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THE PECKING ORDER OF INNOVATION FINANCE

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Abstract

How does innovation affect the hierarchy of financing behaviours? In this paper we analyse the role of innovation inputs (R&D), intermediate outputs (patents) and outcomes (product and process innovations) as sources of asymmetric information in an investment framework. In contrast with the majority of studies on firm capital structure we focus on unlisted rather than listed companies and explore the effects of information asymmetries in the context where they are most severe, that is, among small and medium sized firms. We identify the effect of innovation, alongside the size of the firm, its age and its human capital, on the order of external capital allocations. Our results show that innovation is negatively associated with a standard pecking order characterised by increasing agency costs, and that the more uncertain the innovation signal, the stronger its effect on the pecking order.

Jelcodes:O30,D80

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Keywords: R&D, innovation, capital structure, investment risk, entrepreneurial finance.

JEL Classification: G32, O31, O32, D80

1. Introduction

The ability to access financial resources is a key enabler of entrepreneurship and firm growth. However, financial market imperfections can lead to misallocation of capital and under-exploitation of investment opportunities. Departures from optimality conditions are generally ascribed to information asymmetries and adverse selection which arise in the investment process when potential borrowers do not send reliable signals about their quality or when investors cannot capture these signals (Jensen and Meckling, 1976; Stiglitz and Weiss, 1981).

The nature and scope of financial market imperfections vary together with the form of capital that is supplied and with the agents' ability to bridge information gaps. Against the Modigliani-Miller (1958) theorem on the irrelevance of capital structure, the pecking order theory of corporate finance posits that firms will access additional capital according to a specific order of preferences: first of all, other things being equal, they will prefer internal to external finance, and secondly they will favour debt over equity (Myers and Majluf, 1984; Myers, 2000).[1] Firms have informational advantages over external agents when investment risk does not arise from observable sources such as the market or currencies, but is instead idiosyncratic to the firm. This reduces the transparency of the company as an investment opportunity and increases the agency cost of outside finance to compensate for higher risks. Institutional differences between alternative sources of external capital reflect different propensities to risk as well as different information-processing abilities.[2]

Among the firm characteristics that can influence the pecking order, innovation poses an interesting challenge. Innovative firms can be valuable investment opportunities, but are also riskier for investors 1) because they typically undertake research and development activities of uncertain outcomes (technology risk), 2) because full disclosure of information on innovation projects can prevent the protection of imitable intangible assets (value appropriation risk) and 3) because the achievement of R&D targets does not guarantee success in the market place (market risk). Firms may find it prohibitively expensive to reveal information about intended and potential outcomes of these investment opportunities to

[1] The link between information asymmetries and forms of capital has been studied in the context of banks (Berger et al., 2001; Berger and Udell, 1998; 2006; Ughetto, 2008), lease and supplier finance (Tamari, 1970; Myers et al., 1976; Porter, 1995), venture capital finance (Gompers and Lerner, 1999, 2001), angel finance (Goldfarb et al., 2013; Wong et al., 2009; Harrison and Mason, 2000). However, despite the growing emphasis on pecking order models, very few studies take into account simultaneously a broad spectrum of external finance allocation decisions.

[2] For a recent review of pecking order and alternative theories of capital structure see Frank and Goyal (2008).

suppliers of external finance (Hall, 2009). In addition, investors will be aware of the increased risks of moral hazard and expropriation by incumbents induced by asymmetric information. External finance is therefore provided only at a premium, and this may expose innovative firms to financial constraints (Hall, 1992; Brown and Petersen, 2009, 2010; Bond et al., 2003, 2010; Mulkay et al., 2001; Harhoff, 1998; Carpenter et al., 1998).

In this paper we investigate the relationship between the types of external capital obtained by firms and the firms' innovation characteristics. We focus on the role of informational transparency and assess the effect of innovation signals among the factors that shape the hierarchy of financing decisions. Our results demonstrate that the allocation of external finance is significantly influenced by the borrower's innovation profile, and show how different dimensions of innovation associated with varying degrees of risk affect the pecking order of external capital.

We study innovation as a source of agency costs among small and medium-size enterprises, a context where information asymmetries are especially severe. We use data from an original survey of UK and US SMEs which include information on firm financing alongside several indicators of innovation. While other data sources used in the literature provide detailed information on either the former or the latter, joint coverage of financing and innovation activities is rare. On this basis, we extend capital structure theory by identifying innovation as a source of asymmetric information that can explain systematic deviations from the standard pecking order of increasing agency costs. Moreover, by analysing the effect of different dimensions of innovation (its inputs, intermediate outputs and outcomes) on the hierarchy of capital allocations, we also contribute to the innovation economics literature on the financing strategies of SMEs.

The paper is structured as follow. In section 2 we review the relevant prior art and develop testable hypotheses on the effect of innovation on the pecking order of external finance. In Section 3 we present our data and methods of analysis. Section 4 contains the main results of the paper, which we discussed in the following section (5). Section 6 concludes with a more general reflection on the contribution of the paper and its implications for further research.

2. The hierarchy of financing decisions and their determinants

The pecking order hypothesis predicts that borrowers follow a specific order of preferences for different types of finance. In the first instance, firms will fund new projects with internal resources (i.e., operating cash flow) and will seek external finance only when available internal funds have been exhausted (Myers and Majluf, 1984; Myers, 2000). If they cannot access internal funds, firms will prefer debt over equity among alternative sources of external capital (Myers and Majluf, 1984; Himmerberg and Petersen, 1994; Harhoff, 1998). Debt is a more senior form of capital and is thus less sensitive to private information than equity. Since equity is the relatively more expensive option associated with the most severe information asymmetries, firms will issue equity only under duress, when they have exhausted their debt capacity (Myers, 1984; Lemmon and Zender, 2010). In an attempt to minimise adverse selection costs, firms will therefore use internal finance first, then debt, and finally equity.

Despite a considerable amount of theoretical and empirical studies on this topic, there is no consensus in the literature on the extent to which pecking order theory is able to explain the financing behaviour of firms, as suggested by Shyam-Sunder and Myers (1999), and the predictive power of this hypothesis has not proved universally superior to alternative explanations (Frank and Goyal, 2003; Fama and French, 2005; de Jong et al. 2011). There are different interpretations and technical implementations of the theory's building blocks (Lemmon and Zender, 2010; Leary and Roberts, 2010). Moreover, it has proved difficult to generalise the conditions under which the pecking order should apply, with the consequence that different views persist on the merits of pecking order relative to competing theories of capital structure (e.g. trade-off theory).

The debate is especially contentious on the relative merits of equity vs. debt as external sources of finance, while empirical studies tend to confirm the prediction of pecking order theory about the preference for internal over external finance, as demonstrated by Frank and Goyal's (2008) review of the determinants of leverage. Under fairly weak assumptions about the existence of transaction costs, internal funds will be preferred. Commenting on the problem of investment cash flow sensitivity, Kaplan and Zingales (1997: 173) observe that "…While it is easy to show that constrained firms should be sensitive to internal cash flow while unconstrained firms should not, it is not necessarily true that the magnitude of the sensitivity increases in the degree of financing constraints. This is the crucial question, given that investment is sensitive to cash flow for the vast majority of firms analyzed. (It is easy to

justify this sensitivity based on the fact that external funds are more costly than internal funds for all firms as long as some transaction costs are involved.)"

The literature discusses at length the role of firm size in selecting the most appropriate theory of capital structure. For smaller firms, the information that is available to investors for the evaluation of investment opportunities can be seriously limited by the absence of a track record and lack of collateral. However, on the basis of pecking order theory it is not entirely clear whether SMEs should behave differently from larger firms, other things being equal, unless credit rationing makes debt unavailable to SMEs and leaves equity as the only means of external financing. Frank and Goyal (2003) and Fama and French (2005) argue that small, high-growth firms are more sensitive to asymmetric information problems. They would therefore rely on equity rather than debt when they need external finance (Devos et al., 2012) as a reflection of financial constraints rather than a contradiction of pecking order (Chang and Song, 2013). While small firms may have high growth rates more often than large firms, however, it is the growth characteristic of a firm, not its size as such, which makes it opaque to investors. It is possible that "when there is asymmetric information about risk, adverse selection arguments for debt apply and firms prefer to issue external equity over debt. Thus, adverse selection can lead to a preference for external debt or external equity depending on whether asymmetric information problems concern value or risk (Frank and Goyal, 2008, p. 22).

An additional layer of complexity has been added to modern capital markets by the rise of entrepreneurial finance, which has substantially enriched the range of external sources of capital available to firms, and in particular to SMEs (Chemmanur and Fulghieri, 2014). This increases institutional variety and adds further options to the spectrum of finance types beyond a 'simpler' choice between debt and equity. Specialist investors can contribute greater expertise in evaluating the commercial prospects of the firm's growth potential relative to traditional lenders, and venture capitalists have proved to be especially skilled at handling the high risk of new entrepreneurial activities (Gompers and Lerner, 1999, 2001; Harrison and Mason, 2000; Goldfarb et al., 2013; Wong et al., 2009).

Berger and Udell (1998) elaborate on the idea of a finance continuum where insider finance, angel finance, private and public equity, and different forms of lending and trade credit co-exist as alternative or complementary sources of finance. The likelihood that these come into use varies with firm size, age and availability of information. The central idea is that firms will pursue different types of capital over time. First of all, firms will use internal

funds when they are younger. They will then access different forms of debt and/or equity finance as they grow older and larger, via the accumulation of collateralisable assets, learning about lending technologies, and compliance to stricter information disclosure protocols (Guiso, 1998; Berger and Udell, 2006).[3] An increase in the institutional variety of external capital markets may not violate the principles of pecking order theory, but simply extend the hierarchy of financing behaviours. The result is an extended pecking order that includes – by increasing levels of information asymmetry – debt, public equity, private equity and angel finance.

3. Innovation, asymmetric information and the pecking order

Innovation activities decrease the transparency of firms as investment propositions because of the uncertain nature of technical change and the market risk associated with new products and processes. R&D requires long-term investments and its output can often be characterised by radical (Knightian) uncertainty. In addition, R&D involves the accumulation of idiosyncratic intangible capital (intellectual property and skills) difficult to resell on a secondary market if the project fails to achieve the desired targets. Finally, new products and new processes may emerge as the successful outcomes of R&D processes, even though their returns are not guaranteed given the unpredictability of potential demand (Hall, 2009).

From an investment point of view, the evaluation of R&D projects calls for different competences (for example, a degree of technical or scientific knowledge) and different propensities to risk in comparison with ordinary investments. Low informational transparency can result in limited supply – or no supply at all – of different forms of external capital. The literature has been quite clear that R&D can considerably aggravate firm financial constraints (Hall, 1992; Harhoff, 1998; Brown and Petersen, 2009, 2010; Bond et al., 2003, 2010; Mulkay et al., 2001). What are then the implications of innovation for the hierarchy of financing decisions?

Since transaction costs can generate a wedge between the cost of external and internal funds in any firm, there is no theoretical reason to believe that there should be a difference between innovative and non-innovative firms in having a preference for internal resources as

[3] The empirical evidence is also mixed on the effects of age on the pecking order, as discussed by Robb and Robinson (2014), who find from analyses of the Kauffman Survey that new firms are more likely to obtain debt than equity despite the possible revealed preference for equity given the financial constraints that characterise start-up firms.

the more advantageous financing option. The available empirical evidence indicates quite clearly that this is indeed the case (Cosh et al., 2009; Hall and Lerner, 2009; Hall, 2009; Revest and Sapio, 2011; Mina et al., 2013). The question whether debt or equity should be preferred by more innovative firms once internal resources are exhausted is rather more complicated, because innovative firms can be valuable investment opportunities, hence suitable for debt financing, but are also considerably riskier and prone to agency costs, hence more suitable for equity financing (Aghion et al. 2004).

Robb and Seaman (2014) show that information asymmetries are especially severe between entrepreneurs (as owner-managers of younger firms) and lenders, and that the problem will be aggravated by lack of tangible assets and concurrent reliance of intangibles. Banks will be less likely to finance R&D performing firms. Following Stiglitz and Weiss (1981) and Berger and Udell (1998), they also argue that banks might ration capital rather than increase interest rates because of moral hazard and adverse selection concerns. Moreover, and in line also with transaction costs theory (Williamson, 1988; 2002), they find that firm-specific assets as indicated by R&D activities induce a greater likelihood of equity financing relative to debt. Cosh et al. (2009) consider the effect of introducing an innovation, but not the effect of R&D expenditure, and find a weak negative result for the percentage of external finance obtained by the firm, and overall inconclusive results for the main sources of external capital considered one at a time.

Fulghieri et al. (2013, p. 3) argue that deviations from the pecking order are possible when the firm's assets are more exposed to asymmetric information. In this case they will first access equity and then revert to debt as they mature. More specifically, we could observe a reversal of preferences between debt and equity in a firm "whose assets in place have been obtained by the exploitation of past growth opportunities (such as the outcome of R&D activities) and that is also endowed with new growth opportunities (such as new R&D activities). In these situations it is plausible that the firm has relatively more accurate information on its assets in place, on which more information has become available over time to its insiders, rather than on the new growth opportunities, where critical information on their true value still has yet to be revealed. If the new growth opportunities have greater volatility […] the original Myers and Majluf conjecture may not hold."

Among external sources of capital, some investors have the potential to increase firm value beyond the provision of financial resources per se, as is strongly emphasised in the literature on angel (Wong et al., 2009; Harrison and Mason, 2000) and venture capital finance

(Bergemann and Hege, 1998; Gompers and Lerner, 1999; Kortum and Lerner, 2000; Bascha and Walz, 2001; Mayer et al., 2005; Neus and Walz, 2005; Riyanto and Schwienbacher, 2006; Schwienbacher, 2008). In addition to higher technical and scientific knowledge and human capital, venture capitalists employ a variety of instruments (splitting investments in multiple stages, taking seats on the portfolio companies' boards or aligning management incentives by stock options or similar remuneration schemes) that mitigate information problems at the stage of screening and monitoring (Gompers and Lerner, 1999, 2001; Casamatta, 2003; Wright and Lockett, 2003; Kanniainen and Keuschnigg, 2003, 2004; Hsu, 2004; Manigart et al., 2006; Casamatta and Haritchabalet, 2007). The superior skills of VC at the screening stage are especially important for small innovative firms seeking investment, as reflected in the substantial difference theorised between VC finance and institutional (debt) investors (Berger and Udell, 2002; Keuschnigg and Nielsen, 2004; Ueda, 2004; Bettignies and Brander, 2007). VC will be especially sensitive to signals of innovation potential, which should yield – at the higher risk – higher returns.

Summarising the theoretical predictions about information asymmetries and firm characteristics, first of all we expect that the more innovative firms will be less likely to obtain debt relative to equity and risk capital. We formulate the following hypothesis:

Hypothesis 1: Innovation decreases the probability of debt financing, but increases the probability of equity and VC.

We also expect that innovation will generate a systematic deviation from a standard pecking order of preferences in which firms should first access the source of finance associated with lower agency costs and then move on to the relatively more expensive source. Information asymmetries induced by innovation will increase agency costs across the whole hierarchy of financing decisions and the greater these information asymmetries the lower the probability that firms will access external capital following an order of increasing agency costs. We therefore hypothesise that:

Hypothesis 2: Innovation is negatively associated with a standard pecking order characterised by increasing agency costs of external finance.

Innovation can be characterised by several dimensions associated with varying degrees of risk and with more or less symmetric distributions of information about outcomes. Research and development expenditures and unreported R&D activities form the basis of fundamentally uncertain innovation processes. As an input factor rather than an output of innovation, R&D bears the highest risk for investors (Hall, 2009). Patents instead can be seen as an intermediate outcome of R&D, signalling successful research or development, or as an input for the firm's future technology and market developments. Since firms tend to patent only what is deemed worthy of legal protection and because patents are public documents, they are also stronger (more informative) signals of potential value (Lemley, 2000; Hsu and Ziedonis, 2008; Harhoff, 2009; Conti et al., 2013). This protection mechanism of a firm's intellectual property (IP) also reduces the market risk of innovation because it provides a statutory barrier to imitation (Jaffe et al. 20021). Finally, successful exploitation of innovation inputs results in superior products or methods of production. The introduction of tangible new products and processes, will be an observable outcome of innovation and will further reduce potential information asymmetries.

Frank and Goyal (2008) propose that if asymmetric information is due to risk then adverse selection arguments for debt will apply, and not only would we observe deviations from the standard pecking order, but we would have stronger effects for innovation activities that bear the greater risk (and are weaker indications of value). We expect that:

Hypothesis 3: The greater the information asymmetry of innovation activities the stronger their effects on the pecking order of external finance.

4. Data and methodology

4.1 Data Sources

The dataset we use in this paper is derived from a unique survey of UK and US businesses jointly carried out by *[anonymised for submission]* and *[anonymised for submission]* in 2004-2005. The basis for the sampling was the Dun & Bradsheet (D&B) database, which contains company-specific information drawn from various sources, including Company House, Thomson Financial, and press and trade journals. The sample covered all manufacturing and business service sectors. It was stratified by sector and employment size (10-19; 20-49; 50-99; 100-499; 500-999; 1,000-2,999; and 3,000+), with

larger proportions taken in the smaller size bands as in both countries the vast majority of businesses (more than 98%) are firms employing fewer than 100 people. The data were collected through a telephone survey between March and November 2004 (response rate: 18.7 percent for the U.S. and 17.5 percent for the U.K., with negligible risk of response bias), followed by a postal survey of large firms in spring 2005 leading to a total sample of 1,540 U.S. firms and 2,129 U.K. firms.

One of the original features of the survey was that it covered detailed questions about the firms' innovation activities, as is typical of the European Community Innovation Surveys (CIS), alongside questions about the businesses' financial profile, which in the standard CIS are limited to the degree to which the availability or the cost of finance constitute barriers to innovation. This survey contains less information on firm capital structure compared to the Kauffman surveys (DesRoches et al. 2013), but has much more information about firms' innovation inputs, processes and output. The dataset provides separate firm-level observations for the type of finance (debt, equity and what form of equity) firms obtain. Contrary to most empirical studies on this topic this information does not constitute an ex ante criterion for data selection, as is often the case for research based on investors-generated databases (for example, banks' records of loans or VC finance databases such as VentureXpert). Moreover, and even though it does not contain repeated observations over time, unlike the Kauffman survey (DesRoches et al. 2013) the dataset is not limited to start-up firms from the same cohort.

4.2 Sample

Our sample comprises firms that obtained finance during the two years prior to being interviewed. This generates a working sample of 851 firms, 454 in the U.S. and 397 in the U.K. Firms answered the survey questions almost completely. There are some gaps in the data, however, which would have prevented us from using a large portion of the survey responses. In particular, firms were often reluctant to answer questions about profitability and R&D spending. In addition, firm size prior to the survey was missing for about a quarter of firms.

In order to avoid the loss of observations due to missing values, we first substitute missing values with data from the FAME (Financial Analysis Made Easy) database if available. The remaining missing values are imputed by random regression imputation

(Gelman and Hill 2006) to replicate the correlation structure among explanatory variables.[4] The number of imputations is generally low and below 5 percent per variable for all variables except firm size, R&D expenditures and Internationalisation. Ratios calculated from survey variables, such as profit margins or R&D intensity, are censored at the 1 percent and 99 % quantile before imputation to eliminate outliers with unreasonable values. Finally, we winsorize variables that are not themselves imputed but which are obtained by dividing two other variables at the 2 percent and 98 percent quantile. If values are missing in our dependent variables, we drop these observations, which slightly reduces the sample size available for individual regressions.

Insert Tables 1 and 2 about here

4.3 Dependent variables and estimation strategy

The dependent variables in this paper are constructed from survey items that ask firms whether they obtained finance from a set of sources. On one dimension, firms may obtain finance in the form of equity, debt or other types of finance. As a second dimension to these financing decisions, firms may obtain funds from venture capital firms or informal venture capital, the latter of which includes business angels. These two dimensions generate 29 possible combinations, of which 26 are occupied by the firms in our sample. Figure 1 shows the absolute frequencies across combinations while Table 2 includes relative frequencies for each dimension. Table 4 shows correlation coefficients for the dependent and independent variables. Firms obtained debt more often than equity, with 78 percent of firms obtaining some amount of debt compared with 30 percent of firms obtaining equity. About 8 percent of firms said they received funding from venture capital firms, while 5 percent received informal VC support. About 15 percent of firms received a combination of equity and debt in the two-year period prior to the survey.

Insert Figure 1 about here

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[4] All relevant details on the imputation method we used, including a description of step-by-step process we followed for each variable, are available from the authors upon request.

We use as dependent variables: firstly, success at obtaining any amount of the different sources of finance; secondly, the observation that one particular type of finance is the dominant form of external capital (i.e. it accounts for the largest share of the external finance received by the firm); and thirdly, different combinations of sources of finance defined as follows. We organise the combinations identified in Figure 1 into financing classes that are consistent with pecking order theory and can therefore be used to test hierarchical outcomes. These classes are shown in Table 3. We test pecking orders consisting of 4, 6 and 8 mutually exclusive classes. The 4-class model includes a) firms that obtained any kind of venture capital, b) those that obtained equity, but no VC, c) those that obtained debt, but no equity or VC and d) firms that obtained funds from other sources, but no VC, equity or debt. Pecking order 6 allows for co-occurrence of sources of finance and pecking order 8 includes combinations that distinguish between venture formal and informal sources of entrepreneurial capital. These orders reflect the variations in agency costs derived by pecking order theory.

Insert Tables 3 and 4 about here

4.4 Independent variables

The primary focus of this study is on the effects of innovation on the financing decisions firms make. R&D intensity is the preferred choice to capture innovation activity according to standard practice in the literature (Scherer 1965, 1983, Pakes and Griliches 1980, Pakes 1981, Hausman et al. 1984). Since prior innovation research has used a range of measures, including the log of R&D expenditures, R&D expenditures scaled by various size variables, or the number of R&D employees, we choose a suitable combination of these indicators: We proxy for size by taking the logarithm of employment and control for R&D intensity by including the ratio of R&D expenditure and a firm's sales. This allows us to avoid the use of multiple size-dependent measures. Tables 2 and 4 show summary statistics and correlation for the variables used in our analyses.

Contrary to the vast majority of prior contributions we are not limited to the use of one indicator – R&D – in our analysis of the market for external finance. It can be argued that indicators of innovation might have different effects from R&D on the supply of capital given the easier access to information by investors in the case of tangible innovation outputs relative

to innovation inputs that may or may not turn into profitable products. As called for by Aghion et al. (2004) and Hall (2009), we address the problem with a richer set of indicators of innovation that include *input* (R&D intensity), *intermediate output* (patents) and *innovation output* (product and process innovations). These indicators are associated with different levels of risk and different degrees of information asymmetries between potential borrowers and lenders and can provide powerful insights into financing behaviours. We further include the (log) number of patents. Patents may, on the one hand, be an indicator for opaque intangible capital and aggravate financial constraints. On the other hand, the certification effect of patent authorities granting a patent involves lower information asymmetries than the observation of R&D activities and increases the likelihood of future returns as a statutory barrier to imitation. We then include indicators for whether the firm has introduced a product or service that is new to the industry, or a novel manufacturing or service process that is new to the industry.

We also include in our analysis information on additional characteristics on *intellectual property protection* mechanisms. Forms of intellectual property protection other than patents can include formal (e.g., copyright, non-disclosure agreements) and informal mechanisms (e.g. secrecy, complexity of design, time to market). On the one hand, these can play a role as buffers against risk but are also an indication of intangible assets which reduce the transparency of the firm as an investment opportunity. The overall attitude of the firm towards protecting its IP may be highly relevant. The value of IP remains unproven prior to the test of the market and crucially depends on subjective judgements made by stakeholders. A trade-off might arise because of an agency problem between borrower and lender easily traceable to the economic problem of the public nature of information. On the one hand, investors will want to invest in a product or service that cannot be freely imitated by competitors and will be sensitive to the strategies put in place by firms to protect their know-how. On the other hand, lenders, who will share the objective of protecting IP, might be reluctant to disclose private information to external agents, but these might include other investors. Since the financing process entails the disclosure of private information, unwillingness to share information is likely to affect financing decisions. As a consequence, over-protectiveness can have significant detrimental effects not only on the firm's innovative performance (Laursen and Salter, 2005), but also a direct negative effect on the probability that firms obtain external finance. We include an index of the breadth of IP protection that is the number of innovation protection methods used by the firm (registration of design, trademarks, patents,

confidentiality agreements, copyright, secrecy, complexity of design and lead-time advantage on competitors).

We include information about firms' human capital, since firms with larger proportions of human capital tend to have fewer tangible assets, aggravating potential financing problems. We measure human capital as the fraction of employees holding a university degree and expect it to be negatively associated with the likelihood of obtaining debt finance. In addition, we measure CEO education by two dummy variable indicating whether the CEO has a PhD or an MBA.

Our control variables include essential firm characteristics such as *size*, *age* and *sector*. Because we are interested in differences across firms due to their innovation profile, we classify industries according to the OECD (2005) classification of research-intensive industries and use dummies for broad industry affiliation to control for sectoral effects. We further include measures of market scope (measured by the degree of *internationalisation*), intensity of *competition*, firms' *growth ambition*, *profitability* and whether the firm is an *independent* entity.

We expect larger and older firms to be more likely to access debt markets than younger and smaller and more financially constrained firms. Higher profitability typically leads to a lower dependency on equity finance due to the firm's ability to contract on an existing and positive operating cash flow (for which profits can be seen as a proxy). Businesses in high-tech industries and those with substantial intangible capital should be more opaque and may obtain equity relatively more often than debt compared with other firms. The growth orientation of firms, which is likely to require funding of uncertain expansion investments, should lead to lower probability of obtaining debt or instruments that rely on collateral or easily measured covenants.

A firm's degree of internationalisation, or, more precisely, the part of internationalisation that is unrelated to firm size may impair an assessment of the firm's prospects by outside investors who may thus require compensation for the added risk. A larger number of competitors, on the other hand, can signal a well-established market with many parties producing information about future returns in this market. This transparency would then lead to easier access to finance. We expect subsidiary firms to have advantages compared with independent firms when raising finance due to the parent's informational advantage and the ability to sometimes rely on the parent's assets as collateral.

4.5 Estimation strategy

The data we use in this paper are cross-sectional and might pose endogeneity problems. In order to reduce this risk, wherever possible we use lagged values referring to the beginning of the period of observation for the regressors, which are derived from specific questions on the firm's characteristics or behaviours three years prior to the survey (i.e., in 2000/2001). These lagged observations are not available for our indicators of innovation, but it is very unlikely that causal mechanisms could go from the probability of obtaining finance to innovation over the same period given that any investment in innovation takes time to generate any outcome.[5] In addition, even though the survey asked respondents about their innovation activities during the previous 3 years, the financing questions targeted the shorter period of the previous 2 years, thus further reducing endogeneity risks.

In a first set of models, we estimate the likelihood that a firm obtains any one of the distinct types of finance regardless of whether any other funding was obtained by the firm. In a second set of models we classify firms according to the dominant source of finance and estimate multinomial logit models for the relative likelihood of obtaining a particular type of finance. Finally, since pecking order theory is concerned with the hierarchy of financing decisions we use ordered probit models to test the explanatory power of innovation for the set of hypothesized pecking orders with 4, 6 and 8 classes of external financing. This is a direct and systematic test of pecking order theory which to the best of our knowledge is absent from the literature.

5. Results

Estimations of probit models for the likelihood that firms obtain any amount of different finance types show that according to expectations R&D is positively associated with equity and negatively associated with debt (Table 5). Patents also have significant positive and negative effects, respectively, on equity and debt. Product innovation, instead, has only a weakly negative effect on the probability that firms obtain debt. Venture capital responds

[5] It is important to make a theoretical judgement about the structure of the data because even lagged values in time series may not be sufficient to resolve the question of causality if observations of innovation or related firm characteristics exhibit low variation over time. Only long panels could purge the data of unobservable firm heterogeneity, but these are very rarely available. Here we follow Cosh et al. (2009), who argue that external finance does not have a contemporaneous effect on profitability, turnover or profit margin in the same year, and obtaining finance will not lead to an innovation in the same year. They therefore use the current capital expenditures to account for planned growth (i.e., not historical capital expenditures which reflect historical growth) and for the fact that firms disclose to potential lenders their most recent quarter profits and capital expenditures, as well as expected profits and capital expenditures.

positively and significantly to R&D and to process innovation, but disaggregation of formal from informal venture capital adds a weakly significant positive effects of patents on formal VC and a positive effect of product innovation on informal VC (with a surprising negative, although weak, effect of patents). Examination of the control variables confirms the interpretation that these effects are related to information asymmetries: results for the indicator of human capital are consistent with the effect of R&D (they both measure intangibles), and the breadth of IP protection mechanisms is positively and significantly associated with both formal and informal venture capital.

Insert Table 5 about here

When we consider the probability that firms obtain the largest share – not any amount – of their external capital from different finance types, results are very similar. Multinomial logit models in Table 6 identify negative effects of R&D on debt (relative to equity), and positive effects of R&D on venture capital (relative to other forms of equity). Results for patents and human capital are consistent with the previous results obtained from probit models. We can therefore confirm the predictions of Hypothesis 1.

Among the additional indicators of the firms' intangibles, we find a positive effect of the CEO having a PhD on the probability that the firm obtains informal venture capital, which can be interpreted as a possible sign of the high-tech nature of the firms backed by informal venture capital, and a positive effect of the CEO having an MBA on the probability of obtaining formal venture capital. This result is not as significant as the effect of R&D and human capital, but it is nevertheless quite interesting since it seems to point to the value of acquiring skills such as business planning or the importance of social capital generated through the MBA course, which is likely to reach out to the investors' community.

Insert Table 6 about here

Among the control variables, the probit models shown in Table 5 reveal that older firms are more likely to obtain debt and less likely to obtain equity and VC, even though firm size is

not positively associated with debt and it seems that the larger firms in our sample have an advantage in accessing formal venture capital. It is possible that the larger firms in our sample of SMEs, which are not 'large' by any standard definition, maintain an informational advantage due to size in relation to VC investments. The size of investments by venture capital firms is further bounded from below, since VC funds often face high fixed costs of investment that is only possible to be outweighed by high expected portfolio returns for large investments. These results are consistent with the results obtained from the multinomial logit estimations (Table 6) where older firms are more likely to obtain debt relative to equity and less likely to obtain venture capital, while a larger size helps to obtain venture capital. Among the stronger predictors of debt relative to the other sources of finance included in the model, profit margin exerts a strong positive effect, which is perfectly consistent with the theoretical predictions about cash flow.[6]

We test the role of innovation in the *hierarchy* of financing decisions, and not simply in decisions about individual sources or between pairs of sources, by applying ordered probit modelling to our data. Table 7 presents the results we obtain from estimating the effects of innovation variables on the hypothesised orderings of 4 (Model 1), 6 (Model 2) and 8 (Model 8) classes of external financing. The models are consistent in identifying significant negative effects of R&D and patents on the standard pecking order characterised by increasing agency costs (that is, an order from debt, to equity, to formal VC, to informal VC). Both product and process innovations generate instead negative but insignificant results. The indicators of intangibles that induce strong information asymmetries (human capital staff and breadth of IP protection mechanisms) have consistently significant and negative effects on the pecking order. As far as IP protection mechanisms are concerned, it seems that the negative effect of uncertainty about outcomes dominates the positive effect of their role as barriers to imitation, and therefore indicators of future value.

Insert Table 7 about here

The effect of age follows our expectations. Older firms approach the different sources of finance in the sequence described by pecking order theory (i.e., starting from debt and then

[6] The effect of profit margin on equity was negative in the previous sets of probit model, a possible indication of financial constraints, but this effect disappears when equity is compared to debt, which is relatively more responsive to cash flow, in line with theory.

moving on to forms of capital with greater agency costs). Size, however, does not behave as expected by the argument that smaller firms are more opaque investment propositions and will be at a disadvantage in accessing the more senior type of finance. The effect of size on the pecking order is negative. This means that if we can account directly for more sources of asymmetric information, such as innovation activities, size per se may also be related to asymmetric information (through the complexity of the business) which prevents SMEs from following their preference for debt according to a standard pecking order. The results we obtain for the indicator of profit margin are in line with pecking order: coefficients for profits are positive and strongly significant in all models and suggest quite clearly that the relationship between cash flow and the pecking order holds true. It is also worth pointing out that the degree of internationalisation of the firm, a plausible sign of a dynamic business, is positively associated with the standard hierarchy of financing decisions because it signals to external finance providers a good opportunity for investment. Since innovation as a source of asymmetric information is negatively associated with the standard pecking order, these results corroborate the prediction of Hypothesis 2.

Our final hypothesis concerned the informational content of different innovation activities. We argue that there are different dimensions to innovation and that innovation inputs (R&D), intermediate output (patents) and the market introduction of new products and processes corresponded to different degrees of uncertainty about the likelihood of outcomes and about firm value. R&D, as the most uncertain activity, is expected to induce the greatest information asymmetries and exert the strongest negative effect on the standard pecking order, followed by patents, and then by indicators of actual innovations. This is what we find in Table 7. R&D systematically exerts the strongest effect on the hierarchy of financing decisions if measured by the impact of a one standard deviation change in each variable on the pecking order. R&D also has the greater statistical significance, but the coefficients' covariance is too large to detect a statistical difference between R&D and patents. Patents also generate increasing agency costs, but their effect is slightly weaker compared to the effect of R&D. The effects of revealed innovations, however, are not significant after accounting for R&D and patenting: investors are able to observe the outcome of innovation activities and this will eliminate or dramatically reduce risk because the R&D project, with some form of IP protection, has delivered, and some initial market reaction may also be observed as a predictor of potential value. If information asymmetries are reduced, so will be the relevant agency

costs, and indicators of realised innovation will no longer generate a deviation from the standard pecking order. Hypothesis 3 is therefore confirmed.

An addition to these estimations we run two sets of further analyses. The first additional test (unreported but available upon request) concerned the two institutional settings from which the sampled companies are drawn, the UK and the US. It is important to control for the country of origin of the firm because this may reflect a priori differences between external capital markets and these may bias results if they are left unaccounted for. The models in Table 5 and Table 6 reveal, perhaps surprisingly, that US firms are less likely than UK firms to obtain venture capital.[7] Clarysse (2009) and Bottazzi and Da Rin (2002) note that in the mid-2000s in the UK there was no shortage of external finance for firms seeking it. In particular, VC finance was available but it was distributed rather 'thinly', while the US market was characterised by larger volumes of VC with more concentrated distributions across firms. The country dummy was also significant in the pecking order models (Table 7). This seems to indicate that the hierarchy of financing decisions is more marked in the US than in the UK and could be explained by a greater maturity or greater discipline in US external capital markets which makes the relationship between external finance and firm characteristics more predictable. We split the sample by country and run additional tests with four classes of external financing. All coefficients discussed above pull in the same direction for the two subsets of observations. The models lose statistical power since we have fewer observations per class of external financing, but confirm that there are stronger results for indicators of innovation in the US system, which seems to be relatively more sensitive to firm characteristics from an investment perspective.

In the final set of analyses we explore the extent to which the predicted ordering of external financing reflects the hierarchy of financing decisions unconstrained by theory. Rather than estimating the predicted orders, we identify the orderings that best fit the unorganised raw classes of external financing. More specifically, we test all permutations of financing classes and select the ordered probit model with the greatest likelihood. The results we obtain from optimised models are identical to the hierarchy of 4 and 6 classes presented respectively in Model 1 and Model 2 of Table 7. There was only a minor difference in the relative order of formal and informal VC in the model with 8 classes. Model 4 (optimised) is included in Table 7 beside Model 3 (theory-driven) and shows an apparent preference for

[7] Table 5 shows that US firms are also more likely to obtain debt finance but this result is not significant in the multinomial logits presented in Table 6.

formal over informal venture capital in a reversed pecking order although this may be simply due to some noise in the measure for informal venture capital (e.g., inclusion of instances of finance that are not strictly risk capital associated to control rights). Overall, the similarity between optimised and theory-driven models is a clear indication of strong empirical support for the hypotheses we formulated on the basis of asymmetric information and the agency costs of external finance.

6. Conclusion

Within the extensive literature on the determinants of firms' capital structure, the pecking order hypothesis has received considerable attention. However, doubts remain on both theoretical and empirical grounds about the predictive power of this conjecture since several observed deviations from it do not fit with the standard pecking order of increasing agency costs. While there are overall clear indications that internal finance is preferred to external finance where available, there is no consensus on the relative preference of firms for debt over equity and on the contexts in which this expectation should or should not be met. SMEs populations are one such context. SMEs are an important group of firms because of their share of employment in the macroeconomy and because of their potential to generate growth through entrepreneurship (Acs and Audretsch, 1990). Frank and Goyal (2003) and Fama and French (2005) argue that small, high-growth firms, do not have a revealed preference for debt over equity because of asymmetric information problems. What type of external capital do SMEs rely on and what drives the hierarchy of their financing decisions?

With this paper we wanted to understand what firm characteristics or what activities induce information asymmetries that produce deviations from the pecking order. We argued and showed through empirical analysis that innovation can explain such deviations. Innovation shapes the hierarchy of financing behaviours and does so in a way that reflects the informational content of different aspects of the innovation process. We were able to identify the role of innovation inputs, intermediate outputs and innovation outcomes as sources of information asymmetry in an investment framework and also to show that the more uncertain the innovation signal, the stronger its negative effect on the pecking order.

The paper has of course a number of limitations. We were constrained by the cross-sectional nature of the data, although we used lagged variables where available, we exploited the favourable time structure of the survey questions, and on this basis proposed a theoretical

argument against endogeneity concerns in line with recent economic literature on this topic (Cosh et al. 2009). Future work on more comprehensive and, ideally, panel data may take these findings even further. An interesting set of problems that could be addressed in future research concerns the relationship between the organisation of innovation processes within and across firms and the firms' capital structure, which calls into question the strategic interaction between collaborations, IP appropriation mechanisms (control rights over intangibles) and firm financing strategies. This can provide a test bed for the predictive power of the pecking order hypothesis relative to control rights theory. Another interesting path for further research concerns a more detailed exploration of the threshold values that punctuate financing hierarchies and their evolution over time in relation to the evolution of R&D project portfolios. This will of course require more information about the amounts of finance obtained by firms as well as project-level information of firm innovation activities in a longitudinal setting. It would however be a powerful platform to further explore the connection between firm capital structure, innovation strategies and firm performance.

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FIGURE 1

Types of finance

This figure shows the composition of our sample with respect to the type of finance obtained by the firm.

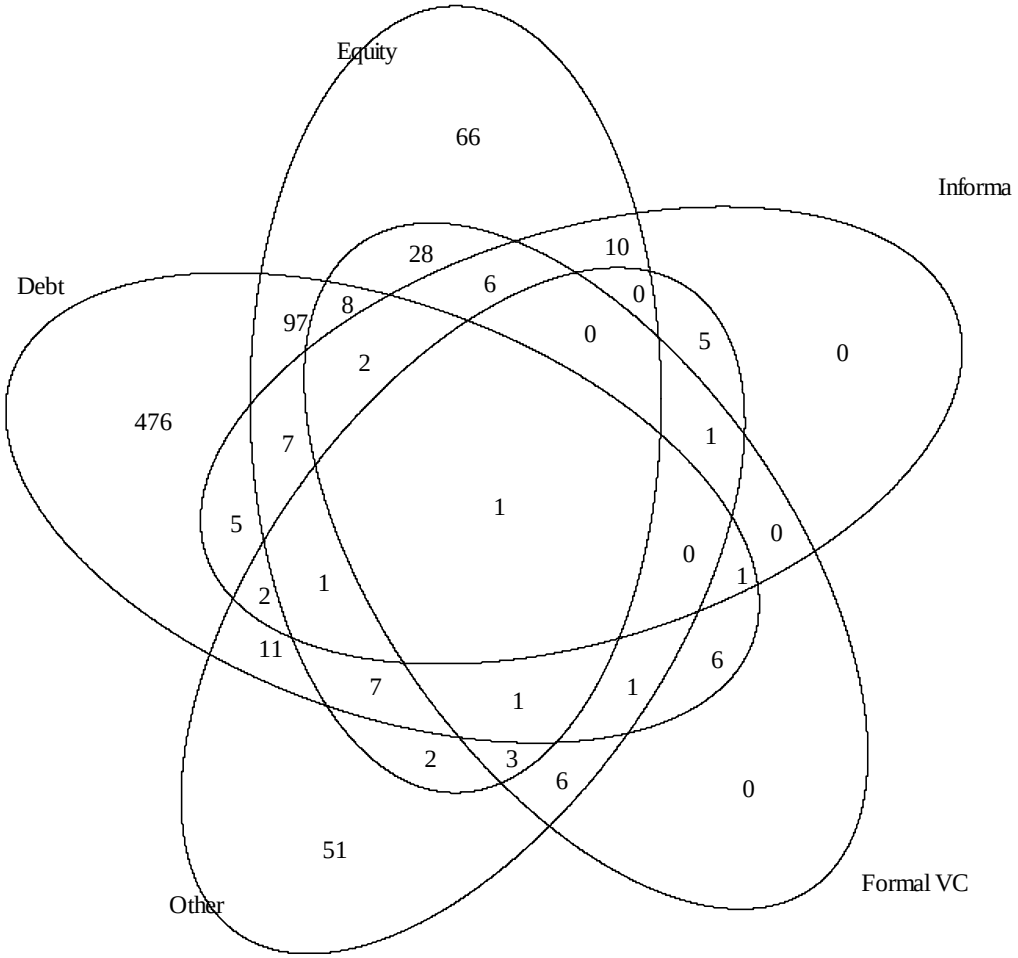

TABLE 1

Variable definitions

Variable name	Definition
Firm obtained equity	The firm obtained financing in the form of equity. Specifically, the questionnaire asks firms, "Of the amount obtained approximately what percentage of the amount you obtained came from…{equity, borrowing, other, venture capital firms, informal venture capital (e.g. Business Angel)}".
Firm obtained debt	The firm obtained financing in the form of borrowing.
Firm obtained other finance	The firm obtained financing in the form of other sources.
Firm obtained formal VC	The firm obtained financing in the form of formal venture capital.
Firm obtained informal VC	The firm obtained financing in the form of informal venture capital (e.g., business angels).
Age (Log)	The natural log of the number of years from incorporation until 2005
Size (Log(Employees))	The natural logarithm of the number of employees in the most recent financial year.
US firm	The firm has its headquarters in the United States. Dummy variable.
Independent firm	A dummy variable equal to one if the firm is independent (i.e., not a subsidiary).
Medium-high tech manuf.	The firm is a medium-high tech manufacturing firm according to the OECD (2005) Science, Technology and Industry Scoreboard.
Medium-low tech manuf.	The firm is a medium-low tech manufacturing firm.
R&D services & software	The firm is an R&D service or software firm.
Other services	The firm is a service firm other than R&D or software.
Other sector	The firm operates under a SIC code not covered above.
Internationalisation	The number of world regions in which the firm does business; coded numerically 1=national to 7=international
Profit margin	Pre-tax profits / turnover; both three years prior to the survey. Values outside the interval [-1, 1] are interpreted as data errors and replaced by imputed values using random regression imputation.
Competitors (Log)	Number of companies that the firm regards as serious competitors plus one, in logs.
Growth ambition	Expected turnover in 10 years, coded 1="A lot smaller" to 5="A lot larger"
CEO has a degree	The firm's Chief Executive or MD has a degree. Dummy variable.
Human capital staff	Approximate number of workforce that have a university degree as a percentage of the total number of employees
R&D expenditures / Turnover	Total R&D expenditure / turnover three years prior to the survey
Log (Number of patents)	The natural log of the firm's number of patents
Product innovation	The firm developed a novel manufacturing or service product innovation that is new to the industry; dummy variable.
Process innovation	The firm developed a novel manufacturing or service process innovation that is new to the industry; dummy variable.
Breadth of IP protection	Number of innovation protection methods used (registration of design, trademarks, patents, confidentiality agreements, copyright, secrecy, complexity of design and lead-time advantage on competitors)

TABLE 2

Descriptive statistics

This table shows descriptive statistics for the variables used in our analyses. Median and standard deviation are not shown for dummy variables.

Variable name	N	Min	Max	Mean	Median	SD	Imputed
Dependent variables							
Firm obtained equity	812	0	1	0.299			0.0%
Firm obtained debt	827	0	1	0.780			0.0%
Firm obtained other finance	812	0	1	0.116			0.0%
Firm obtained formal VC	817	0	1	0.081			0.0%
Firm obtained informal VC	840	0	1	0.049			0.0%
Firm demographics							
Age (Log)	851	0.693	5.720	2.966	2.996	0.861	0.1%
Size (Log(Employees))	851	0	7.679	3.746	3.662	1.170	27.0%
US firm	851	0	1	0.533			0.0%
Independent firm	851	0	1	0.890			0.0%
Medium-high tech manuf.	851	0	1	0.298			0.0%
Medium-low tech manuf.	851	0	1	0.401			0.0%
R&D services & software	851	0	1	0.114			0.0%
Other services	851	0	1	0.154			0.0%
Other sector	851	0	1	0.033			0.0%
Financials & market							
Internationalisation	851	1	7	2.421	2	1.509	20.0%
Profit margin	851	-1	1	0.032	0.035	0.164	41.0%
Competitors (Log)	851	0	6.909	1.976	1.792	0.984	3.9%
Growth ambition	851	1	5	4.618	5	0.738	1.3%
CEO has an MBA	851	0	1	0.182	0	0.386	1.6%
CEO has a PhD	851	0	1	0.060	0.000	0.237	1.6%
Innovation							
Human capital staff	851	0	1	0.304	0.176	0.319	4.3%
R&D expenditures / Turnover	851	0	4.134	0.250	0.012	0.746	31.8%
Log (Number of patents)	851	0	4.220	0.382	0	0.795	1.5%
Product innovation	851	0	1	0.479			0.7%
Process innovation	851	0	1	0.334			1.1%
Breadth of IP protection	851	0	8	4.300	4	2.608	0.0%

TABLE 3

Types of finance

This table shows combinations of finance obtained by the firms in our sample. Firms are asked whether they obtained equity, debt or other finance. In addition, they are asked whether this funding was from venture capital firms or informal venture capital (e.g., business angels). A firm may, for example, simultaneously obtain equity and debt, part of which may come from venture capital firms. To test possible orderings of various combinations of these types of finance, we define three sets of mutually exclusive classes.

Short name	N	Type of capital obtained by the firm
4 classes		
VC	96	Formal or informal venture capital
Eq.no.VC	172	Equity, but no venture capital
Other	51	"Other" finance and neither debt, equity nor venture capital
Debt.no.EqVC	487	Debt, but neither equity nor VC
6 classes		
VC.and.E	44	VC and neither debt nor "other" finance
VC.no.E	51	VC and debt or "other" finance
E.only	66	Equity only, that is, equity but neither of debt, "other", VC
Oth.only	51	"Other" only: No VC, equity or debt
Oth.other	117	Other types: No VC and (equity and debt, but no "other") or ("other" and debt or equity)
D.only	476	Debt only: Debt but no equity, "other" or VC
8 classes		
FVC.and.E	28	Formal VC and equity, but no informal VC, debt or "other" finance
IVC.E	16	Informal VC, but no debt or "other" finance
IVC.no.E	25	Informal VC and debt or "other" finance
FVC.no.E	25	Formal VC and no informal VC and (debt or "other" finance)
E.only	66	Equity only: No debt, "other" or VC finance
Oth.only	51	"Other" only: No VC, debt or equity
Oth.other	117	Other "other" finance (residual category): No VC or "other" finance, but equity and debt OR: no VC but "other" finance and debt or equity
D.only	476	Debt only: Debt but no equity, "other" or VC finance

TABLE 4

Correlation matrix

Pearson correlation coefficients for pairwise complete observations, significance levels: *** p<0.01; ** p<0.05; * p<0.1.

Variable name	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1 Firm obtained equity														
2 Firm obtained debt	-0.41***													
3 Firm obtained informal VC	-0.10***	-0.44***												
4 Firm obtained other finance	0.29***	-0.32***	0.09***											
5 Firm obtained formal VC	0.18***	-0.18***	0.09***	0.16***										
6 Age (Log)	-0.24***	0.18***	0.00	-0.21***	-0.16***									
7 Size (Log(Employees))	-0.08**	-0.02	0.07**	0.01	-0.05	0.36***								
8 US firm	0.07**	0.10***	-0.12***	-0.07**	-0.03	0.01	0.07**							
9 Independent firm	0.02	0.08**	-0.13***	-0.02	-0.06*	0.00	-0.22***	0.13***						
10 Medium-high tech manuf.	0.04	-0.06*	0.03	0.02	0.02	0.03	0.01	0.03	-0.05					
11 Medium-low tech manuf.	-0.09***	0.13***	-0.04	-0.17***	-0.11***	0.13***	0.01	0.06*	0.07**	-0.53***				
12 R&D services & software	0.13***	-0.21***	0.06	0.22***	0.14***	-0.21***	-0.04	-0.06*	-0.06*	-0.23***	-0.29***			
13 Other services	-0.03	0.09**	-0.03	-0.02	0.00	0.00	0.01	-0.08**	0.03	-0.28***	-0.35***	-0.15***		
14 Other sector	-0.01	0.00	-0.03	0.04	-0.01	-0.04	0.01	0.04	-0.02	-0.12***	-0.15***	-0.07*	-0.08**	
15 Internationalisation	0.01	-0.07**	0.00	0.07**	-0.03	0.10***	0.22***	0.01	-0.07*	0.29***	-0.12***	-0.02	-0.15***	-0.09***
16 Profit margin	-0.18***	0.09**	-0.03	-0.06*	-0.06*	0.08**	0.02	-0.03	0.08**	-0.01	-0.01	-0.07**	0.08**	0.00
17 Competitors (Log)	-0.11***	0.06	0.03	-0.08**	-0.04	0.10***	0.08**	-0.02	0.06*	-0.10***	0.02	0.01	0.06*	0.06
18 Growth ambition	0.08**	-0.07*	0.00	0.07**	0.06	-0.22***	0.00	0.07*	0.08**	-0.03	-0.11***	0.14***	0.04	0.04
19 CEO has an MBA	0.05	-0.02	0.05	0.07**	-0.01	0.03	0.17***	0.16***	-0.11***	0.00	-0.02	0.05	-0.03	0.02
20 CEO has a PhD	0.13***	-0.22***	0.09***	0.10***	0.08**	-0.11***	0.05	0.02	-0.05	0.01	-0.09**	0.21***	-0.05	-0.05
21 Human capital staff	0.26***	-0.28***	0.03	0.27***	0.14***	-0.28***	-0.14***	0.21***	0.00	-0.03	-0.35***	0.38***	0.16***	0.03
22 R&D expenditures / Turnover	0.25***	-0.27***	0.01	0.25***	0.21***	-0.25***	-0.19***	0.00	-0.01	0.09**	-0.15***	0.18***	-0.05	-0.02
23 Log (Number of patents)	0.23***	-0.31***	0.07**	0.25***	0.05	-0.04	0.18***	0.09***	-0.07*	0.13***	-0.10***	0.10***	-0.11***	-0.01
24 Product innovation	0.10***	-0.16***	0.05	0.13***	0.14***	-0.13***	0.00	0.06*	-0.01	0.07**	-0.11***	0.09***	-0.03	0.02
25 Process innovation	0.07*	-0.02	0.00	0.11***	0.09**	-0.06*	0.00	0.09**	-0.01	-0.04	-0.03	0.04	0.04	0.04
26 Breadth of IP protection	0.15***	-0.24***	0.13***	0.21***	0.14***	-0.06*	0.13***	-0.21***	-0.08**	0.14***	-0.16***	0.15***	-0.08**	-0.03

Continued on next page

TABLE 4

Correlation matrix (cont'd)

	15	16	17	18	19	20	21	22	23	24	25
16 Profit margin	-0.07**										
17 Competitors (Log)	-0.13***	0.01									
18 Growth ambition	0.09***	-0.05	-0.04								
19 CEO has an MBA	0.05	0.01	-0.04	0.03							
20 CEO has a PhD	0.05	0.03	-0.04	0.03	-0.06						
21 Human capital staff	0.04	-0.07*	-0.01	0.18***	0.10***	0.22***					
22 R&D expenditures / Turnover	0.05	-0.10***	-0.08**	0.09***	0.00	0.18***	0.33***				
23 Log (Number of patents)	0.24***	-0.11***	-0.09***	0.07*	0.07**	0.29***	0.29***	0.30***			
24 Product innovation	0.20***	-0.01	-0.10***	0.15***	0.03	0.07**	0.18***	0.14***	0.24***		
25 Process innovation	0.00	-0.01	-0.01	0.07**	-0.02	0.06*	0.06*	0.10***	0.12***	0.31***	
26 Breadth of IP protection	0.31***	-0.10***	-0.06*	0.11***	0.07**	0.12***	0.17***	0.21***	0.40***	0.36***	0.11***

TABLE 5

Type of finance obtained – Probit models

This table shows results for probit models for the likelihood of obtaining specific types of capital. We use dummy variables equal to one if the firm obtains any amount of equity, debt or venture capital. Standard errors are in parentheses. Significance levels: *** p<0.01; ** p<0.05; * p<0.1.

Model	1		2		3		4		5	
	Any Debt		Any Equity		Any VC		Any Formal VC		Any Informal VC	
Age (Log)	0.150	(0.07)**	-0.260	(0.07)***	-0.329	(0.09)***	-0.359	(0.11)***	-0.217	(0.12)*
Size (Log(Employees))	-0.116	(0.05)**	0.036	(0.05)	0.222	(0.07)***	0.245	(0.08)***	0.077	(0.09)
US firm	0.555	(0.13)***	0.074	(0.11)	-0.344	(0.16)**	-0.502	(0.18)***	-0.033	(0.20)
Independent firm	0.038	(0.17)	0.330	(0.18)*	0.265	(0.22)	0.464	(0.26)*	-0.206	(0.25)
Medium-high tech manuf.	-0.103	(0.31)	0.178	(0.29)	-0.113	(0.36)	-0.316	(0.40)	0.460	(0.54)
Medium-low tech manuf.	-0.023	(0.30)	0.092	(0.28)	-0.489	(0.36)	-0.601	(0.40)	0.129	(0.55)
R&D services & software	-0.164	(0.33)	0.103	(0.31)	0.197	(0.37)	0.037	(0.40)	0.550	(0.54)
Other services	0.348	(0.32)	0.073	(0.30)	-0.359	(0.37)	-0.354	(0.41)	0.230	(0.55)
Profit margin	0.322	(0.32)	-1.251	(0.32)***	-0.111	(0.38)	0.023	(0.43)	-0.336	(0.46)
Competitors (Log)	0.028	(0.06)	-0.112	(0.05)**	-0.122	(0.08)	-0.122	(0.09)	-0.072	(0.09)
Growth ambition	0.035	(0.08)	-0.032	(0.07)	-0.073	(0.11)	-0.089	(0.13)	-0.007	(0.14)
CEO has an MBA	-0.036	(0.14)	0.141	(0.13)	0.135	(0.17)	0.286	(0.19)	-0.094	(0.23)
CEO has a PhD	-0.456	(0.23)**	0.227	(0.22)	0.007	(0.25)	-0.185	(0.28)	0.257	(0.30)
Human capital staff	-0.846	(0.21)***	0.567	(0.20)***	0.582	(0.25)**	0.795	(0.27)***	0.199	(0.31)
R&D expenditures / Turnover	-0.185	(0.07)**	0.189	(0.07)**	0.182	(0.08)**	0.141	(0.08)*	0.198	(0.09)**
Log (Number of patents)	-0.251	(0.08)***	0.161	(0.08)**	0.070	(0.09)	0.172	(0.09)*	-0.209	(0.12)*
Product innovation	-0.233	(0.12)*	-0.043	(0.11)	0.142	(0.16)	-0.039	(0.18)	0.400	(0.20)**
Process innovation	0.144	(0.12)	0.080	(0.11)	0.320	(0.14)**	0.335	(0.16)**	0.202	(0.18)
Breadth of IP protection	-0.016	(0.03)	0.023	(0.02)	0.100	(0.03)***	0.073	(0.04)*	0.095	(0.04)**
Internationalisation	0.038	(0.04)	-0.056	(0.04)	-0.063	(0.05)	0.018	(0.05)	-0.142	(0.07)**
Intercept	0.791	(0.57)	-0.266	(0.53)	-1.309	(0.75)*	-1.616	(0.86)*	-1.861	(1.00)*
Chi-Sq. test p-value	0.000		0.000		0.000		0.000		0.000	
McFadden R^2 (adj.)	0.146		0.096		0.198		0.198		0.071	
Observations	827		812		814		817		840	
Log-Likelihood	-352.130		-427.720		-216.924		-163.951		-132.241	

TABLE 6

Type of finance obtained – Multinomial logit models

This table shows results for a multinomial logit models for the likelihood of obtaining specific types of capital. We use dummy variables equal to one if the majority of finance is obtained from equity, debt or other sources in model 1 and formal venture capital, informal venture capital and other sources in model 2. Standard errors are in parentheses. Significance levels: *** p<0.01; ** p<0.05; * p<0.1.

Model	Equity & Debt (1)				Venture Capital (2)			
	Majority of finance obtained from ... compared to "Equity"				Majority of finance obtained from ... compared to "Other"			
	Debt		Other		Formal Venture Capital		Informal Venture Capital	
Age (Log)	0.535	(0.15)***	0.465	(0.20)**	-0.864	(0.24)***	-0.513	(0.30)*
Size (Log(Employees))	-0.146	(0.11)	0.064	(0.15)	0.414	(0.18)**	0.434	(0.22)**
US firm	0.290	(0.24)	-0.795	(0.35)**	-1.010	(0.42)**	-0.855	(0.51)*
Independent firm	-0.524	(0.39)	-1.179	(0.45)***	0.753	(0.58)	0.258	(0.63)
Medium-high tech manuf.	-0.110	(0.58)	0.270	(0.90)	-0.167	(0.52)	1.302	(0.76)*
Medium-low tech manuf.	0.044	(0.57)	0.289	(0.89)	-1.586	(0.72)**	0.234	(0.84)
R&D services & software	-0.461	(0.61)	-0.039	(0.94)	0.544	(0.49)	1.600	(0.74)**
Other services	0.533	(0.61)	0.098	(0.96)				
Profit margin	1.763	(0.62)***	1.413	(0.88)	0.194	(0.87)	0.519	(1.12)
Competitors (Log)	0.194	(0.12)	0.270	(0.16)*	-0.159	(0.20)	-0.079	(0.24)
Growth ambition	0.186	(0.15)	0.165	(0.21)	0.297	(0.41)	0.009	(0.35)
CEO has an MBA	0.104	(0.28)	0.303	(0.39)	0.748	(0.43)*	0.517	(0.53)
CEO has a PhD	-0.523	(0.47)	0.792	(0.51)	0.261	(0.55)	1.083	(0.65)*
Human capital staff	-1.463	(0.38)***	-0.649	(0.56)	1.228	(0.59)**	0.815	(0.76)
R&D expenditures / Turnover	-0.404	(0.14)***	-0.177	(0.19)	0.359	(0.16)**	0.504	(0.20)**
Log (Number of patents)	-0.463	(0.15)***	-0.289	(0.20)	0.306	(0.20)	-0.563	(0.32)*
Product innovation	-0.272	(0.24)	0.123	(0.34)	0.301	(0.42)	0.719	(0.53)
Process innovation	0.106	(0.23)	-0.134	(0.33)	0.634	(0.35)*	0.437	(0.45)
Breadth of IP protection	-0.054	(0.05)	0.037	(0.07)	0.085	(0.09)	0.166	(0.11)
Internationalisation	0.057	(0.08)	-0.062	(0.11)	0.001	(0.12)	-0.315	(0.18)*
Intercept	0.392	(1.11)	-2.074	(1.59)	-5.034	(2.35)**	-5.348	(2.35)**
LR-test p-value	0.000				0.000			
McFadden R^2 (adj.)	0.113				0.169			
Observations	812				813			
Log-Likelihood	-527.708				-217.362			

TABLE 7

Pecking order – Ordered probit models

This table present results for ordered probit models of hypothesized orderings of 4, 6 and 8 classes of financing. Class definitions are provided in Table 3. Standard errors are in parentheses. The class "VC" includes both formal and informal VC in models 1 and 2, while VC is split into formal and informal VC in models 3 and 4. Significance levels: *** p<0.01; ** p<0.05; * p<0.1.

Model	1	2	3	4
	4 classes	6 classes	8 classes	8 classes
Age (Log)	0.282 (0.06)***	0.261 (0.06)***	0.251 (0.06)***	0.253 (0.06)***
Size (Log(Employees))	-0.121 (0.05)***	-0.133 (0.04)***	-0.133 (0.04)***	-0.124 (0.04)***
US firm	0.199 (0.10)*	0.308 (0.10)***	0.267 (0.10)***	0.311 (0.10)***
Independent firm	-0.137 (0.15)	-0.090 (0.14)	-0.039 (0.14)	-0.095 (0.14)
Medium-high tech manuf.	-0.039 (0.25)	-0.063 (0.25)	-0.174 (0.24)	-0.013 (0.24)
Medium-low tech manuf.	0.134 (0.25)	0.091 (0.24)	-0.009 (0.24)	0.124 (0.24)
R&D services & software	-0.134 (0.27)	-0.195 (0.26)	-0.256 (0.26)	-0.176 (0.26)
Other services	0.210 (0.26)	0.268 (0.25)	0.144 (0.25)	0.290 (0.25)
Profit margin	0.927 (0.27)***	0.692 (0.26)***	0.729 (0.25)***	0.716 (0.26)***
Competitors (Log)	0.079 (0.05)*	0.068 (0.05)	0.061 (0.05)	0.064 (0.05)
Growth ambition	0.052 (0.06)	0.041 (0.06)	0.022 (0.06)	0.023 (0.06)
CEO has an MBA	-0.135 (0.12)	-0.107 (0.11)	-0.076 (0.11)	-0.125 (0.11)
CEO has a PhD	-0.187 (0.19)	-0.242 (0.19)	-0.260 (0.18)	-0.229 (0.18)
Human capital staff	-0.588 (0.17)***	-0.695 (0.17)***	-0.618 (0.17)***	-0.667 (0.17)***
R&D expenditures / Turnover	-0.171 (0.06)***	-0.192 (0.06)***	-0.181 (0.06)***	-0.187 (0.06)***
Log (Number of patents)	-0.152 (0.07)**	-0.159 (0.06)**	-0.116 (0.06)*	-0.175 (0.06)***
Product innovation	-0.038 (0.10)	-0.100 (0.10)	-0.119 (0.10)	-0.092 (0.10)
Process innovation	-0.078 (0.10)	-0.041 (0.09)	-0.023 (0.09)	-0.050 (0.09)
Breadth of IP protection	-0.048 (0.02)**	-0.043 (0.02)**	-0.048 (0.02)**	-0.044 (0.02)**
Internationalisation	0.080 (0.03)**	0.071 (0.03)**	0.086 (0.03)***	0.074 (0.03)**
Class intercepts				
VC | Eq.no.VC	-0.910 (0.47)*			
Eq.no.VC | Other	0.016 (0.47)			
Other | Debt.no.EqVC	0.214 (0.47)			
VC.and.E | VC.no.E		-1.654 (0.46)***		
VC.no.E | E.only		-1.100 (0.46)**		
E.only | Oth.only		-0.649 (0.46)		
Oth.only | Oth.other		-0.382 (0.45)		
Oth.other | D.only		0.099 (0.45)		
FVC.and.E | IVC.E				-1.987(0.46) ***
IVC.E | IVC.no.E			-2.298(0.47) ***	-1.692(0.46) ***
IVC.no.E | FVC.no.E				-1.378(0.46) ***
IVC.no.E | FVC.and.E			-1.810(0.46) ***	
FVC.and.E | FVC.no.E			-1.480(0.46) ***	
FVC.no.E | E.only			-1.249(0.46) ***	-1.148(0.46) **
E.only | Oth.only			-0.798(0.46) *	-0.694(0.46)
Oth.only | Oth.other			-0.533(0.46)	-0.427(0.46)
Oth.other | D.only			-0.054(0.46)	0.055(0.46)
Chi-sq. test p-value	0.000	0.000	0.000	0.000
McFadden R^2 (adj.)	0.086	0.082	0.067	0.076
Observations	806	805	804	804
Log-Likelihood	-759.032	-939.272	-1009.854	-999.374