00)	0.15 <i>(0.14)</i>	0.27 (0.01)	-0.06 <i>(0.54)</i>	0.06 <i>(0.56)</i>	-0.03 <i>(0.77)</i>	-0.12 <i>(0.23)</i>	-0.12 <i>(0.23)</i>	0.16 <i>(0.12)</i>	-0.35 (0.00)	1.00	
12 Equity signal	0.38 (0.00)	0.07 <i>(0.46)</i>	0.22 (0.03)	0.04 <i>(0.66)</i>	-0.05 <i>(0.64)</i>	0.00 <i>(0.99)</i>	-0.20 (0.05)	-0.24 (0.02)	0.05 <i>(0.59)</i>	-0.23 (0.02)	0.20 (0.04)	1.0

Notes. In this table we report Spearman rank correlations for dependent and independent variables to be used in the analysis of determinants of the proportion of external equity. For full definitions of the independent variables, please see Table 2. The coefficients on *initial investment* have been multiplied by 1000. In brackets below the correlations are the p-values. P-values showing significance at the 5 percent level or better appear in **bold**, and at the 10 percent level in *italics*.

Table 5
Results of Multivariate Analysis

	1	2	3	4	5	6	7
Size	0.158 (0.39)	0.172 (0.37)	0.216 (0.25)	0.316 (0.10)	0.114 (0.51)	0.136 (0.42)	0.294 (0.09)
Degree	39.350 (0.01)	29.712 (0.04)	33.525 (0.03)	47.179 (0.00)	24.279 (0.11)	17.874 (0.27)	7.977 (0.65)
Postgraduate degree	-11.262 (0.41)	-8.455 (0.53)	-9.896 (0.47)	-6.180 (0.65)	-7.373 (0.57)	-12.562 (0.34)	-2.449 (0.84)
Management experience	-1.638 (0.32)	-2.023 (0.20)	-1.546 (0.35)	-1.412 (0.40)	-1.752 (0.27)	-1.753 (0.26)	-1.793 (0.23)
Start-up experience	-2.797 (0.82)	-10.602 (0.40)	-0.584 (0.96)	0.704 (0.95)	-2.922 (0.80)	-4.924 (0.68)	-5.386 (0.62)
Control preference	-15.230 (0.02)	-14.199 (0.02)	-14.023 (0.03)	-11.558 (0.06)	-14.540 (0.02)	-12.268 (0.04)	-7.996 (0.15)
Information asymmetry		-17.615 (0.01)					-13.053 (0.04)
Venture risk			8.014 (0.14)				7.309 (0.10)
Age				-0.297 (0.10)			-0.221 (0.11)
Initial investment					0.057 (0.00)		0.036 (0.03)
Equity signal						24.811 (0.00)	17.438 (0.02)
Mean dependent variable	38.44						
S.D. dependent variable	38.26						
S.E. of regression	37.3	36.6	36.8	36.3	35.3	35.9	33.6
Sum squared resid.	129362	123101	124624	121194	114631	118371	99519

Notes. In this table we report the results for the double-censored Tobit regressions of (equation 1). The dependent variable is *external equity*. For full definitions of the dependent and independent variables, please see Table 2. The coefficients on *initial investment* have been multiplied by 1000. In brackets below the coefficients are the p-values. P-values showing significance at the 5 percent level or better appear in **bold**, and at the 10 percent level in *italics*.