The financing of technology-based small firms: a review of the literature

This review assesses the academic literature of recent years on the financing issues faced by technology-based small firms (TBSFs). It was produced as part of the latest report on these firms by the Bank's Domestic Finance Division, published last month.(1) *This report finds that, while there may still be market weaknesses in the provision of relatively small amounts of risk capital to TBSFs at the start-up and early stages, these appear to be less than four or five years ago, and to impact on TBSFs less than was the case then.* Peter Brierley, Head of Domestic Finance Division, *explains why the literature suggests that market imperfections in the provision of finance to small companies may apply with particular force to the start-up and early-stage financing of TBSFs, but concludes that there is little compelling evidence of a major market failure.*

Introduction

Technology-based small firms (TBSFs) are generally defined either as businesses whose products or services depend largely on the application of scientific or technological knowledge,(2) or as businesses whose activities embrace a significant technology component as a major source of competitive advantage.(3) These businesses are generally located in industries such as communications, IT, computing, biotechnology, electronics and medical/life sciences.(4)

Earlier work at the Bank(5) suggested that there might be some inefficiencies in the market for financing TBSFs, especially at the start-up and early stages of finance. Recent official enquiries in this area have focused in particular on possible barriers that high-tech companies in the United Kingdom might face in attracting finance.(6) The profile of this work has been enhanced by the current Government's desire to encourage 'entrepreneurship', by growing interest in the 'new economy', and by the swings in investor sentiment towards high-tech stocks over the past two years.

These factors have motivated a new Bank report on the financing of TBSFs, which was published on 5 February.(7) As background to this report, an extensive review of the economic literature on the financing of TBSFs has been undertaken, the results of which are summarised in this article.

Information asymmetries, moral hazard and adverse selection

There is a huge literature on the appropriate capital structure of companies, dating back to Modigliani and Miller (1958) and earlier. That part of it relating to small and medium-sized enterprises (SMEs) emphasises information asymmetries as one of the most important factors affecting small business finance.(8) These asymmetries arise if small business owners or managers possess more information about the nature of, and prospects for, their businesses than potential finance providers. Information asymmetries can give rise to agency conflicts between entrepreneurs and investors that can affect the willingness of the latter to provide both equity and debt capital.(9)

The literature suggests that equity finance provides the entrepreneur with an incentive to engage in activities that benefit him disproportionately, because part of the associated costs are imposed on the shareholders. Even

(1) Copies of the *Financing of Technology-Based Small Firms Report* are available from the Public Enquiries Group, Bank of England, EC2R 8AH; telephone 020–7601 4012; fax 020–7601 5460; or from the Bank's web site at www.bankofengland.co.uk/hightech2001.pdf
(2) See Allen (1992).
(3) McNally (1995).
(4) See Butchart (1987) for the DTI's sectoral classification.
(5) See Bank of England (1996).
(6) See, for example, the reports by the House of Lords (1997), the CBI (1997), and the Williams (1998), Riches (1998) and Waterstone (1999) committees.
(7) Bank of England (2001).
(8) See, in particular, Berger and Udell (1998).
(9) See Jensen and Meckling (1976) for an early demonstration of this result.

in the absence of such moral hazard, in cases where companies aim to maximise shareholder value, models of capital structure under asymmetric information indicate that firms will only issue shares when they view their stocks as overvalued.(1) Debt markets also suffer from information asymmetries giving rise to moral hazard and adverse selection. In this case, moral hazard occurs to the extent that the entrepreneur raising debt finance has an incentive to increase risk, given that he benefits fully from any associated additional returns, but does not suffer disproportionately if the firm is liquidated—part of that cost is imposed on the creditors. Adverse selection arises if debt providers such as banks find it difficult to discriminate between companies and react to the moral hazard risk by increasing the price of debt to all potential borrowers. This in turn may then discourage all but the highest-risk borrowers, inducing the banks to refuse finance to a greater proportion of borrowers, both good and bad—a form of credit rationing.(2) These are examples of capital market imperfections that may affect both the quantity and price of equity and debt finance provided to SMEs.

These capital market imperfections may apply with particular severity to TBSFs. The notion that such problems may obstruct the external financing of innovative business activities goes back at least to Arrow (1962), although his conclusion that this represents a market failure justifying public sector intervention is much more contentious.(3) This strand of the literature emphasises that the key characteristics of high-tech companies are that: (i) their success is linked to difficult-to-value growth potential derived from scientific knowledge and intellectual property; (ii) they lack tangible assets in the early stages of their life cycles which may be used as collateral; and (iii) their products have little or no track record, are largely untested in markets, and are usually subject to high obsolescence rates. These factors mean that TBSFs are likely to be more vulnerable than SMEs generally to asymmetric information about risk characteristics and default probabilities, especially in view of the difficulties finance providers face in assessing the sophisticated technology and R&D involved and the prospective demand for the end-product.(4)

Furthermore, the staged development process faced by most TBSFs may generate additional risks compared with those relating to SMEs in general. The innovation cycle involves a complex process, beginning with the initial concept of a product, and continuing with prototype development, initial production and, finally, product sales. The financing of this process requires a series of injections of money, and failure to finance adequately any part of the cycle may cause the firm to fail. This in itself tends to increase the risks to any single finance provider. Oakey (1995) finds that such risks are likely to be most acute in the biotechnology sector, where the gestation period for sustained profitability may well be 10–15 years, well beyond the investment horizons not only of banks but also of many venture capitalists.

Funding gaps: empirical evidence

The extent to which SMEs are subject to funding 'gaps' in the provision of finance has been the subject of official reports dating back to the MacMillan Report in the 1930s. More recently, empirical studies investigating whether TBSFs in the United Kingdom face particular difficulties in obtaining finance have produced conflicting results. Utilising data from two company surveys carried out by the Cambridge University Small Business Research Centre, Moore (1994) finds that a sample of 89 high-tech companies raised only 7% of its start-up finance from banks (compared with a figure close to 40% for SMEs generally). A reluctance by banks to finance high-tech start-ups has also been identified in other studies,(5) although Moore's results also indicate that banks were the most important source of external finance for TBSFs (and for SMEs generally) in stages of finance subsequent to start-up. More crucially, Moore tests the availability and cost of finance against a range of firm characteristics, relating to technology, innovation, life cycle, origin, growth, profitability, size and region, in a series of probit regressions. He finds that the most important determinants of the likelihood of a firm facing financing constraints are size and profitability, rather than degree of innovation.

Empirical work by Westhead and Storey (1997), however, has produced rather different results. They develop a variety of regression equations utilising information from a survey of 171 SMEs located on and off science parks in the United Kingdom. The equations regress the degree of difficulty in obtaining finance, as derived from survey responses, on a wide range of firm characteristics,

(1) See especially Leland and Pyle (1977), Myers and Majluf (1984) and Greenwald *et al* (1984).
(2) The seminal article by Stiglitz and Weiss (1981) first demonstrated this clearly.
(3) See, in particular, the critique of Arrow by Demsetz (1969).
(4) See, *inter alia*, Moore and Garnsey (1992), Matthews (1994) and Storey and Tether (1996).
(5) See Oakey (1984) for the UK and Roberts (1991) for the US evidence.

including: the extent to which the firm is high-tech (variously proxied by R&D expenditure in relation to turnover, the number of qualified scientists engaged in R&D in relation to total employees, and the number of patents taken out in the last year); the age of the firm; legal status; industrial sector; growth rate; profitability; and location. Westhead and Storey find that firms with relatively high R&D expenditures are more likely to report continuing financing constraints. The other indicators of technology—the proportion of scientists and the number of patents—are also positively related with financing constraints.

Debt versus equity finance

Although the evidence is conflicting on whether TBSFs face greater difficulties in accessing finance than SMEs generally, some common themes do emerge. Perhaps the most important relates to the unsuitability of debt finance for the early-stage financing of TBSFs. The information asymmetries and moral hazard present at the start-up stage have a particularly marked impact on banks and other debt providers because of the lack of collateral and market presence which characterise most high-tech start-ups. Some studies(1) attribute the source of the information asymmetry underlying debt finance of TBSF start-ups to the difficulties banks face in assessing technical projects and hence in distinguishing between good and bad lending propositions. Others(2) emphasise the inability of TBSFs seeking early-stage finance to relieve moral hazard by meeting banks' requirements for collateral. In the early stages of product development and prototype testing, once the personal assets of the business founder (plus family and friends) have been exhausted, the only remaining business assets of the TBSF are likely to be intangible and therefore unsuitable as collateral. This will not change until the TBSF achieves production levels that generate more tangible business assets, such as receivables and inventories, which can be pledged as collateral, ie at later stages of financing.

This implies that smaller firms pursuing innovation strategies may face greater difficulty in obtaining debt finance for start-up and the early stages of development than their conventional counterparts. Some commentators have speculated that bank-centred systems, such as those that predominate in continental Europe, may be less effective in promoting high-tech industries than stock market-centred systems, such as the United States and the United Kingdom.(3) On this argument, bank-centred systems are identified with conservative approaches to the provision of finance, and with social and financial incentives that reward entrepreneurial zeal less richly and punish failure more harshly. This theory, however, probably underestimates the willingness of banks to provide finance to TBSFs, albeit generally at later stages of finance and indirectly, through venture capital subsidiaries rather than direct lending.

Other empirical studies confirm that debt finance is less important to TBSFs than equity finance. Himmelberg and Petersen (1994) find that SMEs pursuing innovation strategies tend to have lower debt levels than other SMEs. This is supported by Jordan, Lowe and Taylor (1998), who find that the most innovative SMEs are those with the lowest debt-equity ratios. Other studies in the United Kingdom and the United States suggest that high-tech firms may be heavily dependent on internal finance and trade credit, especially for finance in the initial and early stages.(4)

These studies focus mainly on the initial injections of finance at the seed/start-up phase, where information asymmetries are greatest. But growth-oriented TBSFs also face high costs associated with technological product development. One estimate(5) is that the amount of finance required to develop and launch a technology-based product is on average ten to twenty times greater than the initial R&D expenditure. Such firms will generally find that internal sources alone are insufficient to meet the high capital requirements for development and will need to seek external finance while still in the relatively early stages of growth. For these firms also, the literature suggests that equity will be a more appropriate source of finance than debt.

These findings imply that the optimal capital structure for TBSFs is very different to that thought suitable for SMEs generally, the vast majority of which finance themselves broadly in line with the 'pecking order' hypothesis.(6) This postulates that smaller businesses tend to prefer internal finance, while those requiring

(1) For example, Mason and Harrison (1998).
(2) Notably Philpott (1994).
(3) See Black and Gilson (1998) for a statement of this thesis.
(4) See, in particular, Sahlman (1990), Roberts (1991) and Wetzel (1994) for the US evidence and Moore (1994) for the UK evidence.
(5) By Standeven (1993).
(6) Developed initially by Myers (1984).

external finance opt initially for debt rather than equity finance. This preference is associated with information asymmetries. The difficulty investors face in assessing whether returns on SME investments adequately compensate for risk means that SME equity generally has to be issued at a greater discount than debt. The apparent reversal of the pecking order theory for TBSFs may be rationalised if it is assumed that private equity providers such as venture capitalists possess superior information in certain respects than do banks and entrepreneurs.(1) Conventional wisdom assumes that entrepreneurs have better knowledge of project-specific aspects such as the feasibility of the technology, but venture capitalists may have greater information on the project's marketability and operational implementation. In such cases, venture capitalists may be able to mitigate information asymmetries through reliance on particular types of equity finance, such as preferred and/or convertible stock (see below).

One other strand in the literature relevant to the optimal capital structure of TBSFs relates to control rights. This is linked to the use of contracts to eliminate agency problems, but is based on the view that such contracts cannot be 'complete', ie they cannot specify each party's obligations in all circumstances. Hence, they need to be used to determine the allocation of control rights.(2) The entrepreneur will seek a capital structure for his firm by weighing the marginal costs of diluting his control rights through the issuance of equity to new shareholders against the marginal costs of issuing more debt and therefore raising the risk of default. Some commentators(3) argue that the different control rights attached to debt and equity are just as important in determining the capital structure of closely held firms as differences in projected revenue streams or tax treatments. In such models, the optimal balance of control between entrepreneur and outside investor is shown to be state-contingent: it should reside with the entrepreneur in states of the world where his private benefits are relatively high, and with the investor when the entrepreneur's private benefits are relatively low. For venture capital finance of TBSFs, such state-contingent control, dependent also on the performance of the firm, can best be achieved by issuance of a form of quasi-equity, such as convertible preferred stock.

The venture capitalist—small firm relationship: agency problems

The literature assessed so far indicates strongly that information asymmetries and potential conflicts of interest between SMEs and their finance providers may affect financing and investment decisions. The first writer to apply these theories specifically to the venture capital industry was Sahlman (1990) in the United States, and indeed most of the subsequent literature in this area emanates from the United States.(4) In his pioneering study, Sahlman represents venture capitalists as facing a two-level principal-agent relationship with investee companies and end-investors. In the first relationship, the venture capital firm acts as principal, and is subject to the problems of evaluating potential investments in companies (the agents in this case) in an uncertain environment in which moral hazard and adverse selection may exist. In the second relationship, the venture capital firm is the agent, and is subject to the risk that, if it does not perform satisfactorily, it will fail to attract further funding from the end-investor as principal.

As far as the first relationship is concerned, the main requirement of the venture capital fund is for the small firm to provide it with ongoing information to ensure that any current investments are properly monitored and to allow an evaluation of the prospects for additional commitments of capital.(5) The problem is that the entrepreneur's desire for autonomy makes him reluctant to share fully and in a timely manner all relevant information.(6) This means that, at the time of consideration of an investment, the venture capitalist is faced with a potential adverse selection problem because of the difficulty of assessing the entrepreneur's performance. This may induce the venture capitalist to tighten the conditions attached to his financing offer to avoid paying too much for investments subsequently revealed to be poor performers.(7) As noted by Wright and Robbie (1998), this can explain why firms that turn out to be highly successful may initially have been refused venture capital finance, and why only small amounts of venture capital finance go to early-stage deals, where the information asymmetries are greatest. It also seems likely that these information problems will be most acute for TBSFs, in view of the more complex

(1) See Garmaise (1997) for a demonstration of this idea.
(2) See especially Hart (1995).
(3) Notably Aghion and Bolton (1992), Dewatripont and Tirole (1994), and Hart and Moore (1998).
(4) See Wright and Robbie (1998) for a comprehensive recent review, on which part of the analysis in the text is based.
(5) As noted, for example, in Bruno and Tyebjee (1985).
(6) See Sapienza (1989) and Sapienza and Korsgaard (1995).
(7) See the model developed by Amit *et al* (1990) for a formal derivation of this result.

specialist skills required of the entrepreneur and the greater difficulties faced by the venture capitalist in assessing those skills.

Several studies consider how to balance the venture capitalist's need for timely information with the entrepreneur's desire for autonomy and operating control. Both agency theory (as elaborated by Jensen and Meckling (1976)) and transaction cost theory (Williamson (1975)) emphasise the scope for co-operation between venture capitalist and entrepreneur as a means of reducing the need for costly monitoring mechanisms to control behaviour. An especially novel approach is to model the venture capitalist-small firm relationship utilising the Prisoner's Dilemma.(1) Although this approach indicates that both the venture capitalist and small firm have an incentive to procure higher short-term payoffs by 'defecting' from their relationship, it also recognises that both parties can maximise joint returns by mutual co-operation. *Ceteris paribus*, the likelihood of co-operation rises with the quality and frequency of communications, the closeness of the business relationship, the expected payoffs, the degree of time pressure, and the existence of penalties for non-co-operation.

Much of the remaining literature on the venture capitalist-entrepreneur relationship is concerned with assessing the mechanisms available to venture capitalists to ease moral hazard and adverse selection problems arising from agency risk. These can be divided into the following categories: (i) imposition of high hurdle rates; (ii) evaluation or 'screening' of investments; (iii) precise contract specifications; (iv) alignment of incentives through appropriate remuneration and bonding strategies; (v) use of preferred and/or convertible stock; and (vi) close monitoring of investments.

The use of high discount or hurdle rates by venture capitalists in evaluating potential investments is fairly well documented. Furthermore, the evidence from a number of studies(2) suggests that these hurdle rates tend to be higher for start-up ventures, especially of high-tech firms. These results are consistent with the likelihood that agency problems and information asymmetries will be most marked for early-stage investments in TBSFs. High hurdle rates, however, may in some cases actually exacerbate adverse selection by inducing the best firms to seek alternative sources of capital, leaving the less good firms, with no other financing options, as venture capitalists' clients (an idea again associated with Sahlman (1990)). This risk may be reduced by effective due diligence and a closer venture capitalist-entrepreneur relationship.

Several studies have examined the criteria that venture capitalists take into account in screening potential investments.(3) The earlier papers suggest that the key criterion used by venture capitalists relates to the business experience and personality of the entrepreneur; issues associated with the product and market appear to be less important. These findings seem to be contradicted in more recent studies, which conclude that industry and market factors are more important than the entrepreneur and his team. But all these studies rely on face-to-face interviewing techniques using 'verbal protocol' analysis (ie observing venture capitalists 'thinking aloud' over proposals), or use mailed questionnaires. In both cases, sample sizes are very small and the full essence of the screening process is unlikely to be captured. The studies also focus only on early-stage investments. A more extensive study covering a fuller range of investing stages (Fried and Hisrich (1994)) concludes that venture capitalists make use of three broad criteria in screening investments: the viability of the project; the integrity, track record and leadership skills of the management; and the possibility of high returns facilitated by easy exit. Another important paper in this area (Muzyka *et al* (1996)) concludes that venture capitalists opt for a combination of a good management team and reasonable financial and product market characteristics, even if these factors do not match the overall deal/fund requirements exactly. But all the literature agrees that a combination of extensive screening and high hurdle rates results in venture capitalists rejecting the vast majority of proposals. Most estimates suggest that the UK venture capital industry rejects around 95% of all applications for finance each year (see the survey by Bannock Consultants (1991)).

There is also a substantial literature on the optimal design of contracts to reduce or eliminate agency problems between venture capitalists and entrepreneurs.

(1) See especially Cable and Shane (1997).
(2) For example, Mason and Harrison (1999b) estimate that established companies need to generate annual internal rates of return of at least 30%, rising to 60% or more for seed/start-up investments. This is consistent with earlier calculations by Plummer (1987). Murray and Lott (1995) find that venture capitalists impose higher hurdle rates on technology-based projects at each stage of investment than on comparable non high-tech investments.
(3) See, for example, Bruno and Tyebjee (1985), MacMillan *et al* (1985 and 1987), Hall and Hofer (1993), Fried *et al* (1993), Rah *et al* (1994), and Zacharakis and Meyer (1995).

These contracts are designed to specify the rights of the parties and the basis on which their performance is monitored and rewarded (see, for example, Fama and Jensen (1983)). Berger and Udell (1998) usefully classify the various possibilities as follows: (i) staging of venture capitalist investments to ensure optimal exercise of production options and efficient development and termination of projects;[1] (ii) control and choice of particular equity and/or debt instruments;[2] (iii) appropriate entrepreneur compensation schemes, including provisions for the replacement of underperforming entrepreneurs;[3] (iv) restrictive covenants;[4] (v) board representation;[5] and (vi) allocation of voting rights.[6]

To take one high-profile example, the use of remuneration and bonding schemes to reduce agency conflicts between venture capitalists and entrepreneurs involves, *inter alia*, performance-related pay structures and share option schemes for entrepreneurs. Bonding schemes impose penalties on the company if certain performance targets, eg in relation to gearing ratios, are not met. One prominent model (Bergemann and Hege (1998)) is based on an optimal contract between the venture capitalist and entrepreneur that provides for inter-temporal risk sharing. The entrepreneur's share is akin to an options contract, and therefore depends on the length of the contract and the volatility of information flow consequent upon his actions. This model allows for the possibility that, because the venture capitalist cannot always observe if the entrepreneur is diverting funds and under-investing in the company, he may erroneously conclude that the company's prospects are poor and terminate the project even though, had this moral hazard problem not been present, the project would have attracted further funding. It is possible that, for some attractive projects, the likelihood of the entrepreneur diverting the venture capitalist's funds is so high that the venture capitalist will not finance them in the first place. If taken to its extreme, however, this predicts that the least successful firms may receive most venture capital finance,[7] a result which contradicts both common sense and other findings[8] that unsuccessful firms are revealed early and receive less finance.

One implication of this work is that, as has been indicated earlier, venture capitalists may be able to reduce agency problems if they provide quasi-equity rather than full equity finance. The use of convertible and/or preferred stock is fairly widespread in venture capital contracting,[9] because it enables venture capitalists separately to allocate cash flow, voting, board and liquidation rights to exercise appropriate control over entrepreneurs and take precedence over any ordinary shareholders. This limits the entrepreneur's incentives to behave opportunistically under conditions of asymmetric information.[10] It is interesting that the use of convertible preferred stock is especially widespread in high-tech industries such as software and biotechnology. The initial phases of development here often involve tests only the entrepreneur can observe and evaluate, while later stages are more readily assessed by outsiders. Some commentators have advocated favourable tax treatment of preferred stock (ie placing it on an equal footing to debt) largely for these reasons.

Further insights and empirical evidence on these features of typical venture capital contracts are provided in an interesting recent paper by Kaplan and Stromberg (2000). They consider detailed information on 200 venture capital investments in 118 US companies by 14 venture capital firms over the period 1987–99. Some 36% of these companies are located in the IT/software industries and a further 39% in other high-tech sectors such as biotechnology, telecommunications and healthcare. The evidence shows that convertible preferred stock is by far the most commonly used financing instrument, appearing in 189 out of the total of 200 financing rounds. Such instruments generally ensure that the cash flow rights, voting rights and control rights of the venture capitalists and entrepreneurs are contingent on observable measures of financial and non-financial performance. If the company performs poorly, the venture capitalists take full control; as company performance improves, the entrepreneur acquires more cash flow and control rights; if the company performs very well (defined as a median return of more than 30% per year over a four-year period to initial public offering (IPO)), the venture capitalists relinquish most of their control and liquidation rights,

(1) See Admati and Pfleiderer (1994), Bergemann and Hege (1998).
(2) See, *inter alia*, Gompers (1993), Cornelli and Yosha (1997) and Trester (1998).
(3) See Sahlman (1990) and Fiet (1995).
(4) See Chan *et al* (1990).
(5) See Lerner (1995).
(6) See Fenn *et al* (1997).
(7) As pointed out by Lerner (1998).
(8) See Gompers (1995).
(9) See, *inter alia*, Norton and Tenenbaum (1992) and Kaplan and Stromberg (2000).
(10) As demonstrated by Trester (1998).

while retaining their cash flow rights. These state contingencies are found to be more common in start-up and early-stage financings than in later financing rounds, a result which supports the theory that the potential conflicts of interest between the entrepreneur and the venture capitalist will depend on the degree of uncertainty about the project's economic viability, which should be greatest in the high-tech sectors and at the early stages of the project's life.

These results are consistent with the control theories of Aghion and Bolton (1992), Dewatripont and Tirole (1994), and Hart and Moore (1998). They also accord with a variant of the screening models[1] mentioned earlier, because state-contingent provisions not only motivate entrepreneurs to provide effort, but also discourage entrepreneurs with poor projects from accepting the contract.

The venture capitalist—end investor relationship

The second principal-agent relationship, involving the venture capitalist as agent this time and the end-investor as principal, is by comparison an under-researched area. But it is subject to similar agency problems induced by information asymmetries as those implicit in the entrepreneur-venture capitalist relationship. A number of mechanisms can be identified which may be utilised to minimise these agency problems, including: (i) incentives for mutual gain; (ii) prohibition of acts by venture capitalists causing conflicts of interest; (iii) limited life agreements; (iv) mechanisms to ensure gains are distributed to investors; (v) monitoring of venture capitalists by end-investors; and (vi) regular provision of information to end-investors (again, see Sahlman (1990)). These strategies are designed to align the interests of venture capitalists more closely with those of institutional investors.

To attract funds from end-investors, venture capitalists must demonstrate competent behaviour, involving effective screening, due diligence and contract formulation, before investments in risky companies may be made.[2] Agency problems may also be mitigated by the activities of intermediaries between venture capitalists and institutional investors, such as 'gatekeepers', who advise on venture capital fund selection and operate 'funds of funds' which invest in a spread of venture capital funds. Most crucially, the limited partnership structure of most venture capital firms is designed to reduce agency problems by providing a framework within which the interests of the limited partners (ie the end-investors) may be aligned with those of the general partners (the venture capitalists). As demonstrated again by Sahlman (1990) and Hay and Abbott (1993), among others, this can be facilitated by various contractual features, most notably by linking venture capitalists' remuneration to a fixed proportion (currently usually 2%) of total capital committed (the 'annual fee'), plus a proportion (currently generally 20%) of realised capital gains on investments ('carried interest'), thereby relating general partners' compensation directly to the success of the partnership.

It is possible, however, that certain features of these contractual relationships may actually have a perverse effect on the willingness of venture capitalists to invest in early-stage high-tech deals. The annual fee's linkage to capital committed arguably motivates the venture capital firm to increase fund size and make larger investments. A recent study by Murray and Marriott (1998) constructs a 'model' venture capital fund based on plausible assumptions and finds that the internal rate of return to the general partners only becomes positive at a fund size of £10 million and only reaches an acceptable level (say 30%) for a fund size of £20 million. The pressure to increase investment sizes may also lead to a shift to later-stage financing.[3]

The problem, in a nutshell, is that small fund structures are necessary to encourage a flow of investment into 'classic' activities (ie seed, start-up and early-stage finance), but such structures may not be profitable due to relatively high operating costs.[4] On this view, considerable economies of scale are available in the venture capital industry. Early-stage funds tend to incur greater unit costs while having smaller total funds over which to defray costs than later-stage development capital or MBO funds. As venture capital fund sizes increase, the attractiveness of investing small amounts in start-up companies falls. This may have particularly serious implications for investments in TBSFs, where scale-related costs are exacerbated by such factors as increased information costs associated with more

(1) See Prendergast (1999) for a recent general description of these types of model.
(2) See, in particular, van Osnabrugge (2000).
(3) See especially Gompers (1998).
(4) Murray (1999) provides an excellent summary of this line of argument.

complex products, reluctance to invest large sums early in the life cycle of the TBSF, and long product development cycles in some cases.

The risk-reward relationship

The willingness of end-investors to provide finance to venture capital firms that invest in TBSFs will depend ultimately on the risk-reward relationship, ie the extent to which such investments are likely to provide returns commensurate with the risks involved. Returns on venture capital investments depend, *inter alia*, on such factors as: the period of investment; the method of exit; and the company valuation at exit.(1) An assessment of returns therefore requires consideration of the exit process, recognising that the ease and availability of the exit process is fundamental to the provision of venture capital finance. Statistics on the US venture capital industry show a correlation between the availability of exit through IPO (proxied by the number of venture capital-backed IPOs) and the willingness of end-investors to allocate funds to venture capital-backed firms (measured by new capital commitments), with a lag of about one year.

The potential for exit through an IPO may also help to overcome demand-side constraints(2) on the financing of TBSFs, associated with entrepreneurs' reluctance to cede equity control. This may arise because an IPO often effectively ends the venture capitalist's close involvement in the company and provides the entrepreneur with an opportunity to regain control of the company. In other words, the prospect of an IPO gives the entrepreneur a call option on control, contingent on the firm's success. This incentive is not available in a trade sale, where control passes to an acquirer, even if the entrepreneur remains in charge of day-to-day management. According to this theory,(3) the potential for exit through an IPO is critical to the development of an active venture capital market, allowing the venture capitalist and entrepreneur to enter into an explicit contract over the future control of the company. Although this model does not pay sufficient regard to the fact that an IPO more usually results in control passing from either the venture capitalist or entrepreneur to third-party investors, it is consistent with the idea that the success of early-stage venture capital financing of high-tech firms is closely linked to the prospects for exit through IPOs. The existence of well-developed public equity markets, including markets specialising in small high-growth stocks (Nasdaq in the United States is the best example), is on this view vital to encourage greater focus on 'classic' venture capital finance.

The risk-reward trade-off between different types of venture capital activity has unfortunately received only limited attention in the literature. The venture capital market does not possess the characteristics of most other markets, such as rapid flows of information, large numbers of buyers and sellers and relatively homogeneous expectations. Most early-stage investment in new companies is through private equity offerings or capital allocated within established companies. Since such transactions are generally fairly infrequent, it is difficult to develop comparable performance criteria—price information is simply not available at consistent intervals for most venture capital investments. This in turn means that rates of return cannot easily be computed over monthly and quarterly time periods, as is possible in other securities markets. In the same way, the lack of frequently reported market prices makes it virtually impossible to derive soundly-based price measures of riskiness (eg betas) in the venture capital market. This explains why the literature in this area has tended to focus on target rates of return over longer periods of time.

These target IRRs need to be related to actual returns generated by venture capital investments. One of the first studies to look at such returns in the United States was that by Huntsman and Hoban (1980), which finds that the average annual rate of return on a sample of 110 venture investments by three venture capital funds over the 1960–75 period was 18.9%. This estimate may be biased upwards because the sample is drawn solely from surviving firms. This study also uncovers two other findings which have come to be regarded as standard features of the venture capital risk-reward relationship: (i) a high probability—about 1 in 6—of complete failure of the investment; and (ii) the average return being driven mainly by a small number of investments exhibiting extraordinarily high returns. Subsequent US studies reveal the sensitivity of IRRs to the start date of the fund, but a review of the US evidence(4) concludes that venture capital returns are most often in the teens, with occasional periods in the 20%–30% range and rare spikes above 30%.

(1) See especially Hay and Abbott (1993).
(2) See Cressy and Oloffson (1997) for an analysis of such constraints.
(3) See Black and Gilson (1998) for more details.
(4) See Bygrave (1994).

Turning to the UK evidence, an early analysis of returns to venture capital funds launched in the United Kingdom between 1980 and 1990[1] shows an average annual return to end-December 1994 of 12.1%, with large MBOs generating the highest returns, at 23.1% on average, and early-stage deals the lowest, at only 4.0% on average. But these figures are heavily influenced by the recession of the late 1980s, and the resulting failure of large numbers of SME—including TBSF—start-ups. More recent statistics are more encouraging, perhaps not surprisingly given that they cover a period of uninterrupted real economic growth. Net returns for private equity funds raised between 1980 and 1999, measured to the end of December 1999, are 33.6%, 31.1%, 27.2% and 20.0% per annum over periods of one year, three years, five years and ten years respectively.[2] These funds outperformed UK pension funds, and various stock market indices, over all these periods, although very high returns were achieved by only a small proportion of funds (the top decile).

Very recently, Burgel (1999), in a study commissioned by the British Venture Capital Association (BVCA), has produced returns figures and risk indicators for different types and stages of funds. They show that the pooled annual IRR for all UK venture capital funds (134 are covered in the survey) since 1980 is 14.3%, but the annual IRRs for early-stage and technology-based funds are 8.2% and 9.8% respectively. Over the ten-year period to 1998, the IRR for UK early-stage funds, at 7.9% per annum, compares very unfavourably with a 19.7% annual IRR for US early-stage funds. Once again, however, such comparisons are crucially dependent on start dates and periods; excluding the poor returns generated by the UK venture capital industry in the late 1980s can make a huge difference. For example, over the seven-year period 1992–98 or the six-year period 1993–98, the annual IRRs for UK early-stage funds rise to 26.9% or 26.7% respectively.

It is instructive to compare these results with indicators of the risks associated with venture capital funds, measured by the spread of returns generated. Burgel shows that the standard deviations of returns on technology and early-stage funds over the 1980–98 period are actually well below those of development and large MBO funds, although this mainly seems to reflect much greater upside potential for large MBOs in particular. Interestingly, it also appears to be the case that technology funds (but not early-stage funds in general) are subject to lower downside risk than other funds, which seems contrary to the theory that TBSFs are riskier than SMEs in general. But it remains the case that the maximum IRRs recorded for technology and early-stage funds over the full 1980–98 period (at 20.2% and 18.9% per annum respectively) are still well short of the target IRRs mentioned in the literature. If the latter are regarded as the returns that investors believe will adequately compensate for risk, it has to be concluded on the basis of this survey that the long-term risk-reward relationship has been less favourable to investment in UK technology and early-stage funds than in either later-stage UK funds or corresponding US funds.

Business angels

Private equity finance for TBSFs may be provided not only by the formal venture capital industry but also by the business angel (or informal venture capital) market. It has been estimated that the United Kingdom has approximately 18,000 actual and potential business angels, whose current annual investment activity amounts to around £500 million in total in some 3,500 businesses.[3] Surveys[4] indicate, however, that business angels have substantially greater funds available for potential investments, but face problems identifying suitable investment opportunities. This suggests that the UK market is inefficient, reflecting information gaps and high search costs incurred by investors seeking investment opportunities and entrepreneurs seeking finance. The invisibility of the business angel market, its fragmented nature and poor channels of communication between firms and investors create what Mason and Harrison (1996) term a 'discouragement effect', curtailing the search for equity capital.

In addition to these imperfections, the business angel market is also subject to similar kinds of agency risk, moral hazard and adverse selection as characterise the formal venture capital market, although angels do not have to cope with agency problems with end-investors given that they invest their own money. The invisibility and fragmented nature of the business angel market arguably may exacerbate some of these problems.

(1) See BVCA (1995).
(2) See BVCA (2000a).
(3) See Mason and Harrison (1998, 1999a).
(4) See Stevenson and Coveney (1994) and Mason and Harrison (1997).

Several studies[1] suggest that business angels seek to manage agency risk and other market imperfections by becoming actively involved with the company in various supportive roles. There is some evidence[2] that 'serial' business angels (those private investors who have made at least three separate investments), whether operating on their own or as part of syndicates, manage agency risk largely by backing entrepreneurs known personally to them, to another syndicate member and/or to the deal referrer. These studies also confirm that business angels face considerable difficulties in trying to unearth promising investment opportunities, and in identifying suitable partners with whom to share the risk of investing in private unquoted early-stage companies.

US studies tend to conclude that business angel finance complements that of venture capitalists. The evidence there[3] implies that US business angels typically invest in smaller amounts and at earlier stages than US venture capitalists, and are often the main source of very early-stage external equity finance for small high-tech companies. Statistics on the size and type of investment by US private investors indicate that individual business angels, along with internal funds, are currently the principal source of finance for seed and start-up capital of amounts ranging from $25,000 up to $500,000, with business angel networks heavily involved in the provision of early-stage finance in the range of $500,000–$2 million; formal venture capital finance in the United States now seems most focused on the provision of follow-up finance of above $2 million, once the company develops beyond the risky seed/start-up stages towards sustained growth.[4]

Evidence for the UK market is less clear-cut. It has been hypothesised[5] that business angels have the potential to fill a gap in the United Kingdom in the provision of seed, start-up and early-stage finance. This may be facilitated if angels are content with lower annual IRRs (say of around 20% rather than 30% minimum for venture capital firms), and are less concerned than venture capitalists or banks with lack of track record or collateral. But early empirical studies[6] find only limited support for these hypotheses. More recent research[7] finds more evidence of complementarity, but is based only on business angel networks listed in the BVCA directory. The most recent evidence, in Harrison and Mason (2000), suggests that both business angels and venture capitalists have participated in complementary relationships, including deal referral and (to a lesser extent) co-investing and sequential investing. In most cases, however, these relationships account for a relatively small proportion of their investment portfolios.

More light has been thrown on these issues in an extremely useful recent study by van Osnabrugge (1998), which examines in detail the characteristics and objectives of both venture capitalists and business angels in the United Kingdom. This finds some evidence of complementarity, with venture capitalists often providing expansion capital to developing firms which initially received start-up finance from business angels. But it also suggests that business angels are less involved in financing TBSFs than venture capitalists: some 13% of the sample of business angels finance TBSFs, compared with 57% of venture capitalists, and only 24% of total business angel finance goes to the high-tech sectors, compared with 44% of venture capital finance. In a later study, van Osnabrugge (2000) rationalises revealed behaviour differences on the part of business angels and venture capitalists as reflecting different approaches to agency risk control. Business angels place greater emphasis on *ex post* involvement in investments as a risk-reduction method, whereas venture capitalists are more concerned about reducing those risks in the pre-investment process as a means of signalling competence to end-investors.

Overall, the evidence on the extent to which UK business angels are involved in the provision of finance to TBSFs is inconclusive. Van Osnabrugge's rather negative findings receive support from several other studies, suggesting that only a small proportion—around 5%—are technology specialists. Lumme *et al* (1996) find that just 8% of a sample of TBSFs in the Cambridge area raised finance from business angels. But Mason and Harrison (1999a), in a recent survey of business angel networks, find that more than half of their deals are start-up and early-stage ventures and nearly one third of amounts invested are in high-tech sectors. They also discover evidence of greater permissiveness in business angel financing decisions than is likely to be tolerated by the formal venture capital industry, eg lower rejection

(1) See in particular Landstrom (1992 and 1993).
(2) Reviewed in Kelly and Hay (1996).
(3) See, in particular, Freear, Sohl and Wetzel (1990 and 1996).
(4) See Sohl (1998) for a detailed analysis of this process.
(5) By, *inter alia*, Aernoudt (1999).
(6) See especially Mason and Harrison (1995) and Lumme *et al* (1996).
(7) BVCA (2000b).

rates, longer exit horizons and lower target IRRs. But all the UK surveys agree that the UK business angel market is nowhere near as involved in the provision of early-stage finance to TBSFs as its equivalent in the United States. This is variously attributed to: a smaller pool of high net worth individuals in the United Kingdom; higher marginal tax rates; fewer high potential growth companies; and a lack of entrepreneurs who have built successful technology companies, thereby limiting the future supply of technology-oriented business angels.

Corporate venturing

Corporate venturing provides an alternative source of private equity finance for TBSFs. It tends to be found most frequently in the high-tech sectors of the economy, especially pharmaceuticals and software. In many cases, corporate investors are likely to have a greater understanding of the risks involved in the development of new high-tech products than institutional investors. This provides scope for corporate venturing to reduce information asymmetries: to the extent that corporate venturing activity is focused on markets in which the corporate venturer is currently competing, the corporate venturer is in a better position to assess the viability of an investment in a TBSF than the venture capitalist or institutional investor (see the report by Withers Solicitors (1995)). The desire of large companies to broaden their access to new technologies, and thereby to diversify their technological base by sharing costs and spreading risk, suggests that corporate venturing may fill equity gaps in the provision of early-stage finance to TBSFs.

This hypothesis receives some support from what is admittedly fairly limited evidence in the United Kingdom. In a survey of 48 mainly TBSFs, McNally (1995) finds that direct corporate venturing is the most common form of first-round financing. Moreover, more than two thirds of the investee companies in his sample that raise finance through indirect corporate venturing do so at the seed, start-up or early stages, and almost three quarters of total finance from indirect corporate venture funds to the sample of TBSFs is at these stages. This seems to imply that venture capital funds backed by corporate investors are more likely than other venture capital funds to make investments in early-stage TBSFs. But other evidence (such as that reviewed in Mason and Harrison (1994)) suggests that many corporate venturers avoid early-stage financing. In any event, it needs still to be borne in mind that corporate venturing in the United Kingdom remains an activity undertaken by only a relatively small proportion of larger companies, and a source of external equity for only a limited number of TBSFs.(1)

Access to finance and performance

If TBSFs do face greater financing difficulties than SMEs generally, it has been argued that this should be reflected in higher default and failure rates among TBSFs. Westhead and Storey (1994), for example, postulate that, although TBSFs are likely to grow more rapidly than SMEs in general, they are also likely to experience higher default rates. They attribute this to four key factors, all of which, as we have seen, are associated with the degree of risk attached to TBSFs: (i) greater lack of managerial and entrepreneurial skills of owners/founders; (ii) greater difficulties of assessing prospects for products or services; (iii) shorter product life cycles; and (iv) greater uncertainty over the outcome for R&D.

In fact, the empirical evidence is by no means conclusive on this crucial issue. Moore (1994) finds that the difficulty in obtaining start-up capital, and the adequacy of initial finance, are linked to subsequent performance; a greater proportion of companies facing problems in accessing start-up finance subsequently underperform. Bates (1990), in a study that uses logit, discriminant and regression analysis to assess factors relevant to SME survival rates, finds that firms that receive debt and equity finance at start-up are more likely to survive than firms reliant on internal finance. Rather surprisingly, in view of the literature on the superiority of equity over debt finance at start-up, he also finds that a reliance on debt finance does not increase the risk of failure. Other studies,(2) using both US and UK data, identify under-capitalisation as the most important reason for SME insolvency. More recently, Mason and Harrison (1998) also conclude that the post-start-up survival of businesses is in part a function of the ability of management to secure/gain access to finance. Firms launched exclusively on personal finance are more likely to fail, while the ability to acquire additional finance, post start-up, is positively associated with business survival. Such studies, however, do not always recognise properly the endogeneity of debt and other forms of finance, which means that causality may run from

(1) See the report by the CBI (1999).
(2) See Roberts (1991), Hall and Young (1991) and Hall (1992).

performance to ability to raise finance, rather than the reverse. This qualification must be borne in mind when assessing the main inference of these studies, which is that TBSFs are more likely to fail than SMEs generally, because they face greater problems in obtaining suitable finance.

Analysis of relative failure rates can throw more light on these theories. Westhead and Storey (1994) find that the evidence on relative failure rates does not support the thesis that high-tech firms are higher risk than SMEs in general: the survival record of the TBSFs in their sample is actually superior to a random sample of UK small firms. Garnsey and Cannon-Brookes (1993), in a study of a sample of high-tech firms in the Cambridge area, find that failure rates since 1984 are only 33%–50% of the national average for smaller companies. These results are rather surprising in view of the theoretical literature on the risks associated with TBSFs compared with SMEs in aggregate. They may, however, reflect possible sample bias in the surveys; the Cambridge study, for example, may say more about regional variations in insolvencies among SMEs generally than about divergencies in failure rates between high-tech and conventional companies.

Storey and Tether (1996), in their comprehensive evaluation of the performance of TBSFs in a large number of European countries, quote studies carried out in Germany, Italy and France which also suggest that TBSF failure rates are below those of SMEs in general. They argue that the reluctance of many institutional investors in those countries to increase the proportion of funds allocated to high-tech start-ups between 1985 and 1995 does not reflect concern over any likely additional risks, but rather an inability to distinguish between firms likely to be successful and those likely to be unsuccessful. Given the greater reliance on sometimes unproven new technologies, on this view the variability of performance of TBSFs, ie the distinction between successes and failures, may be greater than that of SMEs generally, even if overall failure rates are similar. This may be one way of reconciling conflicting empirical results. Another is that the results will be sensitive to the choice of samples and time periods over which performance is assessed. But the evidence overall on relative failure rates provides little support for the thesis that TBSFs face significantly greater financing difficulties than SMEs on average.

Role of the public sector

Public sector initiatives to support the financing of TBSFs, whether based on public expenditure or the tax system, may be justified if market imperfections mean that the private sector does not provide capital to firms on competitive terms. Activities in the high-tech sectors of the economy may be more likely to generate positive externalities, the benefits of which are not taken fully into account by private markets. An extensive literature(1) reveals how R&D expenditure by TBSFs may generate social returns in excess of private returns; the investing firms, however, may not capture these spillover effects. They may, therefore, invest below the socially optimal level of R&D, for fear that subsequent profits may accrue mainly to competitors introducing imitations or to developers of complementary products. Such problems may be especially acute among smaller companies, because they are less able to defend their intellectual property rights.(2)

But this review of the literature suggests that conclusive evidence on whether there is a major market failure in the provision of finance to small high-tech companies in the United Kingdom is lacking. This means that the case for general public sector initiatives is also unproven. Indeed, in the absence of market failure, such initiatives may themselves cause distortions by subsidising, at considerable public cost, non-viable firms, which are not attracting private capital because they do not offer good investment opportunities. The information that is then conveyed to other potential investors may be misleading, either inducing wrong decisions or, as private investors learn from their mistakes, acting as a deterrent to the future provision of finance to all firms, regardless of viability.

There is little empirical evidence on the effectiveness of existing schemes of public sector support for TBSFs, either in the United States or the United Kingdom. One exception is the recent study by Lerner (1999), which looks at the US Small Business Innovative Research (SBIR) Programme. This was established in 1982 to stimulate small business innovation by providing inducements to TBSFs to meet federal R&D requirements. Lerner considers a sample of 1,435 firms participating in SBIR programmes over a ten-year period, and finds that SBIR awardees enjoyed substantially greater employment and sales growth than matching firms, and were also more likely subsequently to receive

(1) See Griliches (1992) and Jaffe (1996) for reviews of this literature.
(2) This argument is associated with Lerner (1999).

venture capital financing. In particular, the relationship between SBIR awards and growth appears to be much stronger in high-tech sectors of the economy.

There have been even fewer studies of the effectiveness of UK public sector schemes to support TBSFs, partly because most of the initiatives are comparatively recent. But Moore and Garnsey (1992) did look at the effectiveness of the Small Firms Merit Award for Research and Technology (SMART). This provides grants to help SMEs to access technology and research, and to develop innovative products and processes. In providing such grants, SMART awards in effect aim to reduce information asymmetries by attaching a track record of achievement to TBSFs, thereby also helping to lever in additional funds through a form of accreditation process. Moore and Garnsey reach the conclusion that the long-term financial viability of the firm is enhanced by the injection of finance for innovation via the SMART scheme, although this rather weak test should not be taken as a justification in itself of the scheme.

This suggests that public sector intervention should be targeted at those areas where market imperfections can be identified. Research at the Bank (2001) concludes that public sector initiatives should be aimed specifically at improving the provision of small amounts of risk capital to TBSFs at the seed, start-up and early stages. This is especially so given that debt finance, which is readily accessed by SMEs in general, is frequently not an available or appropriate source of funding for TBSFs at these stages of their life cycles.

Conclusion

In conclusion, this review has emphasised that the information asymmetries, moral hazard and adverse selection that feature in aspects of SME financing potentially apply with particular force to the provision of start-up and early-stage finance to TBSFs. This reflects the key characteristics of high-tech companies, notably that their value is linked primarily to longer-term growth potential, they lack tangible assets in the early stages of their life cycles which may be used as collateral, and their products are usually subject to high obsolescence rates. These factors are compounded by the greater difficulty that finance providers face in assessing the technology, and the greater uncertainties over both the cost of R&D and the prospective demand for the new product. Public sector initiatives should be targeted specifically at these problem areas, because conclusive evidence of a major market failure in the provision of finance to TBSFs more generally is lacking.

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