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The Financing of Research and Development

Bronwyn H. Hall
Department of Economics,
University of California, Berkeley,
Institute of Fiscal Studies, London, and NBER

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Abstract

Evidence on the "funding gap" for R&D is surveyed. The focus is on financial market reasons for underinvestment in R&D that persist even in the absence of externality-induced underinvestment. The conclusions are that 1) small and new innovative firms experience high costs of capital that are only partly mitigated by the presence of venture capital; 2) evidence for high costs of R&D capital for large firms is mixed, although these firms do prefer internal funds for financing these investments; 3) there are limits to venture capital as a solution to the funding gap, especially in countries where public equity markets are not highly developed; and 4) further study of governmental seed capital and subsidy programs using quasi-experimental methods is warranted.

Keywords: *Research and Development (R&D), Finance, Investment and Evidence*

Corresponding Author: Bronwyn H. Hall

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Background to the Study

It is a widely held view that research and development (R&D) activities are difficult to finance in a freely competitive market place. Support for this view in the form of economic-theoretic modeling is not difficult to find and probably begins with the classic articles of Nelson (1959) and Arrow (1962), although the idea itself was alluded to by Schumpeter (1942). The argument goes as follows: the primary output of R&D investment is the knowledge of how to make new goods and services, and this knowledge is nonrival: use by one firm does not preclude its use by another. To the extent that knowledge cannot be kept secret, the returns to the investment in it cannot be appropriated by the firm undertaking the investment, and therefore such firms will be reluctant to invest, leading to the under provision of R&D investment in the economy.

Since the time when this argument was fully articulated by Arrow, it has of course been developed, tested, modified, and extended in many ways. For example, Levin et al (1987) and Mansfield et al (1981) found using survey evidence that imitating a new invention was not costless, but could cost as much as fifty to seventy-five per cent of the cost of the original invention. This fact will mitigate but not eliminate the underinvestment problem. Empirical support for the basic point concerning the positive externalities created by research that was made by Arrow is widespread, mostly in the form of studies that document a social return to R&D that is higher than the private level (Griliches, 1992; Hall, 1996). Recently, a large number of authors led by Romer (1986) have produced models of endogenous macro-economic growth that are built on the increasing returns principle implied by Arrow's argument that one person's use of knowledge does not diminish its utility to another (Aghion and Howitt, 1997).

This line of reasoning is already widely used by policymakers to justify such interventions as the intellectual property system, government support of R&D, R&D tax incentives, and the encouragement of research partnerships of various kinds. In general, these incentive programs can be warranted even when the firm or individual undertaking the research is the same as the entity that finances it. However, Arrow's influential paper also contains another argument, again one which was foreshadowed by Schumpeter and which has been addressed by subsequent researchers in economics and finance: the argument that an additional gap exists between the private rate of return and the cost of capital when the innovation investor and financier are different entities. This paper concerns itself with this second aspect of the market failure for R&D investment: even if problems associated with incomplete appropriability of the returns to R&D are solved using intellectual property protection, subsidies, or tax incentives, it may still be difficult or costly to finance R&D using capital from sources external to the firm or entrepreneur. That is, there is often a wedge, sometimes large, between the rate of return required by an entrepreneur investing his own funds and that required by external investors. By this argument, unless an inventor is already wealthy, or firms already profitable, some innovations will fail to be provided purely because the cost of external capital is too high, even when they would pass the private returns hurdle if funds were available at a "normal" interest rate. In the following, I begin by describing some of the unique features of R&D investment. Then I discuss the various theoretical arguments why external finance for R&D might be more expensive that internal finance, going on to review the empirical evidence on the validity of this hypothesis and the solutions that have been developed and adopted by the market and some governments. The paper concludes with a discussion of policy options.

Research and Development as Investment

From the perspective of investment theory, R&D has a number of characteristics that make it different from ordinary investment. First and most importantly, in practice fifty per cent or more of R&D spending is the wages and salaries of highly educated scientists and engineers. Their efforts create an intangible asset, the firm's knowledge base, from which profits in future years will be generated. To the extent that this knowledge is "tacit" rather than codified, it is embedded in the human capital of the firm's employees, and is therefore lost if they leave or are fired. This fact has an important implication for the conduct of R&D investment. Because part of the resource base of the firm itself disappears when such workers leave or are fired, firms tend to smooth their R&D spending over time, in order to avoid having to lay off knowledge workers. This implies that R&D spending at the firm level typically behaves as though it has high adjustment costs (Hall, Griliches, and Hausman, 1986; Lach and Schankerman, 1988), with two consequences, one substantive and one that affects empirical work in this area. First, the equilibrium required rate of return to R&D may be quite high simply to cover the adjustment costs. Second, and related to the first, is that it will be difficult to measure the impact of changes in the costs of capital, because such effects can be weak in the short run due to the sluggish response of R&D to any changes in its cost.

A second important feature of R&D investment is the degree of uncertainty associated with its output. This uncertainty tends to be greatest at the beginning of a research program or project, which implies that an optimal R&D strategy has an options-like character and should not really be analyzed in a static framework. R&D projects with small probabilities of great success in the future may be worth continuing even if they do not pass an expected rate of return test. The uncertainty here can be extreme and not a simple matter of a well-specified distribution with a mean and variance. There is evidence, such as that in Scherer (1998), that the distribution of profits from innovation sometimes has a Paretian character where the variance does not exist. When this is the case, standard risk-adjustment methods will not work well.The natural starting point for the analysis of R&D investment financing is the "neo-classical" marginal profit condition, suitably modified to take the special features of R&D into account. Following the formulation in Hall and Van Reenen (2000), I define the user cost of R&D investment ρ as the pre-tax real rate of return on a marginal investment that is required to earn *r* after (corporate) tax. The firm invests to the point where the marginal product of R&D capital equals ρ:

$$MPK = \rho = \frac{1 - A^d - A^c}{1 - \tau}(+r\ \delta + \ MAC)$$

τ is the corporate tax rate, δ is the (economic) depreciation rate, and *MAC* is the marginal adjustment cost?

In this equation, A^d and A^c are the present discounted value of depreciation allowances and tax credits respectively. In most financial accounting systems, including those used by major OECD economies, R&D is expensed as it is incurred rather than capitalized and depreciated, which means that the lifetime of the investment for accounting purposes is much shorter than the economic life of the asset created and that A^d is simply equal to τ for tax-paying firms. Many countries have a form of tax credit for R&D, either incremental or otherwise, and this will be reflected in a positive value for A^c. Note that when A^c is zero, the corporate tax rate does not enter into the marginal R&D decision, because of the full deduct ability of R&D.

The user cost formulation above directs attention to the following determinants of R&D financing:

i. Tax treatment such as tax credits, which are clearly amenable to intervention by policy makers.
ii. Economic depreciation δ, which in the case of R&D is more properly termed obsolescence. This quantity is sensitive to the realized rate of technical change in the industry, which is in turn determined by such things as market structure and the rate of imitation. Thus, it is difficult to treat δ as an invariant parameter in this setting.
iii. The marginal costs of adjusting the level of the R&D program.
iv. The investor's required rate of return *r*.

The last item has been the subject of considerable theoretical and empirical interest, on the part of both industrial organization and corporate finance economists. Two broad strands of investigation can be observed: one focuses on the role of asymmetric information and moral hazard in raising the required rate of return above that normally used for conventional investment, and the latter on the requirements of different sources of financing and their differing tax treatments for the rate of return. The next section of the paper discusses these factors.

Theoretical Background

This section of the paper reviews the reasons that the impact of financial considerations on the investment decision may vary with the type of investment and with the source of funds in more detail. To do this, I distinguish between those factors that arise from various kinds of market failures in this setting and the purely financial (or tax-oriented) considerations that affect the cost of different sources of funds. One of the implications of the well-known Modigliani-Miller theorem (1958, 1961) is that a firm choosing the optimal levels of investment should be indifferent to its capital structure, and should face the same price for investment and R&D investment on the margin. The last dollar spent on each type of investment should yield the same expected rate of return (after adjustment for non-diversifiable risk). A large literature, both theoretical and empirical, has questioned the bases for this theorem, but it remains a useful starting point.

Reasons why the theorem might fail in practice are several:

i. Uncertainty coupled with incomplete markets may make a real options approach to the R&D investment decision more appropriate;
ii. The cost of capital may differ by source of funds for non-tax reasons;
iii. The cost of capital may differ by source of funds for tax reasons; and
iv. The cost of capital may also differ across types of investments (tangible and intangible) for both tax and other reasons.

With respect to R&D investment, economic theory advances a plethora of reasons why there might be a gap between the external and internal costs capital; these can be divided into three main types:

i. Asymmetric information between inventor and investor.
ii. Moral hazard on the part of the inventor or arising from the separation of ownership and management.
iii. Tax considerations that drive a wedge between external finance and finance by retained earnings.

Asymmetric Information Problems

In the R&D setting, the asymmetric information problem refers to the fact that an inventor frequently has better information about the likelihood of success and the nature of the contemplated innovation project than potential investors. Therefore, the marketplace for financing the development of innovative ideas looks like the "lemons" market modeled by Akerlof (1970). The lemons' premium for R&D will be higher than that for ordinary investment because investors have more difficulty distinguishing good projects from bad when the projects are long-term R&D investments than when they are more short-term or low-risk projects (Leland and Pyle, 1977). When the level of R&D expenditure is a highly observable signal, as it is under current U.S. and U.K. rules, we might expect that the lemons' problem is somewhat mitigated, but certainly not eliminated. In the most extreme version of the lemons model, the market for R&D projects may disappear entirely if the asymmetric information problem is too great. Informal evidence suggests that some potential innovators believe this to be the case in fact. And as will be discussed below, venture capital systems are viewed by some as a solution to this "missing markets" problem.

Reducing information asymmetry via fuller disclosure is of limited effectiveness in this arena, due to the ease of imitation of inventive ideas. Firms are reluctant to reveal their innovative ideas to the marketplace and the fact that there could be a substantial cost to revealing information to their competitors reduces the quality of the signal they can make about a potential project (Bhattacharya and Ritter, 1983; Anton and Yao, 1998). Thus, the implication of asymmetric information coupled with the costliness of mitigating the problem is that firms and inventors will face a higher cost of external than internal capital for R&D due to the lemons' premium. Some empirical support for this proposition exists, mostly in the form of event studies that measure the market response to announcements of new debt or share issues. Both Alam and Walton (1995) and Zantout (1997) find higher abnormal returns to firm shares following new debt issues when the firm is more R&D-intensive. The argument is that the acquisition of new sources of financing is good news when the firm has an asymmetric information problem because of its R&D strategy. Similary, Szewcxyk, Tsetsekos, and Zantout (1996) find that investment opportunities (as proxied by Tobin's q) explain R&D-associated abnormal returns, and that these returns are higher when the firm is highly leveraged, implying a higher required rate of return for debt finance in equilibrium.

Moral Hazard Problems

Moral hazard in R&D investing arises in the usual way: modern industrial firms normally have separation of ownership and management. This leads to a principal-agent problem when the goals of the two conflicts, which can result in investment strategies that are not share value maximizing. Two possible scenarios may co-exist: one is the usual tendency of managers to spend on activities that benefit them (growing the firm beyond efficient scale, nicer offices, etc.) and the second is a reluctance of risk averse managers to invest in uncertain R&D projects. Agency costs of the first type may be avoided by reducing the amount of free cash flow available to the managers by leveraging the firm, but this in turn forces them to use the higher cost external funds to finance R&D (Jensen and Meckling, 1976). Empirically, there seem to be limits to the use of the leveraging strategy in R&D-intensive sectors. See Hall (1990, 1994) for evidence that the LBO/restructuring wave of the 1980s was almost entirely confined to industries and firms where R&D was of no consequence.

According to the second type of principal-agent conflict, managers are more risk averse than shareholders and avoid R&D projects that will increase the riskiness of the firm. If bankruptcy is a possibility, managers whose opportunity cost is lower than their present earnings and potential bondholders may both wish to avoid variance-increasing projects which shareholders would like to undertake. The argument of the theory is that long-term investments can suffer in this case. The optimal solution to this type of agency cost would be to increase the long-term incentives faced by the manager rather than reducing free cash flow. Evidence on the importance of agency costs as they relate to R&D takes several forms. Several researchers have studied the impact of antitakeover amendments (which arguably increase managerial security and willingness to take on risk while reducing managerial discipline) on R&D investment and firm value. Johnston and Rao (1997) find that such amendments are not followed by cuts in R&D, while Pugh, Jahara, and Oswald (1999) find that adoption of an Employee Stock Ownership Plan (ESOP), which is a form of antitakeover protection, is followed by R&D increases. Cho (1992) finds that R&D intensity increases with the share that managerial shareholdings represent of the manager's wealth and interprets this as incentive pay mitigating agency costs and inducing long term investment.

Capital Structure and R&D

In the view of some observers, the leveraged buyout (LBO) wave of the 1980s in the United States and the United Kingdom arose partly because high real interest rates meant that there were strong pressures to eliminate free cash flow within firms (Blair and Litan, 1990). For firms in industries where R&D is an important form of investment, such pressure should have been reduced by the need for internal funds to undertake such investment and indeed Hall (1993, 1994) and Opler and Titman (1993) find that firms with high R&D intensity were much less likely to do an LBO. Opler and Titman (1994) find that R&D firms that were leveraged suffered more than other firms when facing economic distress, presumably because leverage meant that they were unable to sustain R&D programs in the fact of reduced cash flow.

In related work using data on Israeli firms, Blass and Yosha (2001) report that R&D-intensive firms listed on the United States stock exchanges use highly equity-based sources of financing, whereas those listed only in Israel rely more on bank financing and government funding. The former is more profitable and faster-growing, which suggests that the choice of where to list the shares and whether to finance with new equity is indeed sensitive to the expected rate of return to the R&D being undertaken. That is, investors supplying arms-length finance require higher returns to compensate them for the risk of a "lemon."

Although leverage may be a useful tool for reducing agency costs in the firm, it is of limited value for R&D-intensive firms. Because the knowledge asset created by R&D investment is intangible, partly embedded in human capital, and ordinarily very specialized to the particular firm in which it resides, the capital structure of R&D-intensive firms customarily exhibits considerably less leverage than that of other firms. Banks and other debtholders 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. In the words of Williamson (1988), "redeployable" 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. Empirical support for this idea is provided by Alderson and Betker (1996), who find that liquidation costs and R&D are positively related across firms. The implication is that the sunk costs associated with R&D investment are higher than that for ordinary investment.

In addition, servicing debt usually requires a stable source of cash flow, which makes it more difficult to find the funds for an R&D investment program that must be sustained at a certain level in order to be productive. For both these reasons, firms are either unable or reluctant to use debt finance for R&D investment, which may raise the cost of capital, depending on the precise tax treatment of debt versus equity. Confirming empirical evidence for the idea that limiting free cash flow in R&D firms is a less desirable method of reducing agency costs is provided by Chung and Wright (1998), who find that financial slack and R&D spending are correlated with the value of growth firms positively, but not correlated with that of other firms.

Taxes and the Source of Funds

Tax considerations that yield variations in the cost of capital across source of finance have been well articulated by Auerbach (1984) among others. He argued that under the U.S. tax system during most of its history the cost of financing new investment by debt has been less that of financing it by retained earnings, which is in turn less than that of issuing new shares. More explicitly, if r is the risk-adjusted required return to capital, τ is the corporate tax rate, θ is the personal tax rate, and c is the capital gains tax rate, we have the following required rates of return for different financing sources:

Debt	$r(1-\tau)$	interest deductible at the corporate level
Retained earnings	$r(1-\theta)/(1-c)$	avoids personal tax on dividends, but capital gains tax
New shares	$r/(1-c)$	eventual capital gains tax

If dividends are taxed, clearly financing with new shares is more expensive than financing with retained earnings. And unless the personal income tax rate is much higher than the sum of the corporate and capital gains rates, the following inequalities will both hold:

$$(1-\tau) < \frac{1-\theta}{1-c} < \frac{1}{1-c}$$

These inequalities express the facts that interest expense is deductible at the corporate level, while dividend payments are not, and that shareholders normally pay tax at a higher rate on retained earnings that are paid out than on those retained by the firm and invested.[5] It implicitly assumes that the returns from the investment made will be retained by the firm and eventually taxed at the capital gains rate rather than the rate on ordinary income.

It is also true that the tax treatment of R&D in most OECD economies is very different from that of other kinds of investment: because R&D is expensed as it is incurred, the effective tax rate on R&D assets is lower than that on either plant or equipment, with or without an R&D tax credit in place. This effectively means that the economic depreciation of R&D assets is considerably less than the depreciation allowed for tax purposes -- which is 100 percent -- so that the required rate of return for such investment would be lower. In addition, some countries offer a tax credit or subsidy to R&D spending, which can reduce the after-tax cost of capital even further.[6]

The conclusion from this section of the paper is that the presence of either asymmetric information or a principal-agent conflict implies that new debt or equity finance will be relatively more expensive for R&D than for ordinary investment, and that considerations such as lack of collateral further reduce the possibility of debt finance. Together, these arguments suggest an important role for retained earnings in the R&D investment decision, independent of their value as a signal of future profitability. In fact, as has been argued by both Hall (1992) and Himmelberg and Petersen (1994), there is good reason to think that positive cash flow may be more important for R&D than for ordinary investment. The next section reports on a series of empirical tests for this proposition.

Small Firms, Startup Finance, and Venture Capital

As should be apparent from much of the preceding discussion, any problems associated with financing investments in new technology will be most apparent for new entrants and startup firms. For this reason, many governments already provide some of form of assistance for such firms, and in many countries, especially the United States, there exists a private sector "venture capital" industry that is focused on solving the problem of financing innovation for new and young firms. This section of the paper reviews what we know about these alternative funding mechanisms, beginning with a brief look at government funding for startups and then discussing the venture capital solution.

Government funding for startup firms

Examples of such programs are the U.S. Small Business Investment Company (SBIC) and Small Business Innovation Research (SBIR) programs. Together, these programs disbursed $2.4 billion in 1995, more than 60% of the amount from venture capital in that year (Lerner 1998a). In Germany, more than 800 federal and state government financing programs have been established for new firms in the recent past (OECD 1995). In 1980, the Swedish established the first of a series of investment companies (along with instituting a series of measures such as reduced capital gains taxes to encourage private investments in startups), partly on the United States model. By 1987, the government share of venture capital funding was 43 percent (Karaomerliolu and Jacobsson 1999). Recently, the UK has instituted a series of government programs under the Enterprise Fund umbrella which allocate funds to small and medium-sized firms in high technology and certain regions, as well as guaranteeing some loans to small businesses (Bank of England 2001). There are also programs at the European level.

A limited amount of evidence, most of its U.S.-based, exists as to the effectiveness and "additionality" of these programs. In most cases, evaluating the success of the programs is difficult due to the lack of a "control" group of similar firms that do not receive funding.[9] Therefore most of the available studies are based on retrospective survey data provided by the recipients; few attempts to address the question of performance under the counterfactual seriously. A notable exception is the study by Lerner (1999), who looks at 1435 SBIR awardees and a matched sample of firms that did not receive awards, over a ten-year post-award period. Because most of the firms are privately held, he is unable to analyze the resulting valuation or profitability of the firms, but he does find that firms receiving SBIR grants grow significantly faster than the others after receipt of the grant. He attributes some of this effect to "quality certification" by the government that enables the firm to raise funds from private sources as well.[10]

Venture Capital

Many observers view the rise of the venture capital (VC) industry, especially that in the United States, a "free market" solution to the problems of financing innovation. In fact, many of the European programs described above have as some of their goals the provision of seed capital and the encouragement of a venture capital industry that addresses the needs of high technology startups. Table 1 shows why this has been of some concern to European policymakers: the amount of venture capital available to firms in the United States and Europe was roughly comparable in 1996, but the relative allocation to new firms (seed money and startups) in Europe was much less, below 10% of the funds as opposed to 27%. A correspondingly greater amount was used to finance buyouts of various kinds.

In the United States, the VC industry consists of fairly specialized pools of funds (usually from private investors) that are managed and invested in companies by individuals knowledgeable about the industry in which they are investing. In principle, the idea is that the lemons premium is reduced because the investment managers are better informed and moral hazard is minimized because a higher level of monitoring than that used in conventional arm's length investments is the norm. But the story is more complex than that: the combination of high uncertainty, asymmetric information, and the fact that R&D investment typically does not yield results instantaneously not only implies option-like behavior for the investment decision but also has implications for the form of the VC contract and the choice of decision maker. That is, there are situations in which it is optimal for the investor (VC) to have the right to shut down a project and there are other situations in which optimal performance is achieved when the innovator has control.

Conclusions

Based on the literature surveyed here, what do we know about the costs of financing R&D investments and the possibility that some kind of market failure exists in this area? Several main points emerge:

1. There is fairly clear evidence, based on theory, surveys, and empirical estimation, that small and startup firms in R&D-intensive industries face a higher cost of capital than their larger competitors and then firms in other industries. In addition to compelling theoretical arguments and empirical evidence, the mere existence of the VC industry and the fact that it is concentrated precisely where these startups are most active suggests that this is so. In spite of considerable entry into the VC industry, returns remain high, which does suggest a high required rate of return in equilibrium (Upside 2001).

2. The evidence for a financing gap for large and established R&D firms is harder to establish. It is certainly the case that these firms prefer to use internally generated funds for financing investment, but less clear that there is an argument for intervention, beyond the favorable tax treatment that currently exists in many countries.

3. The VC solution to the problem of financing innovation has its limits: First, it does tend to focus only on a few sectors at a time, and to make investment with a minimum size that is too large for startups in some fields. Second, good performance of the VC sector requires a thick market in small and new firm stocks (such as NASDAQ or EASDAQ) in order to provide an exit strategy for early-stage investors.

4. The effectiveness of government incubators, seed funding, loan guarantees, and other such policies for funding R&D deserves further study, ideally in an experimental or quasi-experimental setting. In particular, studying the cross-country variation in the performance of such programs would be desirable, because the outcomes may depend to a great extent on institutional factors that are difficult to control for using data from within a single country.

References

Akerlof, G. A. (1997). The market for 'lemons': Quality, uncertainty, and the market mechanism, *Quarterly Journal of Economics* 84: 488-500.

Alam, P. & Karen, S. W. (1995). Information asymmetry and valuation effects of debt financing, *Financial Review* 30(2), 289-311.

Alderson, M. J., & Brian, L. B. (1996). Liquidation costs and accounting data, *Financial Management* 25(2) 25-36.

Anand, B. N., & Alexander, G. (2000). Weak property rights and holdup in R&D, *Journal of Economics and Management Strategy* 9(4), 615-42.

Anton, J. J., & Dennis, A. Y. (1998). *The sale of intellectual property: Strategic disclosure, property rights, and incomplete contracts*, The Wharton School, University of Pennsylvania: working paper.

Arrow, K. J. (1992). *Economic welfare and the allocation of resources for invention," In Richard Nelson (ed.)*, *The Rate and Direction of Inventive Activity*. Princeton, N. J.: Princeton University Press.

Auerbach, A. J. (1994). Taxes, firm financial policy, and the cost of capital: An empirical analysis, *Journal of Public Economics* 23, 27-57.

Bank of England. (2001). *Finance for small firms – An Eighth report*, London: Domestic Finance Division, Bank of England.

Bhattacharya, S., & Jay, R. R. (1995). Innovation and communication: Signaling with partial disclosure, *Review of Economic Studies* L 331-46.

Blair, M. M., & Robert, E. L. (1990). *corporate leverage and leveraged buyouts in the eighties*, Washington, DC: Brookings Institution.

Blass, A. A., & Oved, Y. (2001). *Financing R&D in Mature companies: An empirical analysis*, Bank of Israel, Tel Aviv University, and CEPR: working paper.

Cho, S. (1992). Agency costs, management stockholding, and research and development expenditures, *Seoul Journal of Economics* 5(2), 127-52.

Chung, K. H., & Peter, W. (1998). Corporate policy and market value: A q theory approach, *Review of Quantitative Finance and Accounting* 11(3): 293-310.

Griliches, Z. (1992). The Search for R&D spillovers, *Scandinavian Journal of Economics* 94, S29-S47.

Hall, B. H. (1996). The private and social returns to research and development," in B. L. R. Smith and C. E. Barfield (eds.), *Technology, R&D, and the Economy,* 140-83. Washington, DC: Brookings Institution and the American Enterprise Institute.

Hall, B. H., & John, V. R. (2000). How effective are fiscal incentives for R&D? A new review of the evidence, *Research Policy* 29: 449-469.

Hall, B. H., Jacques, M. L. B. & Bruno, C. (1999). Does cash flow cause investment and R&D: An exploration using panel data for French, Japanese, and United States Firms in the Scientific Sector," in Audretsch, D., and A. R. Thurik (eds.), *Innovation, Industry Evolution and Employment*. Cambridge, UK: Cambridge University Press.

Hall, B. H., Zvi, G. & Jerry, A. H. (1996). Patents and R&D: Is There a Lag?, *International Economic Review* 27, 265-83.

Himmelberg, C. P., & Bruce, C. P. (1994). R&D and internal finance: A panel study of small firms in High-Tech industries, *Review of Economics and Statistics* 76, 38-51.

Jensen, M. C., & William, M. (1996). Theory of the firm: Managerial behavior, agency costs, and ownership structure, *Journal of Financial Economics* 3, 305-60.

Karaomerliolu, D. C., & Staffan, J. (1999). *The Swedish venture capital industry – An Infant, adolescent, or grown-UP*?" Goteborg, Sweden: Chalmers Institute of Technology.

Lach, S. & Mark, S. (1998). Dynamics of R&D and investment in the scientific sector, *Journal of Political Economy* 97(4), 880-904.

Leland, H. E., & David, H. P. (1997) Informational asymmetries, financial structure, and financial intermediation, *Journal of Finance* 32, 371-87.

Lerner, J. (1999). The government as venture capitalist: The Long-run effects of the SBIR program, *Journal of Business* 72, 285-318.

Lerner, J. & Alexander, T. (2000). *Do equity financing cycles matter? Evidence from biotechnology alliances*, NBER Working Paper No. 7464 (January).

Levin, R. C., Alvin, K. K., Richard, R. N., & Sidney, G. W. (1997). Appropriating the returns from Industrial Research and Development, *Brookings Papers on Economic Activity* 1987(3),783-832.

Mansfield, E., Mark, S., & Samuel, W. (1991). Imitation costs and patents: An empirical study, *Economic Journal* 91: 907-918.

Miller, M. H., & Franco, M. (2001). Dividend policy, growth, and the valuation of shares, *Journal of Business* 34, 411-33.

Modigliani, F. & Merton, H. M. (1998). The cost of capital, corporation finance and the theory of investment, *American Economic Review* 48: 261-97.

Nelson, R. R. (1999). The simple economics of basic scientific research, *Journal of Political Economy* 49, 297-306.

OECD. 1995. *Venture capital in OECD countries*, Paris: Organization for Economic Cooperation and Development.

Opler, T. C., & Sheridan, T. (1994). Financial distress and corporate performance, *Journal of Finance* 49(3), 1015-40.

Pugh, W. N., John, S. J. Jr., & Sharon, O. (1999). ESOPs, takeover protection, and corporate decision making, *Journal of Economics and Finance* 23(2), 170-83.

Rausch, L. M. (1998). *Venture capital investment trends in the United States and Europe,* Washington, DC: National Science Foundation Division of Science Resource Studies Issues Brief 99-303.

Romer, P. M. (1996). Increasing returns and long run growth, *Journal of Political Economy* 94(5), 1002-1037.

Scherer, F. M. (1998). The size distribution of profits from innovation, *Annales d'Economie et de Statistique* 49/50, 495-516.

Schumpeter, J. (1992). *Capitalism, socialism, and democracy*, New York: Harper and Row (reprinted 1960).

Williamson, O. E. (1998). Corporate finance and corporate governance, *Journal of Finance* 43: 567-91.

Zantout, Z. Z. (1997). A test of the debt monitoring hypothesis: The case of corporate R&D expenditures, *Financial Review* 32(1), 21-48.

Table 1: Venture Capital Disbursements by Stage of Financing (1996)

	United States	***Europe***
Total VC disbursements (millions $1996)	9,420.6	8,572.0
Share seed and startups	27.1%	6.5%
Share for expansion	41.6%	39.3%
Share other (incl. buyouts)	31.3%	54.2%

Source: Rausch (1998) and author's calculations.