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The financing decisions of innovative firms

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Abstract

The paper examines the relation between forms of financing and the level of expenditure on research and development (R&D). The paper shows that the probability of issuing new equity rises monotonically with the level of expenditure on R&D, whilst the use of debt finance follows an inverted U curve, rising and then falling as R&D expenditure rises. The analysis confirms 'control rights' theories of financing, in which firms follow an established hierarchy of preferences for modes of financing, with debt preferred to equity since it involves less loss of control rights. The mode of financing is linked to characteristic types of innovation, with debt financing associated with incremental innovation and equity funding with R&D intensive innovation, as in pharmaceuticals. The paper concludes by suggesting a linkage between modes of financing, types of innovation and business systems, with the UK's innovation pattern linked to market financing contrasting with the relationship financing of bank oriented systems such as Germany.

JEL classification: G15; G32; 032

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The relation between methods of raising finance and patterns of innovation is a central issue in comparative studies of competitive performance. Economic uncertainties can harm firm policies toward adopting a proactive approach toward innovation and research & development. For instance, a strand of literature argues that firms in *laissez-faire* market systems (e.g., Anglo-Saxon systems) tend to place more emphasis on narrow financial objectives than on broader considerations such as market share (Carr and Tomkins, 1998). This tendency associated with liquid equity

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markets may only be conducive to radical product innovations as it facilitates flotation of high-growth firms, as in the information technology and bio-medical industries. By contrast, firms in Germany and Japan secure and maintain competitive advantage via incremental innovation in production processes and through product enhancement. Therefore, their innovation strategy is more broadly based and encompasses all product markets.

In this respect, the British Department of Trade and Industry has cited the low level of expenditure on R&D as a major source of competitive weakness of British industry (DTI, 2003). UK investment in R&D is highly concentrated in pharmaceuticals, where the UK has the highest level of expenditure in Europe, and in defence related industries. The low level of expenditure on R&D and its narrow focus have been linked to the reluctance of senior managers to invest long-term R&D due to their preoccupation with meeting short term financial performance targets, associated with reliance upon equity market financing. However, as Porter and Ketels (2003) have commented, a more sophisticated understanding of the UK's innovation performance requires research into firms' financial decision making. This paper seeks to increase such understanding by examining the relation between financing choices and R&D intensity over the period 1990–2002 in the UK. It is important to note that most empirical research has hitherto been carried within the US context.

Following Myers (1984) and Aghion and Bolton (1992) the paper argues that firms follow a pecking order in choosing amongst alternative modes of raising finance, including finance for innovation. The first preference is for financing innovation from internal resources. Repeated surveys have shown internal resources as the major source of capital for new investment, in different types of capitalist economies (Berger et al., 1998). Reliance upon internal resources maintains maximum discretion for firm management. The second preference for financing is through borrowing. Borrowing enables *ex ante* assessment of costs and entails less loss of control rights than through the issue of new equity. Finally, raising funds through the issue of new equity is the least preferred means of raising finance. This is because funding through the equity market involves loss of control rights, as well as lower levels of predictability than debt.

The pecking order is about the way firms prioritize their sources of financing (from internal financing to equity), preferring to raise equity as a financing means 'of last resort'. The theory maintains that firms adhere to a hierarchy of financing sources and, hence, internal funds are used first, and when that is exhausted debt is issued, and when it is not feasible to issue any more debt, equity is issued (Myers and Majluf, 1984). Pecking-order theory is based on how firms resolve problems of asymmetric information. If managers think the market overvalues equity then it would raise equity finance. But this sends a signal to the market that the managers consider the firm to be over-valued. On the other hand, if managers are acting to maximize the wealth of equity investors, they will not issue equity as to do so would be to dilute the value of existing holders stakes in the firm. Therefore, debt is to be preferred over equity. As will be argued below, the foundation of the pecking order is also related to the impact of alternative modes of financing upon the distribution of control rights. Our empirical research strategy is therefore driven by perspectives on the allocation of control rights. The different control rights attached to instruments such as debt or equity are as important in determining the financial structure of innovating firms as the difference in their revenue-streams or tax treatments. We therefore suggest that the firm's governance structure is a critical factor in R&D expenditure.

The paper is divided into four sections. Following this introduction, we provide a discussion of the finance literature on the pecking order and on control rights. We then present data on the financing decisions of UK public firms between 1990s and 2002, drawn from Datastream. The discussion section analyses the data in relation to the possible links between mode of financing and level of R&D expenditure. We also discuss in this section the implications of the findings for

international comparisons of the impact of financial arrangements upon innovation performance. The final section concludes with suggestions for further research in the area.

1. Financial studies of firm behavior

Finance literature has mainly looked at the cost implication of debt versus equity financing when considering the determinants of a firm's innovation strategy. This is because the R&D factor of a firm can be viewed in two different angles. One is the growth angle and the other is the intangible asset angle. R&D is important for growth in many industries. It can also serve as a source of competitive advantage. So a higher R&D expenditure can be looked at positively as an important factor for future existence and performance of business. If much of the value of the firm, its assets and future is reliant upon R&D, then it can be a great risk. An unsuccessful research attempt could lead to enormous losses, a reduction in value of assets and could even result in bankruptcy. In such a case R&D would be more intangible and viewed negatively. For instance, in practice a major component of R&D spending is the wages and salaries of highly educated scientists and engineers (Porter and Ketels, 2003). The outcome of their efforts will provide the firm with its knowledge base, from which profits in future years will be generated. The firm will lose these potential revenues if employees leave or are fired, depending on the extent to which the firm's knowledge is tacit.

It is argued that bankruptcy costs are likely to be relatively low for firms with a high proportion of tangible capital among their assets, particularly property, and equipment associated with generally applicable technologies (Brealey and Myers, 2000, Chapter 1). In contrast, innovative firms with a higher proportion of intangible assets, such as knowledge and reputation, and with more specialized equipment may experience higher bankruptcy costs, suggesting that such innovative firms are likely to be less reliant on debt finance, to mitigate higher expected bankruptcy costs.

Williamson (1998) argues that 're-deployable' assets (that is, assets whose value in an alternative use is almost as high as in their current use) are more suited to the governance structures associated with debt. Debt-holders prefer to use physical assets to secure loans and are reluctant to lend when the project involves substantial R&D investment rather than investment in plant and equipment. Empirical support for this idea is provided by Blass and Yosha (2001), who find that R&D-intensive firms listed on the US stock exchange use highly equity-based sources of financing, whereas those listed only in Israel rely more on bank financing and government funding. Alderson and Betker (1996) find that liquidation costs and R&D are positively related across firms. This implies that the sunk costs associated with R&D investment are higher than those for ordinary investment.

Because of the critical role of intangible assets in R&D financing decisions, it is likely that governance issues such as agency costs will arise in R&D investment. For example, by selling equity to outside investors, the firm's managers may signal that its future prospects are less than excellent; otherwise they would have chosen debt finance, rather than equity to benefit from the firm's revenues (Myers and Majluf, 1984). There is thus the possibility that investment decisions are also to a certain extent influenced by factors such as informational asymmetry and other related transactional costs.

1.1. Agency costs

The assumption for a classical firm was that the interests of the firm's financial managers and its shareholders were perfectly aligned, and that financial decisions were in the shareholders'

interest. However, agency costs arise when there is a separation of ownership and control in public corporations. Managers will act in their own interests, and will seek benefits at the costs of shareholders or principals (Jensen et al., 1976). There is no perfect observable measure of the performance of managers. Even if good performance were observable by some informed monitor, the performance would not be verifiable. Hence, as Myers (1984) points out, firms prefer internal finance as a by product of the separation of ownership and control. This is to avoid the 'discipline of capital markets' (Batunol, 1965).

Agency costs can also be triggered by conflicts between debt and equity investors. Debt usually has tax benefits for a firm but it also brings obligations in the form of payment of interest and return of the principal borrowed. However, bankruptcy costs could erode the value of the firm as they are paid out by the firm (Buckley, 1998). As these costs of financial distress result from debt they offset the tax advantage of debt to a certain extent. Research on US data has shown direct costs of financial distress to be 3% of the market value of a firm (Altman and Edward, 1984; Weiss, 1990). Chatterjee et al. (1989) found that financial distress costs increased as firms approached bankruptcy. Buckley (1998) suggests that bondholders and shareholders exercise conflict of interest when a firm has debt as shareholders pursue selfish strategies. During financial distress these conflicts of interest are magnified which result in agency costs and lower the value of the firm.

Bondholders also impose protective covenants to safeguard their debt. These covenants could restrict the firm in using its assets in many forms. Analysis by Simerly and Mingfang (2000) show that with the increase in level of debt, the corporate governance structure can change from one of internal control to external control. This could significantly affect managerial discretion and organizational ability to deal effectively with the competitive environment. This constraint could affect the performance of the firm and acts as a cost affecting the value of firm.

1.2. Debt–equity tradeoffs

The above discussion suggests that firms could alternate between debt and equity finance following a logical pattern. Donaldson (1961) US survey found that firms revealed a strong preference for internal methods of raising finance, with external funding as a last resort, with debt preferred to equity. Berger and Udall's study in 1998 provides further confirmation, again with US data. There is thus the suggestion that the long-term financing strategy follows a pecking order (Myers, 1984). At the top of the pecking order is the internally generated cash flow, followed by debt issue and at the bottom is the issue of new equity. Although firms may prefer internal funding this may not always be possible. Firms are faced with fluctuations in profitability and have dividend policies with target dividend payout ratios, limiting the availability of funds for investment. In doing so, debt is the preferred form. The reason for this is information asymmetry. Financial managers have more information about the firm than the shareholders, so they know whether the equity is overpriced or underpriced in the market. Assuming that equity is underpriced, it is not worth issuing new equity. But if it is overpriced, issuing equity would be attractive. But rational shareholders are aware of this concept and whenever new equity is issued they may suspect that shares are overpriced and may be reluctant to buy. Debt contracts also involve a contingent allocation of control rights, with the firm maintaining control rights when the agreed debt repayments are made.

The viability of debt as a form of financing depends partly upon the nature of the security that the firm is able to offer. Where a firm's assets are physical, with resale value, debt represents a viable form of funding; where the major assets, as with start up firms, are intangible the potential for debt

funding is reduced (Carlin and Mayer, 1999). These choices then have important implications for the way control rights relating to innovation activity are allocated to the outside parties (Lerner, 1994).

1.3. Control rights decisions

Recent theoretical work has emphasized the role of the allocation of control rights in determining debt versus equity finance for innovation. The 'control rights' approach is concerned with the allocation of decision rights—the lower the amount of tangible wealth or assets inside a firm, the more outside investors will insist on having control rights over the firm's decisions in order to satisfy their *ex ante* participation constraint (Aghion and Bolton, 1992; Hart, 1995). The gradual shift to debt financing occurs as more investment funds are required. Ultimately, when the project's size (or scope) becomes sufficiently large and/or when assets become sufficiently intangible, firms will allocate fuller control rights to outside investors by issuing new equity.

Underlying the control rights approach is the recognition that financial contracts are inherently incomplete. Models of contractual incompleteness assume that some important future variables have to be left out of the contract if they are difficult or impossible to describe initially. Grossman and Hart (1986) and Hart and Moore (1990) have developed a theory of vertical integration and ownership based on this type of contractual incompleteness. However, they do not discuss issues relating to financing and capital structure. But the problem of choosing between equity and debt involves a problem of deciding how ownership of the firm should be allocated between the various contracting parties. In this regard, Williamson (1998) suggests that the problem of selecting the adequate capital structure is similar to the question of vertical integration. "The corporate finance decision to use debt or equity to support individual investment projects is closely akin to the vertical integration decision to make or buy individual components or subassemblies". In this framework, investors have to anticipate the problem of 'hold-up' because of manager opportunism. For example, firm managers may want to use the R&D project to increase its market share which may directly conflict with the shareholder concern for maximizing investment returns. Outside investors will not be able to take action against such management tendencies until they acquire some control rights.

Aghion and Bolton (1992) depart from the models of Grossman-Hart and Hart-Moore by explicitly introducing wealth constraints into their framework, and develop a theory of capital structure based on transactions costs and contractual incompleteness. Specifically, they consider the following trade-off that arises in the allocation of control rights: if the funds are raised by issuing equity the firm will have to share control with the new shareholders. This may have important consequences for the way the project is run: the new investors will be in a position to force the firm to take actions which are deemed unsuitable for the project (for example, they may not allow suitable incentives for scientists working on the project). On the other hand, the management can preserve its full ownership rights by issuing debt: this is possible as long as it meets its debt obligations. However, in this case there is the risk of default and the danger for the management of losing control to the creditors in that event. The trade-off for the firm is accordingly between weighing the marginal costs of diluting its control rights to new shareholders against the marginal costs of debt and default. This trade-off ultimately determines the firm's financial structure.

Zender (1991) develops the idea that debt serves as a mechanism for the contingent allocation of control. Wealth constraints play an important role in the agency model he considers where the limited wealth of both the entrepreneur and the investor prevents one of them of becoming a full

residual claimant. The outcome changes, however, when debt financing allows the entrepreneur to be a full residual claimant as long as he can meet his debt obligation and the investor (debt-holder) to become a full residual claimant when the entrepreneur defaults. However, it is important to note that debt is by no means the only way of implementing contingent control arrangements. Other examples include venture capital (where it can be debt, equity or a mixture) and convertible securities (it also means that the firm is giving away control rights in the event that the project is successful. Holders of convertible will convert into equity if the value of the equity is sufficiently high, but otherwise redeem the instrument). Convertible securities can be a cheap way to raise funds for fast growing firms since it allows investors to share the potentially high returns generated by the firm's investments (Kaplan and Strömberg, 2000; Lerner, 1994).

2. Empirical research

The discussion above suggests that the problem of selecting an efficient innovation strategy is closely related to the problem of selecting an adequate governance structure for the firm. Thus, when it is optimal to give full control to the investor, the firm should finance its innovation by issuing equity. In this case, the investor gets most or all of the shares and obtains full control of the firm. If internal ownership is the most efficient arrangement, the firm needs to raise the necessary funds internally. Finally, financial instruments such as debt must also be considered if it is efficient to allocate control contingent on the realization of the outcome. Naturally, in this case two outcomes arise: the ability for retaining control internally is contingent on meeting the debt obligations. If the firm defaults or goes bankrupt it must abandon its control rights to the investor.

In short, the optimal governance strategy is to start first with internal management control (e.g., entrepreneurial control) if that is feasible. If, however, internal control does not sufficiently protect the investor's claims, one can opt for contingent control. If investor's interests are not fully protected by this method, full controls should be transferred to the investor. It will be useful to characterize the following two hypotheses in the light of this discussion:

Hypothesis 1. R&D firms are likely to use some debt finance than firms with no R&D.

Hypothesis 2. R&D firms are likely to raise funds by issuing equity than firms with no R&D, and this probability increases with R&D intensity.

Using these hypotheses, we present evidence on R&D intensity and financial structure from a panel of UK-listed firms over the period 1990–2004. We first examine a balance sheet measure of the importance of debt in the firm's capital structure. The probability that the firm raises funds by issuing new equity are then evaluated, including the composition of the firm's total debt. We also examine the shares of bank debt and secured debt in total debt. Our work differs from others (Hall, 2002) as we are mainly interested in the nature of general financial choices made by innovative firms and how that affect the allocation of decision rights.

Large and medium-sized UK firms are required to report their R&D expenditures. We obtained firm accounts data from Thomson Financial Datastream and convert all financial variables into constant prices using the GDP deflator (computed from UK National Statistics series ABMI and YBHA). We therefore use data from published accounts for an unbalanced panel of 820 firms whose shares are listed on the London Stock Exchange, over the period 1990–2004. The OECD Frascati Manual classification provides a useful benchmark for defining our measure of R&D expenditure. There are two issues regarding the use of the present dataset. First, in our sample, we

have a certain number of firms that are not larger than the size threshold at which R&D reporting becomes compulsory. However, we have taken steps to ensure that our results are robust to the exclusion of the smaller listed companies from our sample.[1] Second, small R&D expenditures are not recorded, which might weaken the empirical analysis to ascertain if there is a threshold effect in the present context of R&D spending and equity financing. However, this is not the case as UK studies on R&D spending do not find much evidence of the effect of firm size on the spending behavior of R&D firms (Vecchi et al., 2007).

It is important to note that the information in firm consolidated accounts relates to their worldwide activities, and not only to their operations in the UK. Our sample includes firms whose main activity is in manufacturing, extraction or construction, but excludes firms whose main activity is in the service sector, including finance.

Datastream uses UK SIC codes to provide a breakdown of firm sales. In line with this classification, it was useful to allocate firms to the industry in which most of their sales occurred. We employed a careful strategy of cleaning the data, and the following criteria were used to drop observations[2]:

- Total capital employed was negative.
- Bank debt or unsecured debt is greater than total debt.
- Total assets were negative, increased by more than 90% or fell by more than 60% in a year.
- Firms report R&D erratically, i.e. switch between reporting zero and non-zero R&D on more than one occasion.
- Accounting years were shorter than 9 months or longer than 18 months.
- Any variable required for our analysis was missing.

2.1. Dependent variables

Total debt/total assets: stock of debt repayable in more than 1 year (321) plus stock of debt repayable within 1 year (309) over total assets (392).

Bank debt/total debt: total bank debt (275 + 387) over total debt (321 + 309). Unsecured debt/total debt: unsecured debt (274) over total debt (321 + 309).

Indicator for new equity issued: a dummy variable equal to one if cash raised from issue of ordinary equity or preferred stock (429) is positive, and equal to zero otherwise.

2.2. Independent variables

We use a dummy variable equal to one if *R&D expenditure* (119) is reported to be positive in at least 1 year, and equal to zero otherwise.

We use R&D expenditure (119) over total sales (104) to measure *R&D intensity*.

We use the following three control variables: (i) operating *profits* (137) over capital stock constructed using the perpetual inventory method; (ii) *real growth sales* as growth of real sales (104) over the year; and (iii) total number of domestic and overseas *employees*, including part-time, in millions (219). We control for employees because of our earlier observation that a major component of R&D spending is the wages and salaries of scientists and engineers (Porter and Ketels, 2003).

[1] Tables containing these analyses are available from the authors on request.

[2] Numbers in parentheses refer to Datastream accounts items.

Table 1
Firm distribution of R&D intensity

Mean	2.97%
Standard deviation	6.31%
Median	1.58%
Lower quartile	0.52%
Upper quartile	2.92%

In our sample, there are 41% of the firms that report positive R&D expenditure in at least 1 year. Table 1 presents the distribution of R&D/sales (R&D intensity) that is highly skewed among those observations with positive R&D. It is interesting to note that the mean of 2.97% is considerably higher than the median of 1.58%, implying that there is a broader, more skewed tail to the right (higher levels of R&D) than to the left of the mean.

Table 2 contains OLS (ordinary least squares) regression results for the ratio of total debt to total assets. We find an interesting non-linear relationship with the use of debt financing, as measured by the ratio of total debt to total assets. Firms with positive R&D tend to use more debt than firms with zero R&D, but among the R&D performing sub-sample the use of debt declines with R&D intensity. Those firms with the highest R&D intensities in our sample tend to have the lowest levels of gearing. Most of these firms are in pharmaceuticals, instrument engineering or telecommunication equipment.

Column 1 includes the following explanatory variables: a zero/one dummy that identifies observations on firms that ever report positive R&D expenditure, and the firm's R&D intensity. A significant positive coefficient on the R&D firm dummy, and a significant negative coefficient on the R&D intensity variable were found. This pattern is robust to the inclusion of additional control variables (column 2). A significant positive effect of firm size on gearing, and a significant negative effect of profitability were found. Column 3 shows that this pattern is also robust to including sector dummies.

Within 'fixed effects' estimates of these specifications are presented in column 4. These effects allow for permanent unobserved heterogeneity across firms in their choice of capital structure. Thus, we would be able to see if the negative coefficient in our earlier results is simply reflecting cross-sectional differences between firms with low and high R&D intensities. Again, a significant negative effect of R&D intensity on the debt/assets ratio is found, suggesting that an increase in R&D intensity is indeed associated with a lower debt/assets ratio.

Table 2
OLS regressions of total debt as a share of total assets

	(1)	(2)	(3)	(4)
R&D firm dummy	0.019 (0.002)***	0.019 (0.003)***	0.029 (0.003)***	
R&D/sales	−0.239 (0.087)***	−0.321 (0.063)***	−0.291 (0.096)***	−0.287
Profitability		−0.007 (0.003)***	−0.007 (0.003)***	−0.007 (0.003)***
Real sales growth		−0.016 (0.009)	−0.014 (0.007)	−0.017 (0.009)*
Employees (millions)		0.659 (0.318)***	0.432 (0.237)**	0.791 (0.470)***
Constant	0.145 (0.005)***	0.165 (0.005)***	0.139 (0.005)***	0.183 (0.004)***
Observations	6236	5411	5368	5368
R-squared	0.03	0.09	0.07	0.03

Notes: column (4) exclude variation explained by firm fixed effects. Robust standard errors in parentheses. *Significant at 10%; **significant at 5%; ***significant at 1%.

Table 3
Probability that new equity is issued

	(1)	(2)	(3)	(4)
R&D firm dummy	0.493 (0.059)***	0.545 (0.061)***	0.438 (0.069)***	
R&D/sales	4.894 (1.695)***	5.792 (1.114)***	6.589 (1.242)***	14.673 (5.576)***
Profitability		0.237 (0.026)***	0.223 (0.022)***	0.284 (0.078)*
Real sales growth		1.276 (0.593)***	1.134 (0.231)***	1.576 (0.199)***
Employees (millions)		22.341 (3.159)***	21.263 (3.345)***	11.119 (10.893)
Constant	−16.734 (0.121)***	−14.894 (0.139)***	−18.893 (0.212)***	−11.476 (0.187)***
Observations	5871	4234	4119	2628

Standard errors in parentheses. *Significant at 10%; **significant at 5%; ***significant at 1%.

Table 4
OLS regressions of the structure of debt

	(1)	(2)	(3)	(4)
R&D firm dummy	−0.114 (0.016)***	−0.053 (0.019)***	0.286 (0.021)***	0.261 (0.027)***
R&D/sales	−0.329 (0.176)***	−0.487 (0.372)**	0.118 (0.154)	0.286 (0.178)
Profitability		0.004 (0.002)*		0.001 (0.003)**
Real sales growth		−0.043 (0.011)***		−0.011 (0.069)*
Employees (millions)		−2.153 (0.291)***		2.387 (0.389)***
Constant	0.493 (0.021)***	0.584 (0.017)***	0.697 (0.013)***	0.487 (0.011)***
Observations	4329	4842	3298	4119
R-squared	0.11	0.14	0.11	0.13

Robust standard errors in parentheses. *Significant at 10%; **significant at 5%; ***significant at 1%.

The above specifications do not distinguish between finance raised by issuing new equity, and finance from 'internal equity' or retained profits. To take into account this possibility, we implement logit regression models in Table 3, where the dependent variable is one for an observation in which new equity is issued, and zero otherwise. A simpler relationship between R&D behavior and the probability that firms raise finance by issuing new equity is found. Firms with positive R&D are more likely to issue equity than firms with zero R&D, and the use of new equity increases further with R&D intensity. Those firms with the highest R&D intensities in our sample thus tend to be the most likely to use new equity finance. The probability of issuing new equity is higher for firms that report R&D compared to firms that do not report R&D, and tends to increase with R&D intensity among those firms with positive R&D (column 1).

Table 4 presents results for the OLS regression models of the share of bank debt in total debt, and corresponding specifications for the share of unsecured debt in total debt, in columns 1 and 2, and 3 and 4, respectively. The shares of bank debt and secured debt in total debt are both lower for firms that report R&D compared to those that do not, and tend to fall as R&D intensity rises. The significance of these patterns is however dominated by cross-sectional differences between firms, and becomes very weak when we control for firm specific 'fixed effects'.

3. Discussion

Both sets of results appear to be largely consistent with the control rights approach, whereby the pecking order between internal finance, debt and outside equity is driven by the interplay between the size of desired investment, the tangibility of assets, the allocation of control rights,

and the investors' participation constraint. The financial behavior of more innovative firms, as indicated by the presence and extent of R&D expenditure, differs significantly from the financial behavior of less innovative firms in more than one way. They are more likely to raise funds by issuing shares, and this probability increases with R&D intensity.

We use data on publicly traded UK firms to investigate whether financing choices differ systematically with R&D intensity. A non-linear relationship with the debt/assets ratio was found. Firms that report positive but low R&D use more debt finance than firms that report no R&D, but the use of debt finance falls with R&D intensity among those firms that report R&D. Second, firms that report R&D are more likely to raise funds by issuing shares than firms that report no R&D, and this probability increases with R&D intensity. These findings support the view that well-functioning equity markets, including private equity finance, encourage firms' activities in major innovations and research and development. Our results are robust to the exclusion of the smaller listed firms (as mentioned above, reporting of R&D expenditure became compulsory for large and medium-sized UK firms in 1989).

Most finance research on capital structure has focused on public corporations with open access to capital markets. These firms have the broadest menu of financing choices available and can adjust their capital structures at relatively low cost. Yet our understanding of these firms' financing choices with regard to innovation is limited. There is much more research about financing tactics—for example the tax-efficient design or timing of a specific security issue than about financing strategy, for example the firm's choice of a target overall debt level for a R&D project.

Recent work has focused on the effects of the type of activity the innovative firm is engaged in, in particular how allocation of decision rights is determined by the financing needs of firms. The 'control rights models' thus predict that outside investors will only be involved when firms need major investments in new technologies or intangible assets (higher intensity R&D expenditures). When there are no such needs insiders (e.g., firm managers or banks) will retain their control over any innovation activity (low intensity R&D expenditures). The findings of this research are in line with the predictions of these theories, including the pecking-order framework that says that the firm will borrow, rather than issue equity, when internal cash flow is not sufficient to fund capital expenditures.

Our results support the institutional literature's emphasis upon the role of outside equity markets (especially in the sense of liberal or outside market economies) in financing major R&D expenditures of innovative firms. In these markets it is possible for innovative firms to raise desirable levels of cash for R&D projects, however, this comes at the cost of ceding control to outsiders. This is in contrast to the insider markets such as Germany where control is retained by insiders (e.g., managers, banks), which is why firms are mostly engaged in incremental type innovative activities. We briefly discuss below both these sets of arguments in relation to their conclusions for the firm behavior regarding innovation and R&D expenditures.

In international comparative studies of 'divergent capitalisms' (to quote the title of Richard Whitley's 1999 study), the US and UK are usually referred to jointly as 'Anglo-Saxon' liberal market economies, with the US as the primary exemplar. As Hall and Soskice (2001) put it, in rather general terms, in liberal or 'outside' market economies 'firms co-ordinate their activities primarily via hierarchies and competitive market arrangements. Market relationships are characterized by the arms-length exchange of goods and services in a context of competition and formal contracting. In response to the price signals generated by such markets, the actors adjust their willingness to supply and demand goods or services, often on the basis of the marginal calculations stressed by neoclassical economics' (2001:8). Outside market economies have high levels of stock market capitalisation, with high transaction turnover. Firms in outside market economies

give priority to maintaining profitability, to maintain share prices and avoid threats of takeover, rather than firm growth or market share or employment security. Systems of financial control and corporate governance are characterized as 'outsider', 'arms-length', with Boards of Directors as the guardians of the interests of shareholders, as the owners of the firms in which they invest: the interests of other stakeholders are marginal.

Outsider systems are seen as fostering innovation through facilitating the creation of new firms and increasing the agility of existing firms in responding to changes in product markets and technology. The financial system, modes of technology transfer, labor markets and education and training systems complement each other in a more or less integrated business system. Hence the financial system is based on 'free market competition' sustained by level playing fields, publicly accessible information and open market access.

The outside market economies provide the most appropriate system for radical innovation. Capital markets provide the resources for investment in new products and services, venture capital attracted by high risk premiums. The absence of 'lock-in' through participation and the availability of labor market institutions to facilitate labor mobility enable labor to move easily to new firms. The absence of employment security rules enables senior management to redeploy labor within the firm. Strong managerial prerogatives enable managers to reorganise production processes. Innovation is especially facilitated in sectors characterized by novelty, appropriability and visibility (Tylecote et al., 2002, p. 2) – information technology, medical engineering, pharmaceuticals.

The fluidity of capital markets enables the rapid development of new, high-tech sectors and revitalised established sectors. However, O'Sullivan (2001) has argued that the relationship between investors and managers in the US does not provide a good environment for the development of the organizational learning and cumulative innovation seen as required for competitive 'middle technology' firms. The emphasis on shareholder value led to 'downsize and distribute' rather than 'retain and reinvest' practices. Moreover, the success of 'Wintelism' – new production systems based on combining central control of design and branding with outsourcing of production to specialized component producers – did not provide the basis for sustainable prosperity. Design innovations could seep to competitors, component producers could evolve 'upstream' and consumer brand loyalty could prove fickle.

The relationship between investors and corporate management in Germany is very different from the relationship between them in Britain and the US. The less the influence of investors is, the greater the influence of managers is. The German financial management regime may be characterized as 'insider' rather than 'outsider', without the strict separation between 'owners' and 'managers' characteristic of Britain and the US. Representatives of capital-providers, primarily banks, belong to corporate supervisory boards. There is a strong emphasis on special relationships between investors and managers, especially between firms and the corporate 'hausbank', most fully developed in the role of regional savings banks in regional medium-sized firms (Lütz, 2000, pp. 9–10; Streeck, 2001). Historically, German firms have followed 'stakeholder' rather than 'shareholder' strategies. The monitoring of performance is not based solely on publicly available information, but on specific banking knowledge and reputation: unlike in Williamsonian theory, asymmetric knowledge has not been regarded as a system weakness.

Most importantly, the banks play a much more central role in financing firms than British banks. German banks hold equity stakes and debt claims in the same firm. Banks are themselves major shareholders. In 1999 banks held 13.5% of shares, an increase from 10.3% at the beginning of the 1990s (Siebert, 2004, p. 32); in 1998 the Deutsche Bank alone held 10.3% of all German shares (Jurgens and Rupp, 2001, p. 6). Their influence as shareholders is reinforced by their role as proxy voters for private shareholders: banks controlled 95% of voting rights in Siemens, Hoechst

and Mannesmann, and over 90% in Bayer, in 1992 (Jurgens and Rupp, 2001, p. 6). Banks are the major external source of funds for German firms; in 2001 bank loans represented 95.54% of corporate credit, compared with 62.96% in Britain and 44.57% in the US (Siebert, 2004, p. 29).

Ehrentreich and Schmidt suggest that 'the German system should provide a better long-term oriented environment to the management' of innovation than the UK or US (1999: 23). This assessment rests on the priority given to the long-term requirements of the firm and the importance of commitment not liquidity, echoing a long tradition of comparative research (Dore, 2000). In particular, the structure of ownership and corporate governance arrangements foster cumulative innovation based upon developing employees with industry and firm specific skills. More generally, the inclusive approach encourages acceptance of flexibility, both in work organization and employment conditions—what Ronald Dore (1988) termed 'flexible rigidities'. The German pattern of corporate control, the forms of enterprise governance, the employment relations system, support a productionist orientation appropriate for sectors in which the rents from innovation are difficult to appropriate (or even apportion) and firm specific and the process innovations themselves often invisible to outsiders. The German approach is appropriate to innovation in engineering or machine tools, with skilled employees making incremental improvements to production processes, and close co-operation between technology suppliers and their customers (for example in food processing machinery). It is less appropriate to software development, where innovation is a competitive not collaborative process. Gerke concludes, 'in financing small companies and especially in setting up companies, there is an extensive market failure due to inadequate market transparency and information asymmetry' (quoted in Ehrentreich and Schmidt, 1999, p. 21). Unsurprisingly, insider dominated systems favor insiders.

Recent finance literature has also begun to take notice of the contrast between arm's-length market based financial systems (e.g., the USA and the UK) and bank-centered capital market systems (e.g., much of Continental Europe and Japan) (Rajan and Zingales, 2001; Black and Gilson, 1998). For example, Hall (2002) notes that 'the 'Anglo-Saxon' economies, with their thick and highly developed stock markets and relatively transparent ownership structures, typically exhibit more sensitivity and responsiveness of R&D to cash flow than continental economies, and much more speculatively, this greater responsiveness may arise because they are financially constrained, in the sense that they view external sources of finance as much more costly than internal, and therefore require a considerably higher rate of return to investments done on the margin when they are tapping these sources'. These perspectives suggest that the application of wider institutional contexts will enrich our understanding of innovative firms' financial behavior and the market structures in which these firms operate.

4. Conclusion

In terms of the role of finance in management, the key question is: what are the goals of financiers, and how do they realize them? Their claims are likely to be influenced by the difference both between and within generic sources of finance, including internally generated funds, debt, and share equity (Hart, 1995). Since the time frames and return expectations may differ between investors, it is important to know how various types of investors may have different preferences in terms of shareholder value (both in the short and long terms) and liquidity vis-à-vis control and private benefits (O'Sullivan, 2001). The paper argues that the impact of financial considerations on the investment decisions may vary with the type of investment and with the source of funds.

This paper explores UK firm-level data to shed light on whether different financing choices affect the strategies of firms with regard to investments in innovation. The empirical literature on

capital structure often includes information on research & development (R&D) activities as control variables (Carlin and Mayer, 1999), without focusing on the financial behavior of innovative firms, and there is relatively little empirical evidence from outside the US. We do not attempt to provide a definitive answer or explanation here, but report patterns suggesting that further research on this subject is likely to be fruitful.

More specifically, we find that as we move from less innovative firms to consider more innovative firms as measured by R&D intensity, more innovative firms may have more attractive investment opportunities and thus become more reliant on external sources of finance, but they go first for debt as it involves giving up less control rights than new equity. However, more R&D-intense firms may have no choice but to issue outside equity in order to meet the investors' participation constraint. This can potentially explain why the probability of issuing new equity rises monotonically with R&D intensity, whilst the use of debt finance starts to decline eventually as R&D intensity increases. This characterization of governance structures can be described as a pecking-order theory of financial structures: first, one can use internal cash flow; if R&D needs are not met by this way, the firm can share ownership by issuing debt; finally, firms can transfer all the control rights to the investor by raising all funds externally.

We also place our results within the context of two different strands of the literature on financing choices of innovative firms: micro-studies of the financial behavior of innovative firms and macro or institutional studies on innovation and research & development. Combining both sets of the literature allows us to make observations about the impact of the market in which firms operate and its effects on innovation related decision choices.

The institutional literature associates outside investors' control with considerably large R&D projects while insiders (e.g., firm and bank mangers) prefer continuous improvements, which could easily be met by bank's lending. Thus, outside market economies provide favorable conditions for basic science but expensive research, while inside economies are far more suited to incremental technological developments. The finance literature is generally silent on institutional constraints under which firms raise finance but extensively discusses the implications of equity versus debt finance. Our research attempts to fill this gap and develops an integrated view of the firm's financing choices and their impact on innovation. A major limitation of the present research is its focus on the UK's R&D market. Further empirical research involving both the *outside* and *inside* economies will be useful to analyze the comparative features of market and organizational institutions and their relationships with innovation and R&D activities.

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