ETLA
ELINKEINOELÄMÄN TUTKIMUSLAITOS
THE RESEARCH INSTITUTE OF THE FINNISH ECONOMY
Lönnrotinkatu 4 B 00120 Helsinki Finland Tel. 358-9-609 900
Telefax 358-9-601 753 World Wide Web: http://www.etla.fi/

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Lotta Väänänen*

AGENCY COSTS AND R&D:

EVIDENCE FROM FINNISH SMEs

* Lotta Väänänen, Etlatieto Oy, Lönnrotinkatu 4 B FIN-00120 Helsinki, E-mail: lotta.vaananen@etla.fi. This paper is a reduced version of the author's M.Sc. Economics Thesis at the Helsinki School of Economics.

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ABSTRACT: This paper examines empirically how firm ownership structure affects its research- and development (R&D) intensity. To begin with, a principal-agent problem created by the separation of the management of a firm (the agent) and its ownership (the principal) is reviewed, and prior empirical literature is looked at. We acknowledge that the empirical estimation of effects of corporate governance on firm's activities has various problems, and provide evidence that ownership structure is determined endogenously. Using a sample of around 600 Finnish SMEs, the results of the Tobit estimations of firm R&D show that 1) entrepreneur's ownership share has a U-shaped relation with a turning point at 51 percent, 2) employees' ownership share has an inverse U-shaped relation, with a turning point at 47 percent, 3) the presence of a venture capitalist is positively related to R&D intensity. The results from the Tobit regressions cannot be interpreted as conclusive evidence of the actual causality between ownership and R&D, because of the endogeneity of the ownership variables. Instrumental variable estimation is used to attempt to solve the problem. Unfortunately only weak instruments are found and the two-stage least squares method gives no significant results as the standard errors became large.

Key words: Ownership structure, R&D, agency costs, monitoring, SMEs

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TIIVISTELMÄ: Tutkimuksen tavoitteena on empiirisesti analysoida yrityksen omistusrakenteen vaikutuksia sen investointeihin tutkimus- ja kehitystoimintaan (T&K). Aluksi tarkastelemme kysymystä päämies-agentti mallin pohjalta ja käymme läpi empiiristä kirjallisuutta aiheen ympäriltä. Tiedostamme, että kysymyksen ekonometriseen analyysin liittyy ongelmia kuten omistusrakenteen endogeenisuus. Empiirinen analyysi perustuu noin 600:n suomalaisen pk-yrityksen kyselyaineistoon. Tobit-estimointien tulokset viittaavat siihen, että 1) yrittäjän omistusosuudella on U:n muotoinen yhteys yrityksen T&K intensiteettiin (alapiste 51%), 2) muiden työntekijöiden omistusosuudella on käänteisen U:n muotoinen yhteys yrityksen T&K intensiteettiin (yläpiste 47%), ja 3) riskisijoittajan omistuksella on positiivinen yhteys T&K intensiteettiin. Nämä estimoinnit eivät tosin anna näyttöä kausaalisuudesta, koska omistusrakenne määräytyy endogeenisesti. Omistusrakenteen instrumentointi ei kuitenkaan tuota merkitseviä tuloksia, koska instrumentit ovat heikkoja.

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1 Introduction

1.1 Objective of the paper

The objective of this paper is to explore both theoretically and empirically the relationship between firm ownership structure and its level of research and development (R&D) spending. Prior research shows that there exists an association between various forms of shareholder structures and innovative activity. However, most empirical studies of corporate governance suffer from a number of econometric problems, and the direction of causality can rarely be established.[1] This study uses an extensive sample of small and medium-sized Finnish firms (SMEs) [2] to empirically examine the issue. By attempting to take care of the econometric issues involved, its aim is to establish how agency costs arising from outside ownership are reflected on firm's decisions to invest in R&D.

1.2 Motivation for the study

The so-called "black box" view of the firm, where the firm is seen as one distinct entity making profit-maximising decisions, does not answer questions about how all the individual parts come together to maximise a common thing, when they all have different interests and incentives. When individuals act as managers, it is only fair to assume that they maximise their own utility. This idea is not new. Jensen and Meckling (1976) were among the first to generate a theory "which explains how the conflicting objectives of the individual participants are brought into equilibrium so as to yield a result."[3]

The association of ownership structure and R&D investments makes an interesting research question for several reasons. One is that agency costs are particularly high in R&D ventures due to the very nature of innovative activity. Investments into R&D have a long-term perspective with highly uncertain, unpredictable future cash flows, as well as a high risk of failure. Another reason why R&D is an interesting measure to analyse is its growing importance in many industries and its implications for economic

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1 See Chapter 3 for a review of literature.

2 Following the recommendation by the European Commission 96/280/EU, an SME is in this study defined as a firm that employs less than 250 people and that either has an annual turnover of at most 40 million euros or a balance sheet total of at most 27 million euros, and less than 25 percent of the shares are owned by large companies.

3 See Jensen and Meckling (1976, p.105).

growth. Thus it is interesting to study whether certain types of ownership structures, particularly in SMEs, are more favourable to providing incentives to undertake R&D.

1.3 Theoretical framework

Agency theory forms the framework for the theoretical analysis in this paper. The existence of a variety of agency conflicts within modern corporations has been widely documented in literature.[4] The most commonly cited agency relationship is that between the owners and the management of a firm. The separation of the management of a firm (the agent) and its ownership (the principal) typically leads to some divergence of interests between the two parties. Furthermore, the relationship between corporate insiders and outside shareholders is subject to information asymmetries. As a result, agency costs arise together with the need for contracting and monitoring to alleviate them. To the extent that neither contracting nor monitoring are complete, the managers' incentives are not fully aligned with those of the owners and thus the agency costs are reflected on decision-making in the company and its operations. Prior research provides evidence that one strategic decision that is subject to manager-stockholder conflicts of interest is a firm's corporate R&D strategy.

1.4 Focus of the study

The starting point in this paper is to determine, on the basis of the principal-agent theorem, how the separation of ownership and control might affect the firm's R&D orientation. More specifically, ownership is characterised by two types of insider ownership: the ownership share of the entrepreneur and the collective ownership share of the other employees, and the level of monitoring exerted on the management. The reasons why a firm's ownership structure may have implications for its R&D investments arise from the nature of these investments. For one, due to the high agency costs inherent in R&D, ownership structures that minimize these costs are likely to be more conducive for R&D. Secondly, R&D investments involve high levels of risk, and managers may have different attitudes towards risk from those of entrepreneurs.

The empirical part of this paper tests how the ownership share of the entrepreneur and the collective ownership share of the other employees affect firm R&D, using a

[4] See, for example, Kaplan and Strömberg (2001).

survey data set of about 600 Finnish SMEs.[5] The main explanatory variables under scrutiny are three ownership variables: 1) The proportion of shares held by a principal owner who has an active role in guiding the firm's operations (later referred to as the ownership share of the entrepreneur). 2) The proportion of shares collectively held by employees of the firm, other than the entrepreneur. 3) The presence of a venture capital as one of the firm owners.

1.5 Structure of the paper

The paper is structured as follows. Section 2 takes a look at agency theory from two perspectives. First, the existence of agency costs and factors affecting their magnitude are examined. Contracting and monitoring costs particularly related to R&D ventures are also looked at. This leads us to examine how a firm's ownership structure, and more specifically the ownership share of insiders, affects a firm's R&D intensity. Section 3 presents a review of literature in the empirical research on corporate governance and econometric issues involved in it. Section 4 summarises the lessons from agency theory combined with findings from empirical research, and defines the hypotheses for this study. Section 5 presents the empirical analysis. The first part presents sample characteristics (section 5.1), describes the measures of ownership (section 5.2) and provides a descriptive analysis (section 5.3). The second part describes the econometric methods used and presents the regression results. In section 5.4, Tobit regressions are run to estimate firm's R&D. In section 5.5, endogeneity of the ownership structure variables is tested for and instrumental variable (IV) estimation is used to attempt to control for endogeneity. Section 5.6 summarises and discusses the results of the empirical analysis. Section 6 concludes.

[5] The data has been kindly provided by the Research Institute for the Finnish Economy (ETLA), and Etlatieto Oy. For detailed description of the survey, see Hyytinen and Pajarinen (2002).

2 Agency Theory

The existence of a variety of agency conflicts within modern corporations is widely documented in literature. The most commonly cited agency relationship is that between the owners and the management of a firm. The separation of the management of a firm (the agent) and its ownership (the principal) typically leads to some divergence of interests between owners and insiders, which is reflected on decision-making in the company and thus its operations. Prior research also provides evidence that one strategic decision that is subject to manager-stockholder conflicts of interest is a firm's corporate R&D strategy.[6] Already Jensen and Meckling (1976) stated that:

> "Indeed, it is likely that the most important conflict arises from the fact that as the manager's ownership claim falls, his incentive to devote significant effort to creative activities, such as searching out new profitable ventures, falls. He may in fact avoid such ventures simply because it requires too much trouble or effort on his part to manage or to learn about new technologies. Avoidance of these personal costs and the anxieties that go with them also represent a source of on the job utility to him and it can result in the value of the firm being substantially lower than it otherwise could be."[7]

This chapter begins with a review of the Jensen and Meckling (1976) paper. Agency costs of equity and debt are discussed, and what affects their magnitude. That leads us to examine the nature of R&D activities, and to show that agency costs are particularly high in innovative ventures and that contracting and monitoring is difficult. Thereafter, the different incentives of managers and entrepreneurs to invest into risky projects are discussed, and venture capital is reviewed in the context of monitoring. To end the chapter, a principal-agent model is presented, determining the effort being put into R&D investments by entrepreneurs versus managers.

2.1 Agency costs

The seminal paper building the theory of the financial structure of the firm as a function of agency costs is that of Jensen and Meckling (1976). Their paper is one of the most cited papers in financial economics,[8] and it was one of the first theories opening the

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6 See, for example, Francis and Smith (1995) and Czarnitzki and Kraft (2002).

7 Jensen and Meckling (1976, p.111).

8 See Journal of Financial Economics, http://jfe.rochester.edu/allstars.htm. With over 100 citations per year, it is by far the most cited of the JFE article.

"black box" of the firm and explaining how the conflicting objectives of the individual participants are brought into equilibrium so as to yield a result. The notion of utility maximising behaviour on the part of all individuals forms the basis for their analysis. They define an agency relationship as

> "a contract under which one or more persons (the principal(s)) engage another person (the agent) to perform some service on their behalf which involves delegating some decision making authority to the agent."[9]

2.1.1 Agency costs of equity

2.1.1.1 How agency costs arise

The starting point is to take a firm fully owned by an entrepreneur who also manages the firm. In managing the firm the entrepreneur makes operating decisions, which maximize his utility. These decisions involve not only the benefits he derives from pecuniary returns but also the utility generated by various non-pecuniary aspects of his entrepreneurial activities. The optimum mix of the various pecuniary and non-pecuniary benefits is achieved when the marginal utility derived from an additional dollar of expenditure is equal for each non-pecuniary item and equal to the marginal utility derived from an additional dollar.[10] One way the non-pecuniary benefit can be seen as the utility from "free time" generated from exerting less effort.

If the entrepreneur sells equity claims on the corporation, agency costs are generated by the divergence between his interest and those of the outside equity shareholders, since he will then bear only a fraction of the costs of any non-pecuniary benefits (reduced effort, free time) he takes out in maximizing his own utility while enjoying their full benefit alone. As the entrepreneur's share of the equity falls, his fractional claim on the outcomes also falls and this tends to encourage him to reduce the effort put into the management of risky ventures.[11]

Jensen and Meckling (1976) show that the value of the firm is lower when outside equity is involved than when it is 100 percent owned by the entrepreneur due to the presence of the agency costs described above. Similarly, they show that the optimal investment when the entrepreneur holds less than 100 percent is lower than in the case

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9 Jensen and Meckling (1976, p.106).
10 Jensen and Meckling (1976 p.110).
11 This could be seen as a reduced R&D intensity of the firm, which is the focus of this study.

where the firm is fully owned by him had he enough personal wealth to finance that level of investment.

2.1.1.1 Monitoring

The entrepreneur's behaviour can be influenced by expenditure of resources on monitoring activities by the outside shareholders. Jensen and Meckling go on to show that the entrepreneur bears the entire wealth effects of these costs so long as the equity market can correctly anticipate them. The lower the entrepreneur's ownership share in the firm, the greater the need to monitor his behaviour, and the more the outside equity holders need to spend resources on monitoring. Thus the wealth costs to the entrepreneur of obtaining additional funds in the equity markets rise as his ownership share falls.

Including the potential for controlling the behaviour of the entrepreneur through monitoring, Jensen and Meckling show that the value of the firm is higher as the monitoring can, to some extent, control the effort put in by the manager. The entrepreneur is willing to enter into this contract because it results in a rise in the firm's value, and the entire increase is reflected in the entrepreneur's wealth. His welfare increases by less than this because he forgoes some pecuniary benefits he previously enjoyed. With monitoring and/or contracting, the optimal level of investment, as well as the firm value, are greater than without them.

2.1.2 Agency costs of debt

Although debt financing does not dilute the manager's ownership stake, and therefore does not encourage him to increase the consumption of perquisites because he bears the full costs these,[12] debt financing also suffers from agency costs. With debt financing, the entrepreneur may have an incentive to engage in activities, which promise very high pay-offs if successful even if they have a low probability of success. If they succeed, the entrepreneur captures most of the gains, and if they fail, the creditors bear most of the costs due to the entrepreneur's limited liability.

Jensen and Meckling show that if the owner has the opportunity to first take sell bonds, and then to decide on the variance of the returns in the investments to make, there is a potential moral hazard problem. By promising to take a low variance project, selling bonds, and then taking a high variance project the entrepreneur can transfer

[12] See Hart (2001).

wealth from the bondholders to himself as equity holder. The value of equity in the low variance project is less than that in the high variance project, and conversely, the value of debt in the low variance project is more than that in the high variance project. However, as the debt market correctly anticipates this effect, it is built into the cost of obtaining debt.

Jensen and Meckling also argue that it is possible for bondholders, by the inclusion of various covenants in the indenture provisions, to control the managerial behaviour to some extent. In fact, the manager has an incentive to voluntarily provide information such as financial statements to enable the monitoring of his behaviour. This is because (as with the agency costs of equity) the entrepreneur bears the entire wealth effects of the agency costs of debt and he also captures the gains from reducing them.

In addition to the above mentioned moral hazard problem, Jensen and Meckling state that the costs of bankruptcy are of concern to potential buyers of fixed claims in the firm. The existence of these costs reduces the payoffs to the lender in case of bankruptcy. The cost of obtaining debt is directly related to the probability of the incurrence of bankruptcy costs. Once again, it can be shown that the owner-manager bears the entire wealth effect of these costs as long as potential bondholders can estimate the magnitude of them.

2.2 Agency costs and R&D

In an R&D intensive firm, the asymmetry of information between insiders and outsiders is prominent and the agency costs are high.[13] R&D activity is subject to high agency costs because of the very nature of innovation activities. Investments into R&D have a long-term perspective with highly uncertain, unpredictable future cash flows, as well as a high risk of failure.

Holmström (1989) discusses how preference incongruities in the principal-agent relationship can have consequences for investment incentives. For one, the effort put into R&D by the agent is largely unobservable (although the amount invested in R&D is known) and thus it cannot be compensated directly. Compensation contracts cannot be designed in terms of the effort (as would be optimal) but have to be based on what is observable. Holmstrom asserts that such incentive schemes introduce risk preferences

[13] See Gompers and Lerner (1999 Chapter 6.) and Holmström (1989). Gompers (1995) shows that agency costs increase as assets become less tangible, growth options increase, and asset specificity rises, all of which are characteristic of R&D intensive firms.

for the agent, as a result of which the agent may be risk-averse while the principal is risk-neutral. Monitoring R&D activities is also difficult and costly, and thus reduces the extent to which monitoring can alleviate the agency costs involved.

2.2.1 Contracting

Contracting is difficult and contracting costs are particularly high in R&D contracts because of the innate characteristics of innovation, its long-term nature, high risk, and unpredictability, as well as its labour-intensity. Contracting is necessarily incomplete, since effort is largely unobservable and cannot be fully contracted for, and because uncertainty is present and the contract cannot be specified for all contingencies.[14]

The nature of inventive activity has consequences for the kind of executive performance measures and compensation design that are appropriate, yet the design of effective incentive contracts is difficult. If managers are to commit to a high R&D strategy, they need to be rewarded for acting that way. Compensation depending on short-term bonus plans tied to current earnings may discourage investments in innovation, and several authors make the same claim.[15]

2.2.2 Monitoring

Monitoring or other mechanisms that exert control on the management can also be used to reduce the agency costs.[16] Monitoring is typically more persistent in companies where there is a large shareholder present, who has sufficient interest in the company to undertake the monitoring activity (which involves costs). Venture capital finance is characterised by extensive monitoring mechanisms and thus is suited for financing R&D intensive firms.[17] On the other hand, monitoring is not expected to facilitate innovation in diffuse-held companies, because of the commonly cited free-rider problem of small shareholders giving them less of an incentive to monitor.

As with compensation contracting, the traditional measures used to monitor executive performance are difficult to adapt to long-term R&D investments. Financial

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[14] See, for example, Hart (2001) and Holmström (1989). See also Kaplan and Strömberg (2002) for a review of contracting between entrepreneurs and venture capitalists.

[15] For example, Bhagat and Welch (1995, p.448) say that "If managers are compensated only through salary, their incentives are similar to those of bondholders, that is, favor low-risk, short-term projects over high-risk, long-term projects such as R&D."

[16] Bhagat and Welch (1995, p.448) also note that "monitoring by blockholders, and the discipline imposed by the managerial labor market and the corporate control market will align management incentives. Hence, management compensation contracts and firm ownership contracts have the potential to influence R&D expenditures."

[17] See Gompers and Lerner (1999, Chapters 6-9).

measures of output, such as current earnings, in corporate control mechanisms are not suited for monitoring R&D intensive firms. Monitoring needs to be more close-up and face-to-face, like venture capitalists paying regular visits to the firm, taking a seat on the board, etc. Nevertheless, monitoring of highly R&D intensive firms is necessarily incomplete, as the actions and effort are not easily observable.

2.3 Ownership Structure and Agency Costs

2.3.1 Optimality of ownership structure

Although agency costs will be incurred by the separation of ownership and control, and although monitoring and bonding activities take place, they are expected to satisfy the conditions for efficiency. Whatever the firm's ownership structure, it is expected to be one that maximises the returns to the shareholders of the firm, if it has been brought about by them.[18] Only relative to an ideal case of zero agency costs would this be inefficient. Since agency costs are fully born by the entrepreneur, he has the incentive to minimize them. Furthermore, agency costs will only be incurred if the benefits from their creation outweigh the costs. The benefits can be, for example, profitable investments made possible by outsiders' capital investments that exceed the entrepreneur's personal wealth. Similarly, the entrepreneur can gain benefits from diversifying his wealth, especially if the firm's investments are risky and long-term in nature.

If the entrepreneur does not raise capital he will suffer an opportunity loss represented by the increment in value offered to him by the additional investment opportunities. Thus, even though he will bear the agency costs of external financing and related monitoring, he will find it desirable to obtain additional capital as long as the marginal wealth increments from the new investment projects are greater than the marginal costs of either debt or equity. The choice between debt and equity depends on their relative marginal costs.

Even in large companies characterised by high levels of external financing, it is beneficial that managers also hold some ownership stake in the firm to reduce the potential agency conflict and align the interests of shareholders and managers. This is especially the case in R&D intensive companies. The presumption underlying here is that

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[18] See Jensen and Meckling (1976, p.124).

there is a positive relationship between insider equity ownership and corporate risk-taking, including R&D investments.[19]

2.3.2 Consideration of risk

The consideration of risk needs to be incorporated into the analysis of agency costs and R&D. For one, it is often claimed that the principal and the agent may have different attitudes towards risk, which may affect the way the firm is run. The typical assumption is that the principal is risk-neutral as his wealth is optimally diversified. The agent is assumed to be risk-averse due to private costs associated with failure, for example the possibility of being dismissed.[20] He alone bears these private costs, while his benefits from the success of risky ventures are limited. Thus he may have an incentive to avoid risky strategies in order to reduce the risk of failure, and his investments into highly uncertain projects may be less than would be optimal from the principal's point of view. However, it could also be assumed that the entrepreneur is risk-averse. Particularly, if practically his whole wealth is invested in the firm and is not diversified optimally. However, the entrepreneur has limited liability and this should affect his risk-taking the opposite way.

2.3.2.1 Managers' incentives and attitude towards risk

Factors expected to influence the behaviour of managers include the nature of their wealth portfolios and the pecuniary and non-pecuniary benefits and costs that they derive from their positions. When corporate insiders lack appropriate incentives, they may reduce corporate risk-taking in order to lower the personal costs of such decisions. Included among these costs are the potential loss of employment, the extra effort required to master new technologies or manage new ventures, and the anxieties inherent in high-risk corporate undertakings.

Holmstrom (1989) discusses how the source of funds, the amount of capital, and the terms on which these are made available, all influence the operation of the firm and the behaviour and prospects of its members. He describes how the division of owner-

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[19] Hart (2001 p.7) questions the relevance of financial structure in solving the agency problem and argues that the best way to deal with it is to put the agent on an optimal incentive scheme. Optimal management compensation contracts are out of the scope of this study. For one, the empirical data does not allow us to identify other aspects of management compensation than the ownership share. Secondly, compensation plans such as options and bonuses are likely to be less important in private SMEs than in large publicly traded companies, and this justifies the focus on ownership shares (See Bitler et al (2002)).

[20] See Jensen and Meckling (1976), Holmstrom (1989), and Czarnitzi and Kraft (2002).

ship between insiders and outsiders together with the extent of shareholder monitoring, have an impact on how the business is run, particularly its innovative activities. He presents reasons why reputation concerns may lead to managerial conservatism and why the problem can be expected to be more severe for large firms. For one, the market learns from a firm's past what to expect from it in the future, and the management can make decisions that influence perceptions about the firm's potential. They may tend to act myopically, since by choosing projects with faster paybacks, firm maintains its current returns and this raises expectations. Holmstrom claims that larger firms are likely to be less innovative because they are more often publicly traded and subject to constant monitoring from the markets. Market monitoring is based on observable output measures such as profit, etc. Since the actual actions of the management cannot be observed, the fall in current returns due to R&D investments may not be perceived favourably by the market.[21]

2.3.3 Venture capital and monitoring

Firms that are R&D intensive, young, have high future growth rates and typically negative current cash flows are subject to high agency costs. Venture capitalists (VCs), due to their specialised monitoring mechanisms, are able to finance these kinds of firms with high agency costs. The mechanisms that venture capitalists use to mitigate agency conflicts among entrepreneurial firms and outside investors have been explored in depth in a series of theoretical studies. These relate to the active monitoring and advice that is provided, the screening mechanisms employed when choosing investments, the staging of investment, and the wide-spread use of stock options and grants in management compensation.[22] Firms with venture capital finance are able to maintain high R&D intensities due to the monitoring that reduces the potential for moral hazard and other sources of agency costs. Gompers and Lerner (1999) provide empirical evidence that

> "venture capitalists concentrate investments in early stage companies and high technology industries where informational asymmetries are significant and monitoring valuable".[23]

When the venture capitalist provides finance for the firm, and the management of the company decides on the use of it, it is a principal-agent relationship with a potential

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21 Mueller and Spitz (2002) also find that risk-aversion of managers and signalling of firm quality lead to a non-linear relationship between managerial ownership and the risk exposure of the firm.

22 See Gompers and Lerner (1999, Ch 6. p.130), and Gompers (1995).

23 See Gompers and Lerner (1999, Ch 6. p.132).

moral hazard problem.[24] The venture capitalist employs a variety of control measures to address this problem.[25] Management employment contracts can be designed so that they generate appropriate incentives. The venture capitalist also actively participates in managing the firm, and pays a large number of visits to the company. The VC is typically represented on the board of the firm, having normally one third of the seats. The financing is normally provided in stages, so that the VC can observe the progress of the firm (and the product) before deciding whether to continue investing in it. According to Holmstrom, VC finance suits early-stage companies and once the initial high asymmetries have been reduced, the market can take over the role of monitoring.

2.3.4 Endogeneity of ownership structure

The issue under study is complicated by possible reverse causality running from firm's R&D orientation to its ownership structure, where there are counteracting effects taking place. Firstly, more R&D intensive firms are likely to face higher external financing needs, and when resorting to external financing, equity financing is likely to be favoured. Agency costs are presumably higher with debt, and firms may face difficulties in obtaining it due to the intangible nature of assets. Secondly, since more R&D intensive firms are likely to be more risky, there may be an incentive for entrepreneurs to seek more external equity financing in order to be able to share risk and diversify their own wealth portfolios. Both of these reasons imply that higher the firm's R&D intensity, the more external equity financing it will resort to. However, perhaps the most important effect in light of this study is that agency costs of R&D are taken into consideration when choosing the way the firm is owned and financed, as these costs enter into the costs of financing.[26] Due to high agency costs, entrepreneurs of highly R&D intensive firms are likely to keep high shares of ownership. Thus this is an opposing effect to the above-mentioned need for external financing and need for risk-diversification.

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[24] Gompers and Lerner (1999 Chapter 6.) claim that entrepreneurs might invest in strategies, research, or projects that have high personal returns but low expected monetary pay-offs to shareholders, that they have incentives to pursue high-variance strategies, or that they may want to keep the company going simply because they receive significant private benefits from managing their own firm.

[25] See Gompers (1995).

[26] Jensen and Meckling (1976).

3 Review of Empirical Literature

This chapter reviews a number of empirical corporate governance studies that deal with agency costs of external financing and how they are reflected in firms' operations. First, a study on the existence of agency costs is looked at. Thereafter, we review a number of studies showing how firm ownership structure affects firm performance. Ownership structure and innovation is a less researched topic, and we review two studies under this heading, paying attention to how ownership structure is measured in order to draw some lessons for how to define ownership variables in this paper. Finally, the econometric problems that arise in corporate governance studies are looked at, and the above-mentioned studies are analysed with respect to how they take care them.

3.1 Existence of agency costs

As described in the previous section, Jensen and Meckling's (1976) seminal paper on agency costs and the theory of the firm provides an examination of how agency costs arise from both outside equity and debt financing, and how they can be reduced by activities that exert control over the agent. Ang et al. (2000) use a sample of 1708 small corporations to empirically examine the existence of agency costs. They find evidence for them, and provide confirmation of the predictions made by Jensen and Meckling. Their study provides measures of agency costs for SMEs by comparing two efficiency ratios of firms,[27] to the zero agency cost base case, which is a firm owned solely by a single owner-manager. They find that agency costs: 1) are significantly higher when an outsider rather than an insider manages the firm, 2) are inversely related to the manager's ownership share, 3) increase with the number of non-manager shareholders, and 4) to a lesser extent, are lower with greater monitoring by banks. However, they make no attempt to control for the endogeneity of the ownership structure.

3.2 Ownership structure and firm performance

Most of the empirical research on corporate governance deals with the relation between firm ownership structure and performance. The methods used vary, for example some

[27] The two efficiency ratios they use are operating expense/annual sales and annual sales/total assets of the firms.

attempt to control for the potential endogeneity of ownership structure while others do not. The results from these studies vary too. Below, I will discuss some of the most recent papers, which devote significant efforts to solving the endogeneity of ownership.

Demsetz and Villalonga (2001) show that once controlling for the endogeneity of ownership structure, no relationship is found between management shareholdings and firm performance measured by accounting profit.[28] They have a 223-firm sample of large firms, and they use a simultaneous equation model to explain firm performance measured by Tobin's Q, and the fraction of shares owned by management. They also make ownership multi-dimensional and include the ownership share of the five largest shareholders in explaining firm performance, but they do not control for its potential endogeneity. They state that the fact that no relationship exists is consistent with the notion that market responds to forces that create suitable ownership structures for firms. The robustness of their results is checked using other measures of performance and allowing for non-linearities.

Other studies have found that there does exist a relationship. Cui and Mak (2002) find that Tobin's Q has a W-shaped relationship with managerial shareholdings, initially declining with increasing ownership, then rising, declining and finally rising again. They choose a sample of high R&D firms that are listed on the NYSE, AMEX and NASDAQ, by ranking industries by their R&D expenditure and choosing the top seven industries. They use three proxies for managerial ownership: total ownership by directors and management, ownership by the CEO, and average individual managerial ownership. Using two-stage least squares (2SLS) regression, where predicted managerial ownership is obtained in the first stage, they control for its endogeneity and their results remain. They do a Hausman test and in fact find that there is no endogeneity.

Anderson and Reeb (forthcoming) study whether founding family ownership affects firm performance in large public firms, using a sample of firms from the S&P 500. Their estimations are based on a panel of 2713 observations on 403 non-utility/non-banking firms (1992-1999). They discuss both potential costs and benefits of family ownership, one potential benefit being that "families potentially have longer horizons than other shareholders, suggesting a willingness to invest in long-term projects". Using a dummy variable indicating the presence of founding family in the firm, they find that these firms perform better. Using a continuous ownership variable and its square, they find that performance first increases as family ownership increases up to about 60 per-

[28] They also provide a survey of the post 1985 empirical research on ownership structure and firm performance.

cent but then decreases with increasing family ownership. Their performance measures are Tobin's Q and return on assets (ROA). They acknowledge that their analysis potentially suffers from an endogeneity problem. They instrument for family ownership using firm's size and its square, as well as firm's monthly stock return volatility as a measure of risk. They use instrumental variable regressions, and their results are consistent with their OLS results. They do a number of robustness checks and find that their results are robust to various alternative specifications.

Mueller and Spitz (2002) examine the investment and entrenchment effects of managerial ownership in a sample of small and medium-sized firms in the German business-related service sector. The data originates from a quarterly survey. Their estimations are based on a panel data of 2797 observations on 1351 firms (1997-2000). They discuss potential sampling biases and say that they are unlikely to be a problem. They find that increasing managerial ownership up to around 80 percent has a positive impact on firm performance, then the effect becomes negative. They also find that firms perform better when fewer managers with ownership stakes are involved. This could be because it may be more difficult for more managers to come to an agreement, and because the incentive for a single manager is lower. They use lagged specifications in fixed effect estimation as well as a General Method of Moments (GMM) estimator, and the inverted U-shaped relation remains in both specifications. They acknowledge the endogeneity of ownership structure and investigate also the determinants of managerial ownership. They find that ownership share first decreases with risk and then increases, finally decreasing again. They also simultaneously determine managerial ownership and firm performance using a three-stage least squares regression method. This instrumental variable method takes into account the potential endogeneity of managerial ownership as well as that of firm performance. The results from all the methods they use come to the same conclusion.

3.3 Ownership structure and innovation

Empirical research on the effects of firm ownership structure on firm's R&D investments is more limited than work on its effects on firm performance. Francis and Smith (1995) is one study looking at ownership structure and innovation. Using various measures of innovation, they find that diffusely held firms are less innovative than firms with either a high concentration of management ownership or a significant equity block held

by an outside investor.[29] Diffusely-held firms have fewer patent awards, tend to grow by acquisition rather than internal development, and tend to increase their R&D spending in economic upturn while decrease in the downturn.[30] They try to control for the endogeneity of ownership but their attempts to control for the determinants of ownership structure identified in prior research are largely unsuccessful. Thus they make no inferences about the direction of causality.

Czarnitzki and Kraft (2002) empirically examine the relationship between insider ownership and innovation, and in fact find a negative significant relationship. They use a panel of 3000 observations on 1715 innovating firms.[31] They use Tobit regressions to estimate firm's R&D/sales, and their results show that owner-led firms, as well as management-led firms with large capital owners have less expenditure for R&D than other firms.[32] They make attempts to control for the endogeneity of ownership structure by using lagged ownership variables, and by also running instrumental variable regressions. Their results are consistent with no evidence for its endogeneity.

Baldwin et al. examine the relationships between financial structure, R&D intensity and innovation. They find that firms that devote much of their investment expenditure to R&D also exhibit less debt-intensive financial structures. Using simultaneous equations, they also find that debt-intensive financial structures also constrain investments into R&D.[33]

3.3.1 Measures of ownership used in prior studies

A brief discussion of the measures of ownership structure used in the above two studies is given here. Francis and Smith (1995) categorise firm ownership into four different types, reflecting different degrees of agency costs and monitoring activity. One is a diffusely-held firm, one is a CEO-held firm (CEO and his family own at least 30 percent of the voting stock), one is a management-owned firm (CEO and his family own less than 5 percent and the management as a group own at least 20 percent), and the last is an outsider-held firm (CEO and his family own less than 5 percent and a small group of

[29] The measures of ownership used in prior studies will be briefly discussed below.

[30] They argue that the managers of diffusely-held firms are more concerned about the current returns of the firm and thus take actions that aim to maximise those.

[31] From the German Community Innovation Survey (CIS).

[32] See Czarnitzki and Kraft (2002 p.11). They reason their (somewhat surprising) results by claiming that although managers "get punished for insufficient profits by a dismissal, on the other hand they get a reward for high growth rates via increased salaries", i.e. they argue that the positive incentive effect of firm size (reflected in salaries) dominates the negative incentive effect of risk.

[33] Berger and Bonaccorsi di Patti (2002) study how capital structure affects firm performance using simultaneous equations to estimate the two. They acknowledge that ownership variables need to be controlled for, but do not account for their endogeneity.

outside investors owns at least 20 percent). Czarnitzki and Kraft (2002) differentiate between a managerial-led and an owner-led firm, and the degree of control exerted on management by outside shareholders. They use a Herfindahl index of the concentration of owners' shares, and a dummy variable equal to one if the managers hold any shares. Their owner-led firm is one in which managers have any ownership stake in the firm. The second type is one where there is a strongly controlled manager, i.e. managers have no ownership but ownership is concentrated to few shareholders that have the ability to control the management. Their third type is on where there is little control on management, and management holds no shares of the firm.

3.4 Econometric issues

Börsch-Supan and Köke (2000) discuss four categories of econometric problems that must be solved in order to infer causal effects of corporate governance: reverse causality, missing variables, sample selectivity, and measurement error in variables. They also provide methodological lessons for future empirical research on how these issues can be overcome. They discuss these issues with reference to studies that explain firm performance, but they are similarly applicable to explaining firm R&D.

The first issue that Börsch-Supan and Köke discuss is structural reverse causality. In the context of this study it would mean that firm's R&D intensity affects its ownership structure. It is sensible to expect that R&D-intensive firms need and attract external equity financing, particularly venture capital. They also bring up a similar problem, spurious correlation, which occurs when an unobserved variable simultaneously determines a firm's ownership structure and its R&D. For example, the entrepreneur's personal wealth may affect both his ownership share in the firm as well as the level of R&D (or risk) he is willing to take. Both of these are cases where ownership structure and firm R&D are co-determined, and thus ownership structure is endogenously determined. Recent corporate governance research acknowledges that ownership structure should be treated as an endogenous variable.[34] As seen above, some studies attempt to control for its endogeneity while some do not. The lessons from Börsch-Supan and Köke are that panel data is necessary to provide the instruments that are needed in these types of stud-

[34] See, for example, Francis and Smith (1995), Demsetz and Villalonga, Mueller and Spitz (2002), Bitler at al. (2002), Berger and Bonaccorsi di Patti (2002), Baldwin et al. (2002), Czarnitzki and Kraft (2002).

ies, and that collecting time-series information on all relevant variables is needed to reduce the endogeneity caused by unobserved common factors.

In addition to the problem of endogeneity, sample selection can be a problem in these studies. Selecting the sample on the basis of an endogenous variable can cause biased estimates. For example, using a sample limited to the largest, listed firms in performance studies causes sample selection bias. Cui and Mak (2002) and Demsetz and Villalonga (2001) both use a sample of publicly listed, large firms, which is very likely a cause for sample selectivity and biased estimates. Both, Czarnitzki and Kraft as well as Francis and Smith, limit their sample to firms that come from industries that have some (arbitrarily chosen) level of R&D intensity or similar measure of innovative activity.

Omitting key explanatory variables is also a common cause of bias in empirical corporate governance studies. In view of this study, characteristics related to the entrepreneur are likely to affect firm's R&D intensity but these are usually not observed.[35] Börsch-Supan and Köke also emphasise that empirical studies should allow for a non-linear influence of ownership by including it in linear and quadratic form[36] and identify and include all the relevant corporate governance mechanisms. The entrepreneur's wealth is probably one of the most important variables that are typically omitted due to lack of data. Bitler et al. (2002) study the entrepreneur's ownership share in private small businesses and have a set of variables on the entrepreneur, including his wealth. They show that many of the entrepreneur variables are significant in explaining ownership.

Finally, Börsch-Supan and Köke note that measurement error in variables can bias estimation results, and say that particularly measures of competition and measures of ownership structures are likely to suffer from this. They recommend using a range of measures to check the robustness of the estimation results.

3.4.1 Literature on ownership structure

A brief look at the literature on firm ownership structures provides us with a set of variables that need to be included in estimating it later in the first stage of the IV estimations. Firm size and firm risk are the two variables that appear in (almost) all studies.

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35 In this study, characteristics of the entrepreneur are not observed. The survey however provides information on the firm's CEO, such as his experience and education. These are included in the R&D estimations but do not become statistically significant.

36 This is taken care of in this study.

Most of the studies show that riskiness of the firm affects its ownership and financial structure, that is, both its leverage and the distribution of shares between insiders and outsiders. Demsetz and Lehn (1985) present results that risk is related to firm ownership structure. All of their measures of profit instability are positively related to ownership concentration while the squared values of these variables are negatively related to ownership concentration. Mueller and Spitz (2002) also provide support for the notion that risk is a significant factor affecting firm ownership.

Demsetz and Villalonga (2001) use firm size, its debt to assets ratio, two measures of risk, a measure of performance, and industry dummies to explain management ownership. Their results show that management holds smaller shares of equity in larger firms, and also that market risk has a positive effect on the fraction of shares owned by management. Cui and Mak (2002) include firm's lagged R&D intensity, in addition to the variables used by Demsetz and Villalonga. They find that lagged R&D intensity is negatively related to the total managerial ownership but its square is positively related (a U-shaped relationship).[37]

[37] This is an indication of likely structural reverse causality in the model to be estimated in this paper.

4 Hypotheses

The theoretical analysis and review of prior literature has helped us determine several potential effects of ownership structure on firms' R&D intensity. It has also shown that there are possible reverse effects of firm's R&D intensity affecting the way the firm is owned. In this section, these are summarised to help us formulate the hypotheses to be tested for in this study.

It was seen that agency costs arise from the separation of ownership and control. These in turn can hinder the R&D intensity of a firm, an activity particularly prone to high agency costs and difficulties in exerting control. Higher shares of entrepreneur ownership keep the agency costs low compared to a high degree of separation or diffuse ownership. The need for monitoring, which is costly for R&D firms, is also lower the higher the insiders' ownership share. Thus high levels of insider ownership should be optimal for high R&D firms. However, given that external financing is required, high monitoring is needed and venture capital finance should be more conducive for R&D. Based on the anticipated effects of insider shareholdings, both entrepreneur and employees, and of the presence of venture capitalist monitoring, on firm's R&D intensity, the three hypotheses discussed below are formed.

It could be argued that firm's R&D intensity does not reflect the agency costs of separation of ownership and control, because R&D intensity is directly observable and verifiable by the owners. Possibly, agency costs would be better reflected in the outputs of innovation, or rather, the efficiency of firm's R&D investments. However, the cross-sectional data does not allow us to observe innovation outputs due to the time lag necessary for R&D to be turned into innovation. However, it is justifiable to assume that R&D intensity reflects agency costs, because high agency costs imply that it would not be optimal for the shareholders to make the firm commit to a high R&D strategy. The potential for managers to behave contrary to the shareholders benefit is higher in R&D activities where their effort is not observable.

4.1.1 Entrepreneur's ownership share and R&D

Based on previous research and lessons from agency theory, the main hypothesis in the paper is that there is a positive association between the proportion of shares held by the entrepreneur and the level of R&D. One reason for this is that the higher the share of the returns to be captured by the entrepreneur (i.e. higher his ownership share), the more effort he is willing to put into the management of complex R&D projects. Secondly, as-

suming risk-neutrality of the entrepreneur, he does not have a negative incentive to put effort into R&D due to risk considerations.

Higher shares of entrepreneur ownership keep the agency costs low relative to high degree of separation or diffuse ownership. The lower the agency costs, the higher the incentive to undertake R&D. The first hypothesis is that:

- Increasing the share of entrepreneur's ownership is positively related to R&D intensity.

4.1.2 Employees' ownership share and R&D

The second hypothesis is that employees' collective ownership share is positively related to firm's R&D intensity but not necessarily in a linear fashion. Risk-aversion might be a relevant assumption for a manager with some ownership, as he has no control and faces private costs related to the risk of the operations he manages, for example the threat of dismissal in case of failure. Thus although high ownership has a positive incentive effect, the increased risk can have a negative effect.

Higher shares of employee (manager) ownership keep the agency costs low relative to a high degree of outsider ownership.[38] The incentive to undertake R&D depends on how the managers' compensation is tied to the profits of the firm (ownership share) and the variance of the expected profits i.e. reflected by risk of R&D investments. The second hypothesis is, therefore, that:

- Increasing the share of employees' ownership is positively related to R&D intensity. At high levels of ownership, the relationship may turn negative due to the effect of increasing risk.

4.1.3 Monitoring by a venture capitalist

Prior research also indicates that the extent of monitoring activity by shareholders is positively related to the level of company R&D spending. Monitoring is expected to be higher when there is a presence of a venture capitalist owner. Venture capitalists are known for their extensive monitoring mechanisms, which alleviates agency costs. The higher the degree of monitoring, the higher will be the firm's level of investments into R&D. The third hypothesis is that:

- Venture capital ownership is positively related to R&D intensity.

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[38] It is not possible in this study to account for the potential agency conflict between the manager shareholders of the firm, as the number of managers holding shares in each case is not known.

4.1.4 Endogeneity of ownership structure

The reasons for suspected endogeneity of the ownership structure come from the theory of firm ownership structure that was described earlier.[39] The characteristics of R&D are shown to be particularly prone to high agency costs. Monitoring and contracting are costly because R&D investments have uncertain outcomes that are difficult to measure. Due to these particularly high agency costs, the optimal ownership structure of an R&D intensive firm could involve a higher ownership share of the entrepreneur than an otherwise identical firm. However, there are also two opposing effects running from R&D to ownership. A high R&D firm is likely to face more external financing needs and thus lead to a reduced ownership share of the entrepreneur. Similarly, a high R&D firm tends to be riskier, and thus makes it more optimal for the entrepreneur to seek external equity financing to diversify his own wealth. These factors may in fact imply higher shares of outside equity ownership in R&D intensive firms. What could also be expected is that an R&D intensive firm has a strong principal owner (even if it is not the entrepreneur), or alternatively a venture capitalist as a shareholder, as these types of concentrated ownership structures provide incentives to better monitor and thus should favour firms with high agency costs. These anticipated effects, through both risk diversification as well as agency costs, make it impossible to predict the direction of the relation but can be expected to be non-linear due to the opposing effects.

Thus, a high R&D firm is likely to be characterised by both, high insiders' ownership shares but also a presence of outsider equity for the reasons stated above.

[39] See Jensen and Meckling (1976).

5 Empirical Analysis

It has become evident from the theoretical discussion that theoretical analyses of corporate governance do not provide straightforward answers, due to too many counteracting mechanisms that are taking place. Although empirical studies have their share of econometric problems, they may help in determining the relative magnitude of the various effects, if endogeneity of the ownership structure is successfully controlled for. The empirical part of this study uses recently collected survey data on Finnish SMEs. The data contains detailed information on the ownership and financial structure of these firms, their R&D investments and various other firm characteristics. Thus the data set is rich with typically unpublished information on SMEs. In view of the research problem formulated here, the analysis of SMEs is particularly interesting. SMEs often have ownership structures characterised with high ownership shares of the entrepreneur.

Section 5.1 describes the survey data used. Section 5.2 introduces the ownership variables used in the consecutive analysis. Section 5.3 deals with a descriptive analysis of the types of ownership structures found in Finnish SMEs, and the distribution of these different types among firms of differing sizes, ages, industries and R&D intensities. Section 5.4 presents an econometric analysis testing for the effects of various ownership structure variables on the firm's R&D intensity. R&D intensity is regressed on the ownership variables while controlling for factors shown to be determinants of R&D in prior studies: industry, firm size, and firm age among others. The model is extended to incorporate other factors possibly affecting firms' R&D intensity, including variables related to its profits, growth orientation, export intensity, and the competitive pressure on the firm.

It has been acknowledged that the empirical study of the effects of the ownership structure on firm's R&D intensity suffers from serious econometric problems. For one, as already mentioned, ownership structure is most likely an endogenous variable, being affected by the firm's R&D intensity and thus the model is complicated by reverse causality. In section 5.5, the empirical analysis therefore goes on to attempt to account for the endogeneity of ownership structure by instrumental variable estimation. The ownership structure equations are formulated, and suitable instruments for each of the ownership variables are searched for. Section 5.6 summarises and discusses the results.

5.1 Data description

The data set utilised in this study originates from a survey administrated by the Research Institute of the Finnish Economy (ETLA) and Etlatieto Ltd, which was conducted between December 2001 and January 2002.[40] The survey respondents are representatives of active, for-profit, non-financial and non-agricultural corporations (excl. proprietorships, partnerships, and subsidiaries) registered in Finland. High-tech (NACE Rev.1: 244, 30, 321, 322, 353) and medium-tech (NACE Rev.1: 24 excl. 244, 29, 31, 323, 33, 34, 352) as well as information-intensive service (NACE Rev.1: 642, 721, 722, 73, 743) sectors were over-sampled. The over-sampled sectors account for 60% of the sample; the remainder consists of firms in basic manufacturing, services and trade.

It is worthwhile to note some results from prior studies concerning firm financial structure on this same data set. Hyytinen and Pajarinen (2002) report descriptive analysis of the financial structure of SMEs. They show that the capital structure of SMEs significantly varies with the size and age of firms, and find that the three most important sources of funds are the principal owner's equity, trade credit provided by non-financial firms and debt provided by financial institutions. Their analysis also offers interesting insights into the financing of innovative SMEs, which they show differs in various aspects from that of other SMEs. According to them, the evidence is consistent with the partially reversed pecking order in which equity is preferred to debt. For one, they show that R&D intensive and innovative firms exhibit lower debt ratios than others. They also provide evidence that the most important source of funds for innovative firms is equity attributable to the principal owner (unlike for their counterparts).

5.2 Measures of ownership

Our data enables us to determine various types of shareholders and their ownership shares in the firm. For the purpose of the econometric analysis, we construct three measures of ownership structure. The first measure is the ownership share of a principal owner that is active in the firm's operations and his family, referred to as the *entrepre-*

[40] The survey was conducted as computer-assisted telephone interviews carried out by Tietoykkönen Ltd. Initially 2600 firms were contacted. A response rate of 36 percent resulted in a sample of 936 firms, which was further refined by dropping out firms with inconsistent or missing replies to key questions concerning the firm financial structure. This resulted in a sample of 745 firms to be included in this study, although the number of firms in the econometric estimations falls to around 600 or less due to missing responses to important questions like the firm's R&D intensity.

neur's ownership share. The second measure is the *ownership share of employees*, i.e. the collective ownership share of the firm's employees, other than the entrepreneur. These two measures aim to capture the degree of agency costs arising from ownership of outsiders; the higher the ownership share of the entrepreneur (or alternatively the firm's employees), the lower the agency costs involved. The third measure of ownership is a dummy equal to one if the firm has a *venture capitalist* as a shareholder. This should account for high degrees of control exerted on the behaviour of the management by the shareholders, for example monitoring.

In addition to the above three ownership variables, which are to be used in the estimations, some dummy variables are created for the purpose of the descriptive analysis. One is a dummy equal to one if the firm is fully owned by a principal owner and his family, referred to as *family firm*. Another is a dummy equal to one if the firm is fully owned by its employees, referred to as *employee firm*.

5.3 Descriptive analysis

Table 1 presents descriptions of all the variables used in this descriptive analysis and later on in the econometric analysis.

Table 1. Variable description

Variable	Description	Unit
RDINT	R&D expenditure/sales	%
TOL_1	Food and textiles	0,1
TOL_2	Printing and publishing	0,1
TOL_3	Wood, pulp, chemical and rubber products	0,1
TOL_4	Construction, other manuf., basic metals	0,1
TOL_5	Machinery and equipment	0,1
TOL_6	Office, accounting and computing machinery	0,1
TOL_7	Electrical machinery and transport equipment	0,1
TOL_8	ICT equipment	0,1
TOL_9	Medical, precision, and optical instruments	0,1
TOL_10	Trade, hotels and restaurants, transport	0,1
TOL_11	Telecom and data services	0,1
TOL_12	Software	0,1
TOL_13	R&D services	0,1
TOL_14	Other business supporting services	0,1
WEST	Firm resides in Western Finland	0,1
EAST	Firm resides in Eastern Finland	0,1
NORTH	Firm resides in Province of Oulu or Northern Finland	0,1
REGION	Firm resides in an agricultural municipality	0,1
AGE	Age of the firm in years	years
AGE^2	Square of firm's age	
EMP	Number of employees in the firm	persons
EMP^2	Square of the number of employees	
HIGHEX	Firm's export/sales exceeds 25%	0,1
PROFIT(t-1)	Firm made a positive profit the previous year	0,1
DEBTR	Firm's debt to total assets	%
POWER	One product makes 90% of sales and its market share >50%	0,1
INNO	Firm has innovated a new product/process in past 3 years	0,1
PATENT	Firm owns patents	0,1
INTANG	Firm owns intangible assets other than patents	0,1
GROWTH	Projected growth rate for the next 3 years	%
PERSHARE	Entrepreneur's ownership share in the firm	%
PERSHARE^2	Square of entrepreneurs' ownership	
EMPSHARE	Employees' collective ownership share	%
EMPSHARE^2	Square of employees' collective ownership	
VC	Firm has a venture capitalist as one of the owners	0,1
EMPLOYEE	Firm is 100% owned by employees	0,1
FAMILY	Firm is 100% owned by entrepreneur+family	0,1
PERSHARE IV	Average ownership share (industry)*no. of employees (firm)	
PERSHARE IV^2	Square of the above	
EMPSHARE IV	Average ownership share (industry)*age (firm)	
EMPSHARE IV^2	Square of the above	
AUDIT	Firm is audited by one of the "Big Five".	0,1

Notes: The industry classification is based on the EU industry standard NACE Rev.1. TOL_1 includes NACE 15, 17, 18, 19; TOL_2 = 22; TOL_3 includes 20,21, 24, 25, TOL_4 includes 26, 27, 28, 36, 37, 40, 45; TOL_5 = 29; TOL_6 = 30; TOL_7 = 31; TOL_8 = 33; TOL_9 includes 50,51, 52, 55, 60,61, 63; TOL_10 includes 64, 72, (excl. 722); TOL_11 = 722; TOL_12 = 73; TOL_13 includes 74, 80, 81,85, 90, 92, 93. The "Big Five" accounting firms are KPMG Wideri, Arthur Andersen, SVH PriceWaterhouse-Coopers, Tuokko Deloitte & Touche, or Tilintarkastajien Oy Ernst & Young.

Table 2 presents descriptive statistics for firms in the sample. In panel A of Table 2 we see descriptive statistics for the chosen variables for the whole sample, in panel B we see those for the *family firms*, and in panel C for the *employee firms*. These mean

values of various characteristics are tested with a difference of means t-test for whether they are independent of the type of ownership.[41] Essentially the t-test tests whether the mean values of the variables are the same in both of the two samples. Only those variables, which show statistically significant differences, will be discussed in the text.

Firms in the sample range from less than a year old to 118 years old, with a mean age of 16 years. They employ just over 17 people on average. 10 percent of the firms in the sample have a high share of exports, i.e. a share of exports/sales of over 25 percent. Over 90 percent of the firms made a positive profit the previous year. 6 percent of the firms are one-product firms with monopoly power, i.e. firms that have one product or service that accounts for over 90 percent of their sales and in which they have significant market power, i.e. a market share of more than 50 percent in their main market area. 54 percent of the sampled firms have innovated a new product, service or a process in the past three years. 13 percent of the firms hold patents, and 22 percent hold some other form of intangible assets. The firms are relatively growth-oriented, as the mean expected annual growth rate in turnover[42] over the next three years is 19 percent. Firms' R&D intensities vary from zero to twenty five times the firm's turnover. The mean R&D/sales figure is 13 percent.

Almost half of the firms in the sample are fully owned by the entrepreneur and his family. The descriptive statistics for family-owned firms show that they are slightly smaller on average, employing a mean of 13 people. Family-owned firms are slightly more likely to have shown a profit the previous fiscal year. They run lower debt ratios on average and are also less growth-oriented, with a mean expected annual growth rate of 11 percent in the next three years. About one sixth of the firms in the sample are fully owned by the employees other than the entrepreneur, i.e. they have no principal owner and all the shares are held by managers. These firms are younger, with a mean age of just over 13 years.

There are some characteristics that both family-owned and employee-owned firms show. They are less export-oriented, with only 5 percent of the firms having high exports (compared to the 10 percent of the whole sample). Both types of firms are also less likely to have innovated during the past three years. Particularly the employee-

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41 The results reported here for the whole sample do not represent mean values for the representative SME population in Finland due to the sampling method used in the survey to enable the inclusion of more innovation oriented firms (the results presented are unweighted).

42 As projected by the entrepreneur.

Table 2. Descriptive statistics

PANEL A: Whole sample

	Obs	Mean	Std. Dev	Min	Max
AGE	744	16.1	17.0	0	118
EMP	745	17.5	27.7	1	230
HIGHEX	745	0.10	0.30	0	1
PROFITP	693	0.91	0.28	0	1
POWER	742	0.06	0.24	0	1
DEBTR	745	0.37	0.28	0.00	1.00
INNO	739	0.54	0.50	0	1
PATENT	744	0.13	0.33	0	1
INTANG	742	0.22	0.41	0	1
GROWTH	678	0.19	0.49	0.00	10.00
RD	609	0.13	1.09	0.00	25.00

PANEL B: Firms 100% owned by entrepreneur and family

	Obs	Mean	Std. Dev	Min	Max	t-test	
						t	P>|t|
AGE	315	16.3	14.0	0	93	-0.24	0.812
EMP	316	**13.0**	20.4	1	145	4.14	0.000
HIGHEX	316	**0.05**	0.23	0	1	3.81	0.000
PROFITP	294	**0.94**	0.25	0	1	-1.82	0.069
POWER	314	0.06	0.23	0	1	0.20	0.845
DEBTR	316	**0.34**	0.28	0.00	1.00	1.85	0.064
INNO	314	**0.49**	0.50	0	1	2.11	0.036
PATENT	316	0.11	0.31	0	1	1.02	0.307
INTANG	314	**0.25**	0.43	0	1	-1.66	0.098
GROWTH	283	**0.11**	0.17	0.00	1.50	3.88	0.000
RD	269	**0.04**	0.10	0.00	0.67	2.01	0.023

PANEL C: Firms 100% owned by employees of the firm

	Obs	Mean	Std. Dev	Min	Max	t-test	
						t	P>|t|
AGE	129	**13.6**	14.5	1	98	2.09	0.038
EMP	129	15.2	23.6	1	179	1.18	0.240
HIGHEX	129	**0.05**	0.21	0	1	2.84	0.005
PROFITP	118	0.92	0.28	0	1	-0.08	0.938
POWER	129	0.05	0.23	0	1	0.27	0.784
DEBTR	129	0.33	0.27	0.00	1.00	1.52	0.130
INNO	127	**0.42**	0.50	0	1	3.03	0.003
PATENT	129	0.09	0.29	0	1	1.33	0.185
INTANG	129	**0.12**	0.33	0	1	3.28	0.001
GROWTH	115	0.15	0.25	0.00	2.00	1.41	0.158
RD	102	**0.04**	0.10	0.00	0.58	1.95	0.052

Notes: See Table 1 for the definitions of the variables. The mean values that are marked in bold are significantly different in the sample of family-owned firms to those in the sample of firms not 100% owned by the entrepreneur and family (panel B). Similarly, the mean values that are marked in bold are significantly different in the sample of employee-owned firms to those in the sample of firms not 100% owned by the employees (panel C).

owned firms exhibit less characteristics of innovation; they also are less likely to hold other intangibles. Interestingly, family-owned firms tend to be more likely to hold other intangibles. The average R&D intensity of both family-owned and employee-owned firms is much less than in the whole sample, yet there is also a significant difference in the standard deviations. The maximum R&D intensities seen in these types of firms are well below their sales levels, 67% for family-owned and 58% for employee-owned firms.

In summary, the results show that some of the characteristics vary a great deal between the different types of ownership, while others vary little. They also show that the most growth-oriented and R&D intensive firms are neither family-held nor employee-held, but do involve some outside equity ownership.

Table 3a presents in the first column the percentage of firms in the sample that are 100% owned by the entrepreneur and his family (*family-owned*), conditional on firm size, firm age, and firm R&D intensity. In the second column, we see the proportion of firms in the sample that are 100% owned by its employees other than the entrepreneur (*employee-owned*), conditional on the same characteristics. It also shows the mean ownership share of the entrepreneur and his family (*pershare*), the mean ownership share of the employees (*empshare*), and last, the total insiders' ownership share by combining the above two (*inshare*). Table 3b presents in a similar manner the proportion of family and employee firms, as well the mean ownership shares, in different industries.

Table 3. a. Ownership structures

		Family-owned	Employee-owned	Pershare	Empshare	Inshare
Young	107	27 %	22 %	39 %	42 %	80 %
Adolescent	172	42 %	20 %	55 %	29 %	84 %
Old	465	46 %	15 %	60 %	25 %	85 %
Small	412	50 %	18 %	60 %	28 %	88 %
Large	333	34 %	16 %	50 %	29 %	80 %
No R&D	227	53 %	19 %	62 %	27 %	88 %
Low R&D	298	42 %	18 %	55 %	29 %	84 %
High R&D	208	32 %	14 %	49 %	30 %	79 %
Sample	745	42 %	17 %	56 %	28 %	84 %

Notes: See Table 1 for the definitions of the variables. The first two columns show the proportion of firms in the sample that are family-owned and employee-owned, conditional on certain firm characteristics. The last three columns show the mean ownership share of the entrepreneur, employees and insiders (entrepreneur+employees), respectively, conditional on these characteristics.

Table 3.b. Ownership structures in different industries

	Obs.	Family-owned	Employee-owned	Pershare	Empshare	Inshare
Food and textiles	27	**63 %**	**7 %**	72 %	11 %	83 %
Printing and publishing	21	48 %	5 %	62 %	15 %	77 %
Wood, pulp, chemical and rubber products	62	37 %	18 %	50 %	32 %	81 %
Construction, other manuf., basic metals	87	51 %	20 %	62 %	29 %	90 %
Machinery and equipment	109	44 %	16 %	58 %	25 %	83 %
Office, accounting and computing machinery	14	50 %	14 %	64 %	31 %	95 %
Electrical machinery and transport equipment	47	38 %	15 %	56 %	27 %	84 %
ICT equipment	66	41 %	15 %	57 %	28 %	85 %
Medical, precision, and optical instruments	40	40 %	10 %	63 %	21 %	85 %
Trade, hotels and restaurants, transport	79	51 %	22 %	63 %	27 %	90 %
Telecom and data services	20	15 %	15 %	21 %	25 %	46 %
Software	95	33 %	21 %	48 %	39 %	87 %
R&D	16	6 %	13 %	19 %	29 %	48 %
Other business services	62	50 %	26 %	55 %	34 %	89 %

Notes: See Table 1 for the definitions of the variables. The first two columns show the proportion of firms in the sample that are family-owned and employee-owned, conditional on the industry the firm comes from. The last three columns show the mean ownership share of the entrepreneur, employees and insiders (entrepreneur+employees), respectively, in each industry.

The results show that the younger firms are less likely to be family firms than older firms, while they are more likely to be employee-owned than the older firms. Small firms rather than large firms are more likely to be family-owned. Also firms with no R&D activities are more likely to be family firms. Young firms have a lower mean entrepreneur's ownership share than older ones, while they also have a higher share of employee ownership than older firms on average. The total ownership share of firm insiders (entrepreneur's and employees') varies less with age, which is no surprise as the two opposite relations balance out. High R&D firms show a lower mean share of insiders' ownership than others.

There are differences between the industries in the proportion of firms being either completely family-held or employee-held. The highest proportion of family-held firms is found in the "food and textiles" industry (63%). Family-owned firms are also dominant in the "construction, other manufacturing and basic metals" (51%), in the "trade, hotels and restaurants, transport" (51%), in the "office, accounting and computing machinery" (50%) and in "other business services" (50%). There are low proportions of family-owned firms in the "R&D services" industry (6%) and "telecom and data services" (15%).

The highest proportion of employee-owned firms is in the "other business service" industry. "Food and textiles" and "printing and publishing" industries have the lowest percentage of fully employee-owned firms. The mean share of insiders is significantly low in two industries, "research and development" and "telecom and data services".

Table 4. Descriptive statistics for R&D firms

Descriptive statistics for firms that have some R&D

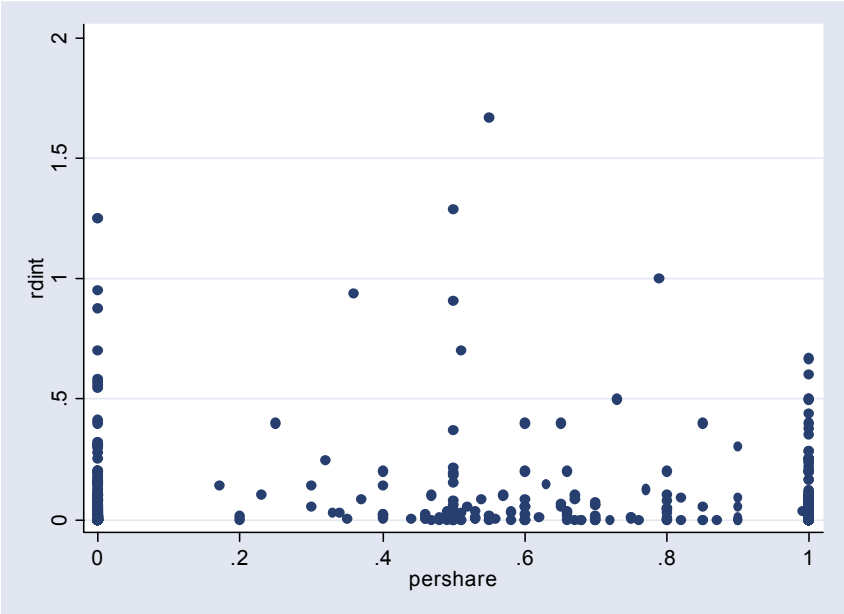
	Obs	Mean	Std. Dev	Min	Max	t-test	
						t	P>|t|
AGE	482	16.0	17.7	0	118	0.282	0.778
EMP	482	**20.7**	30.8	1	230	-5.173	0.000
HIGHEX	482	**0.14**	0.34	0	1	-6.222	0.000
PROFITP	452	0.91	0.28	0	1	-0.158	0.874
POWER	480	**0.05**	0.21	0	1	2.182	0.030
DEBTR	482	0.37	0.28	0.00	1.00	0.372	0.710
INNO	478	**0.70**	0.46	0	1	-14.068	0.000
PATENT	481	**0.16**	0.37	0	1	-5.530	0.000
INTANG	481	**0.28**	0.45	0	1	-6.885	0.000
GROWTH	455	**0.21**	0.35	0.00	3.00	-7.468	0.000
PERSHARE	482	**0.53**	0.44	0.00	1.00	2.230	0.026
EMPSHARE	482	0.28	0.38	0.00	1.00	-0.558	0.577
INSHARE	482	**0.82**	0.32	0.00	1.00	2.632	0.009
VC	482	**0.11**	0.31	0	1	-5.335	0.000

Notes: See Table 1 for the definitions of the variables. The mean values that are marked in bold are significantly different in the sample of R&D firms to those in the sample of non-R&D firms.

The t-test in Table 4 compares the mean value of a characteristic in the R&D firms to their counterparts, i.e. the mean value for the firms with no R&D. From Table 4 we see that firms with R&D are significantly larger, that they are more likely to have a high export share, and less likely to be dominant firms relying on one product. They are naturally much more likely to have innovated a new product or a process in the past three years and, in fact, 70 percent of firms that do R&D today have done so. They are more likely to have patents (16 percent) and other intangibles (28 percent). They also show higher growth rates. In terms of ownership structure, R&D firms have a significantly lower share of entrepreneur's ownership, and a significantly lower share of insider ownership overall. As expected, they are also much more likely to have a venture capitalist as one of the owners.

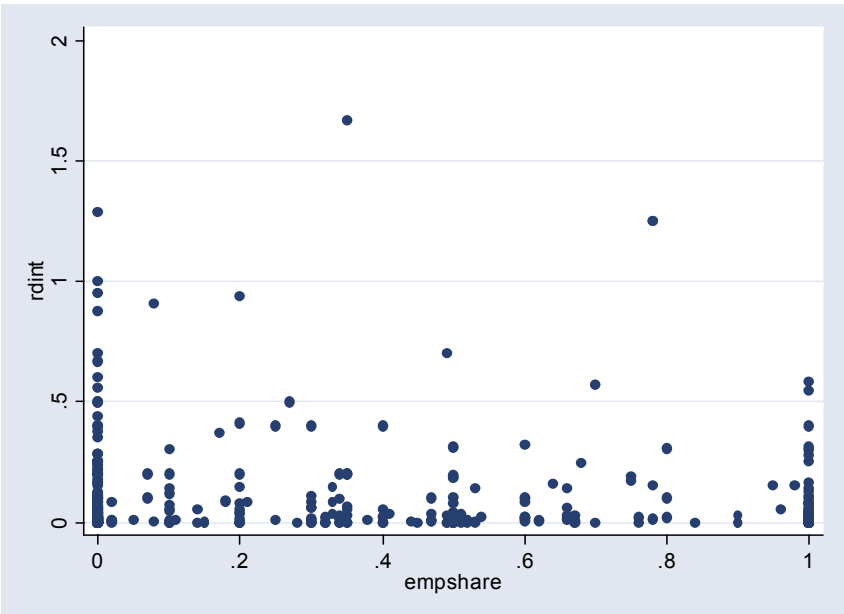
Figure 1 presents a dot plot of ownership share of the family on the x-axis with R&D intensity on the y-axis. There is some concentration of firms at pershare=0, which are firms where there is no entrepreneur in the firm. As we already saw, there is also a high concentration of firms that are 100 percent owned by the entrepreneur and his family. At both of these ends, there is substantial variation in the R&D intensities. There is also some clustering of firms with R&D intensities between 0-10 percent, and an ownership share of the entrepreneur of around 50 percent. The graph reveals no identifiable relationship between entrepreneur's ownership and firm R&D intensity.

Figure 1. Graph of family ownership share vs R&D intensity



Notes: rdint is firm's R&D/sales, pershare is the ownership share of the entrepreneur and his family. Three of the most R&D intensive firms (R&D intensities of about 25, 5, and 3 times their turnover), are excluded from the figure in order to keep the scale large enough to see the distribution. The excluded firms are all firms with pershare=0.

Figure 2. Graph of employee ownership share vs R&D intensity



Notes: rdint is firm's R&D/sales, empshare is the collective ownership share of the employees. Three of the most R&D intensive firms (R&D intensities of about 25, 5, and 3 times their turnover), are excluded from the figure in order to keep the scale large enough to see the distribution. The excluded firms are all firms with empshare=0.

Figure 2 presents a dot plot of ownership share of the employees on the x-axis with R&D intensity on the y-axis. Here there is a similar concentration of firms being

either completely employee-owned, and even more at the other end with firms that have no employee ownership at all.

To get some idea of the relationships that exist between R&D intensity and the ownership shares of the entrepreneur and employees, we run some preliminary OLS estimations on R&D intensity explained by each of these ownership variables and their squares, first separately and then together (altogether 6 different specifications). The results (coefficients of the explanatory variables and their t-values) are reported in Table 5. These results indicate that the relation with respect to each of the ownership variables is non-linear, as the squared values become significant and also take opposite signs to the linear variable. The results show a U-shaped relationship of entrepreneur's ownership share with R&D, and an inverse U-shaped relationship of employees' ownership share with R&D.

Table 5. Preliminary estimations (OLS)

Some preliminary estimations (OLS)				
	RDINT	**Coef.**		**t**
(1)	pershare	-0.208	**	-2.12
(2)	pershare	-0.268		-0.52
	pershare2	0.060		0.12
(3)	empshare	0.071		0.62
(4)	empshare	1.652	***	3.41
	empshare2	-1.671	***	-3.36
(5)	empshare	-0.236		-1.4
	pershare	-0.357	**	-2.47
(6)	empshare	2.33	***	3.49
	empshare2	-2.59	***	-3.97
	pershare	-1.89	***	-2.98
	pershare2	1.67	***	2.6

Notes: RDINT is the dependent variable (R&D/sales). Pershare is the entrepreneur's and his family's ownership share, pershare2 its square. Empshare is the employees' collective ownership share, empshare2 its square.

5.4 R&D estimations

5.4.1 Tobit regression

The first step of the econometric analysis is to run censored Tobit regressions explaining firm's R&D intensity. Tobit analysis is a maximum likelihood technique that combines probit analysis with standard regression analysis. It is most suited for this type of data, where the dependent variable is essentially a continuous variable but also includes cases where it is zero.

The application of censored regression model in this case could be more appropriately called a corner solution model.[43] The situation is that the observable choice (R&D) has characteristics such that it takes on the value of zero with positive probability and is a continuous random variable over strictly positive values. There are two features of the distribution of R&D given x (the vector of explanatory variables) that we are interested in. The first is the expected value of firm's R&D given x, and given that the firm engages in R&D i.e. E(R&D|x, R&D>0). The second is the probability of the firm doing R&D, given x, i.e. Pr(R&D>0|x). The statistical model is: for a randomly drawn observation i from the population,[44]

$$y_i^* = x_i\beta + u_i, \quad u_i \mid x_i \sim Normal(0, \sigma^2)$$

$$y_i = \max(0, y_i^*)$$

5.4.2 Goodness of Fit Tests

The pseudo-R^2 that is reported in the regression output compares the log-likelihood, $\log L$, with the log-likelihood that would have been obtained with only the intercept in the regression, $\log L_0$. The pseudo-R^2 is the proportion by which $\log L$ is smaller, in absolute size, than $\log L_0$.[45] Generally higher pseudo-R^2 implies a better fit of the model but it does not have a natural interpretation as a test for the explanatory power of the model. Variations in the likelihood can be used as a basis for tests, and the explanatory power of the model can be tested with the likelihood ratio statistic: $2\log\frac{L}{L_0} = 2(\log L - \log L_0)$. It is distributed as a chi-squared statistic with $k-1$ degrees

[43] See Wooldridge (2002, Chapter 16).
[44] Wooldridge (2002, Chapter 16).
[45] Dougherty (2001).

of freedom, where $k-1$ is the number of explanatory variables, under the null hypothesis that the coefficients of the variables are all jointly equal to 0.[46] This statistic is reported as LR Chi2 together with its significance for all the estimations in the following tables.

Furthermore, the likelihood ratio tests can be used to compare the likelihood ratios of constrained (the base line) and unconstrained (the extended) model specifications to test the validity of a restriction. The likelihood ratio statistic presented above is used by replacing L by that of the unrestricted model, and by replacing L_0 by that of the restricted model. The test is applied in this study to compare the likelihood ratios of unrestricted models and models under the restriction that the coefficients of certain variables are zero.

5.4.3 Model specification

5.4.3.1 The dependent variable

The dependent variable in this study, R&D intensity, is defined as the ratio of the firm's R&D investments to its turnover (*R&D/sales*).[47]

5.4.3.2 Explanatory variables

The first specification (Column labelled (1) in Table 6) includes only those explanatory variables that are truly exogenous. These include firm's age and size as well as non-linear transformations of these variables, and industry dummies. Firm size is measured by the number of employees. The second specification (2) of the R&D equation incorporates a number of other control variables, including factors related to its past profitability, export orientation, the degree of competition it faces in the product market, and its debt ratio. The third specification (3) includes variables on the firm's past innovativeness, such as whether it has patents or other intangibles, whether it has innovated during the past three years, and on firm's growth orientation.

Each of these three specifications is then run including the ownership variables described above: the entrepreneur's ownership share and employees' ownership share,

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[46] Dougherty (2001).

[47] An alternative definition of R&D intensity, which is the ratio of R&D personnel to the total personnel (R&D employees/Total employees), was also used to test the robustness of the results. The qualitative results remained the same.

as well as squares of these shares to allow for non-linear relationships.[48] It also includes a dummy indicating venture capital.

The estimation equation is shown below. *Pershare* refers to the entrepreneur's ownership share, *empshare* to the collective ownership share of the firm's employees, VC indicates the presence of venture capitalist ownership, and Z is the vector of the controls described above.

$$R\&D_i = \max(0, \alpha + \beta_1 pershare_i + \beta_2 pershare_i^2 + \beta_3 empshare_i + \beta_4 empshare_i^2 + \beta_5 VC_i + \gamma Z_i + u_i)$$

5.4.4 Results from R&D estimations

The results from the three specifications without any ownership variables are presented in Table 6. Practically all of the variables that become significant do so in all three specifications. We see that firm's size appears to have a non-linear effect on R&D intensity. First R&D intensity is increasing with the number of employees and eventually decreasing. Age also has a non-linear effect on the firm's R&D intensity. R&D intensity is first decreasing with age and then increasing. Firm's growth orientation is positively related to its R&D intensity. Having innovated a product or a process in the past three years is positively related to the firm's R&D intensity. Holding patents or other intangible assets is positively related to firm's current R&D. On the other hand, firms that have one product or service (90% of sales come from one) in which they have significant market power (market share > 50%) seem to be associated with lower R&D intensities. High export share of turnover is not significantly related to firm's R&D intensity.

[48] Alternative specifications where firm ownership structure is characterised by three dummies, one indicating family-firms, one indicating employee-firms and one indicating the presence of a principal owner alone and together with the continuous variables, were also estimated. The results, overall, showed a negative association between employee-firms and R&D, and similarly for the presence of a principal owner. Family-firms showed a positive relationship with firm R&D, though it was not significant in all of the specifications.

Table 6. Tobit regressions on R&D

	(1)		(2)		(3)	
RD	Coef.	t-value	Coef.	t-value	Coef.	t-value
TOL_2	-0.158	-0.30	0.006	0.01	0.148	0.28
TOL_3	0.134	0.34	0.042	0.10	-0.169	-0.43
TOL_4	-0.295	-0.77	-0.176	-0.45	-0.062	-0.16
TOL_5	-0.163	-0.43	-0.119	-0.31	-0.098	-0.26
TOL_6	0.223	0.42	0.102	0.19	-0.211	-0.41
TOL_7	0.186	0.46	0.119	0.28	0.227	0.56
TOL_8	0.151	0.39	0.143	0.36	0.099	0.27
TOL_9	0.451	1.06	0.496	1.14	0.035	0.08
TOL_10	-0.403	-1.02	-0.289	-0.71	0.085	0.22
TOL_11	-0.272	-0.51	-0.208	-0.38	-0.181	-0.36
TOL_12	0.703	1.82 *	0.718	1.82 *	0.302	0.81
TOL_13	2.435	4.74 ***	3.078	5.59 ***	3.078	5.74 ***
TOL_14	-0.330	-0.79	-0.353	-0.82	-0.116	-0.28
WEST	-0.108	-0.79	-0.088	-0.63	-0.064	-0.48
EAST	0.103	0.46	-0.027	-0.12	-0.065	-0.30
NORTH	-0.080	-0.37	-0.027	-0.12	-0.232	-1.11
REGION	-0.035	-0.20	0.121	0.67	0.186	1.06
AGE	-0.023	-2.20 **	-0.026	-2.38 **	-0.009	-0.84
AGE^2	0.000	1.86 *	0.000	2.09 **	0.000	1.10
EMP	0.023	3.99 ***	0.027	4.30 ***	0.021	3.49 ***
EMP^2	0.000	-3.25 ***	0.000	-3.71 ***	0.000	-3.16 ***
HIGHEX			0.242	1.21	-0.226	-1.17
PROFIT(t-1)			-0.725	-3.41 ***	-0.364	-1.74 *
DEBTR			-0.577	-2.41 **	-0.480	-2.11 **
POWER			-0.422	-1.61	-0.629	-2.48 **
INNO					0.542	4.06 ***
PATENT					0.194	0.96
INTANG					0.292	2.05 **
GROWTH					1.629	8.84 ***
CONSTANT	-0.399	-1.01	0.426	0.94	-0.623	-1.37
No. of obs		608		569		520
Censored obs		226		210		181
Log likelihood		-759.6		-704.6		-606.5
LR Chi2		98.3		129.3		240.9
degr of freedom		21		25		29
significance		0.000		0.000		0.000
R2 pseudo		0.061		0.084		0.166

* significant at 10%; ** significant at 5%; *** significant at 1%

Including the ownership structure variables into the regressions does not alter the rest of the results (See Table 7).[49] Likelihood ratio tests are done first between the three specifications that include the ownership variables and their respective counterparts in the specifications that do not have the ownership variables. The results of the likelihood ratio tests are shown at the bottom of Table 7. These indicate, that including the ownership variables does improve the model in each of the three cases. Similarly, the three specifications including the ownership variables are tested against each other with a

[49] In reading the results, it should be kept in mind that these ownership variables may be endogeneous to the model, and their coefficients in the Tobit regressions may be biased.

likelihood ratio test. These tests indicate that the best fitting specification is the last one, i.e. specification (6).

Table 7. Tobit regressions on R&D including ownership variables

	(4)		(5)		(6)	
RD	Coef.	t-value	Coef.	t-value	Coef.	t-value
TOL_2	-0.195	-0.38	-0.051	-0.10	0.095	0.18
TOL_3	0.118	0.31	0.050	0.12	-0.135	-0.35
TOL_4	-0.212	-0.57	-0.125	-0.33	-0.019	-0.05
TOL_5	-0.191	-0.52	-0.150	-0.39	-0.076	-0.21
TOL_6	0.160	0.31	0.056	0.10	-0.203	-0.40
TOL_7	0.176	0.45	0.089	0.21	0.279	0.69
TOL_8	0.142	0.38	0.136	0.35	0.142	0.38
TOL_9	0.418	1.01	0.449	1.05	0.101	0.24
TOL_10	-0.317	-0.83	-0.228	-0.58	0.148	0.38
TOL_11	-0.311	-0.60	-0.280	-0.53	-0.165	-0.33
TOL_12	0.623	1.66 *	0.628	1.62	0.317	0.86
TOL_13	2.225	4.43 ***	2.833	5.20 ***	3.036	5.65 ***
TOL_14	-0.331	-0.82	-0.379	-0.91	-0.094	-0.23
WEST	-0.117	-0.89	-0.090	-0.66	-0.047	-0.35
EAST	0.016	0.07	-0.089	-0.40	-0.053	-0.24
NORTH	-0.170	-0.81	-0.100	-0.46	-0.241	-1.16
REGION	-0.058	-0.34	0.090	0.51	0.121	0.69
AGE	-0.016	-1.64	-0.022	-2.05 **	-0.009	-0.89
AGE^2	0.000	1.27	0.000	1.69 *	0.000	1.13
EMP	0.018	3.24 ***	0.023	3.80 ***	0.019	3.27 ***
EMP^2	0.000	-2.59 ***	0.000	-3.25 ***	0.000	-2.95 ***
HIGHEX			0.221	1.12	-0.165	-0.86
PROFIT(t-1)			-0.542	-2.56 **	-0.316	-1.51
DEBTR			-0.592	-2.54 **	-0.473	-2.09 **
POWER			-0.531	-2.06 **	-0.656	-2.59 ***
INNO					0.508	3.85 ***
PATENT					0.187	0.94
INTANG					0.299	2.09 **
GROWTH					1.494	7.97 ***
VC	1.080	5.06 ***	0.998	4.52 ***	0.430	1.97 **
EMPSHARE	2.069	2.45 **	1.881	2.15 **	2.165	2.50 **
EMPSHARE^2	-2.201	-2.67 ***	-2.073	-2.43 **	-2.273	-2.67 ***
PERSHARE	-1.887	-2.35 **	-2.036	-2.45 **	-1.911	-2.33 **
PERSHARE^2	1.838	2.26 **	1.990	2.36 **	2.042	2.44 **
CONSTANT	-0.412	-0.98	0.305	0.64	-0.746	-1.54
No. of obs		608		569		520
Censored obs		226		210		181
Log likelihood		-741.7		-689.8		-600.4
LR Chi2		134.2		158.9		253.0
degr of freedom		26		30		34
significance		0.000		0.000		0.000
R2 pseudo		0.083		0.103		0.174

LIKELIHOOD RATIO TESTS			
Tobit LR-test for	(4) vs (1)	(5) vs (2)	(6) vs (3)
Chi2 (5)	35.9	29.6	12.1
significance	0.000	0.000	0.033
Tobit LR-test for		(5) vs (4)	(6) vs (4)
Chi2 (5)		103.8	282.6
significance		0.000	0.000
Tobit LR-test for			(6) vs (5)
Chi2 (5)			178.72
significance			0.000

* significant at 10%; ** significant at 5%; *** significant at 1%

All of the five ownership variables take on significant values in the regressions, and the likelihood ratio tests between this model and the same model without the ownership variables shows a significant improvement in its explanatory power. The results show that the presence of venture capital ownership is positively associated with high R&D intensity, as could be expected. Entrepreneur's ownership share appears to be negatively related to the firm's R&D intensity at low levels of ownership but positively related to it at high levels of ownership. It has a U-shaped relationship with firm R&D. Employees' ownership share, on the other hand, has an inverse U-shaped relationship with firm R&D, i.e. it is positively associated at low levels and negatively associated at high levels of ownership. We can calculate the turning points for these. Entrepreneur's ownership share begins to have a positive relationship with firm's R&D at 51 percent ownership, while employees' ownership share begins to have a negative relationship with firm's R&D at 47 percent.

These results indicate that there exists an association between insiders' equity shares and R&D intensity. However, it was necessary to distinguish between two types of insiders; 1) the entrepreneur, defined as a strong principal owner that is active in the firm's operations, and 2) the rest of the employees of the firm. Whereas a high ownership share of the entrepreneur was associated with high R&D, a high ownership share of other employees (no individual with controlling ownership shares) was associated with lower R&D. A positive association was also found for the presence of venture capital (monitoring) and R&D. These results are consistent with the view that ownership structure is related to R&D but unfortunately not much can be deduced about them without controlling for the endogeneity of ownership structure.

5.4.5 Marginal effects

To say something about the magnitude of the coefficients, we need to consider the marginal effects of the variables. There are two marginal effects we are interested in, as was discussed when reasoning the use of Tobit regression to analyse the issue at hand. Table 8 presents the marginal effects of each of the ownership variables. The first panel shows the marginal effects on the unconditional expected value of R&D i.e. on E(R&D|x). The next panel shows a more interesting marginal effect, i.e. marginal effect on R&D conditional on being uncensored E(R&D|x, R&D>0). We see that, evaluated at the mean employee ownership of 27 percent, a one percent increase in the ownership share is associ-

ated with a 29 percent increase in the firm's R&D intensity.[50] Similarly we see that, evaluated at the mean entrepreneur ownership of 57 percent, a one percent increase in the ownership share is associated with a 13 percent rise in the firm's R&D intensity. Finally, we also see that the presence of a venture capitalist is associated with a 15 percent rise in the firm's R&D intensity, given that the firm engages in R&D.

Table 8. Marginal effects

Marginal effects

Marginal Effects: Unconditional Expected Value

var	dF/dx	z	x at	combined
vc	0.194	2.29	0 -> 1	
empshare	0.840	2.5	0.27	**0.363**
empshare2	-0.882	-2.67	0.22	
pershare	-0.742	-2.33	0.57	**0.158**
pershare2	0.793	2.44	0.52	

Marginal Effects: Conditional on being Uncensored

var	dF/dx	z	x at	combined
vc	0.145	2.18	0 -> 1	
empshare	0.663	2.5	0.27	**0.286**
empshare2	-0.696	-2.67	0.22	
pershare	-0.585	-2.33	0.57	**0.125**
pershare2	0.625	2.44	0.52	

Marginal Effects: Probability Uncensored

var	dF/dx	z	x at	combined
vc	0.147	2.03	0 -> 1	
empshare	0.723	2.5	0.27	**0.312**
empshare2	-0.759	-2.67	0.22	
pershare	-0.638	-2.33	0.57	**0.136**
pershare2	0.682	2.44	0.52	

Notes: Stata treats empshare and empshare2 (pershare and pershare2) as two distinct variables and thus does not provide the overall marginal effect. It is calculated from the two by the author, and is presented in the right-most column of each of the panels. We do not calculate the z-values for this combined effect.

The last panel of the table shows the marginal effects of the ownership variables on the probability of the firm engaging in R&D i.e. on Pr(R&D>0|x). A one percent increase in the employees' ownership share is associated with 30 percent increase in the probability of the firm engaging in R&D, evaluated at the mean ownership. A one percent increase in the entrepreneur's ownership share is associated with a 14 percent in-

[50] Note that the changes are percentages, not percentage points, i.e. a firm with R&D intensity of 1% would exhibit an R&D intensity of 1.29% as a result of a ten percent increase in the employees' ownership share from 27% to 29.7%.

crease in the probability of the firm engaging in R&D evaluated at the mean ownership. The presence of a venture capitalist is associated with a 15 percent rise in the probability of the firm doing R&D.

5.5 Instrumental variable (IV) estimation

So far we have discussed the potential endogeneity of the ownership structure and shown that it is likely to be endogenous. Reverse causality running from firm's R&D orientation to its ownership structure potentially distorts the results of OLS regressions. So does the existence of unobserved, and thus omitted, variables that affect both R&D and ownership. In this section we first describe what endogeneity is in econometric terms, then show what characteristics a valid instrument should have, and finally describe the Durbin-Wu-Hausman test for endogeneity. Then we formulate the ownership equation, after which we can test for the endogeneity of the ownership variables. They are in fact endogenous, and so we need to attempt instrumental estimation.

5.5.1 Endogeneous explanatory variables

Allowing for one of the variables in the Tobit model to be endogeneous, the model is:[51]

$$y_1 = \max(0, z_1\delta_1 + \alpha_1 y_2 + u_1)$$

$$y_2 = z\delta_2 + \upsilon_2 = z_1\delta_{21} + z_2\delta_{22} + \upsilon_2$$

where y_1 is the firm's R&D and y_2 is a vector of the ownership variables. The error terms (u_1, υ_2) are zero-mean normally distributed, independent of z. If u_1 and υ_2 are correlated, then y_2 is endogeneous. The vector z_2 needs to contain at least one variable that is not in z_1, and this is the so-called instrument. However, in this study, since we have five endogenous variables we also need at least five instruments.[52] Each instrument in z_2 needs to be a variable that is correlated with y_2 but not with u_1.[53]

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[51] See Wooldridge (2002, Chapter 16, p.530).

[52] In fact only three instruments need to be found, and the squares of the instruments for pershare and empshare can be used as instruments for pershare2 and empshare2.

[53] Dougherty (2001) shows that instrumental variable estimators are consistent. However, IV estimators are less efficient and if the bias in the OLS estimate is small enough, it can in fact yield superior estimates looking at the trade-off between bias and variance.

5.5.2 Estimation of ownership shares

The second step of the econometric analysis is to account for the endogeneity of ownership structure by using two-stage least squares regression. The first stage of this instrumental method involves specifying the ownership structure equation(s), i.e. defining the explanatory variables that affect firm's ownership. In addition to all of the variables used in the R&D equation, we need to find instruments for each of the ownership variables that do not correlate with the error terms in the R&D equation but are significant in explaining the firm's ownership variables.

5.5.2.1 Choosing the instruments

Entrepreneur's ownership share is instrumented by an interaction term between the mean ownership of the entrepreneur in each industry times the size of the firm (*pershareIV*). Its square is instrumented by the square of the interaction term (*pershareIV^2*). Similarly, employees' ownership share is instrumented by an interaction term between the mean ownership of the employees' in each industry times the age of the firm (*empshareIV*). Its square is instrumented by the square of the interaction term (*empshareIV^2*). Finally, the instrument for the presence of a venture capitalist is a dummy equal to one if the firm is audited by one of the "Big Five" internationally recognized auditors (*Audit*).

5.5.2.2 Durbin-Wu-Hausman Test

Cong (1999) suggests an augmented regression test (Durbin-Wu-Hausman test) to decide whether it is necessary to use an instrumental variable.[54] This is formed by first estimating each of the endogenous variables by all the exogenous variables, including the instruments. Then the residuals from these estimations are put into the original R&D equation together with the rest of the explanatory variables, and the so-called augmented regression is run. If the residuals become significant, there is endogeneity present.

The results of the augmented regression are reported in Table 9 in the Appendix. The residuals from the estimations for each of the five endogenous variables become highly significant in the R&D estimation, and thus the results are consistent with endogeneity of these variables.

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[54] Cong, R., (1999), www.stata.com.

5.5.3 Results from ownership estimations

Although instrumental methods use linear regression in the first stage, we first run Tobit regressions to estimate entrepreneur's and employees' ownership shares, and Probit regressions to account for the presence of a venture capitalist owner, since these are the most appropriate forms for these estimations.[55] The explanatory variables used are the vector of controls used in the R&D estimations, together with five potential instruments for the endogenous ownership variables. The results are presented in Table 10 and Table 11. From the estimations, we see that increasing firm size initially decreases entrepreneur's ownership share, while after a point the relation reverses (increasing square of firm size increases ownership). Firms with intangibles have higher shares of entrepreneur's ownership. Projected growth rate of the firm is negatively related to entrepreneur's ownership share. The results from estimating the square of entrepreneur's share are almost identical. The proposed instrument variables for entrepreneur's ownership share, *pershareIV* and *pershareIV^2*, become significant in the estimations. They indicate that given the average entrepreneur's ownership share in the industry, increasing the firm size is initially positively related to the ownership share of the firm, and eventually becomes negatively related to it.

The industry dummies pick up almost all the effect in the estimations of employees' ownership share. In addition to the instrument variables, the only other significant effect is the negative relation of empshare with holding intangibles. The proposed instrument variables for employees' ownership share and its square, *empshareIV* and *empshareIV^2*, do become significant in the estimations. Given the average ownership share of employees in each industry, increasing the age of the firm is initially negatively related to the employees' ownership share in the firm but eventually becomes positively related to it.

Firms that reside in an agricultural municipality, are more likely to have venture capital ownership. Firm's age has a non-linear relationship with VC presence, increasing age is initially positively related to it but eventually negatively related. Firm's that did not show a profit the previous fiscal year are also more likely to have a venture capitalist as one of the owners. Firms that hold intangible assets are more likely to have a VC presence. Firm's growth-orientation is also positively related to the presence of a

[55] Tobit regressions are best suited for the ownership share variables, as they are similar to the R&D variable in the previous estimations. Venture capital is a dummy, and thus probit regression is used. In the actual IV estimations, the first stage is an OLS estimation, which performs even less well.

VC. Finally, the coefficient of the potential instrument variable for VC presence, *AUDIT*, is positive and statistically significant. Firms that use internationally recognised auditors are more likely to have a VC as one of the owners.

Table 10. Estimations of entrepreneur's ownership share

	pershare		pershare2	
TOL_2	-0.23	-0.92	-0.24	-0.95
TOL_3	-0.58	-1.79 *	-0.57	-1.76 *
TOL_4	-0.53	-1.83 *	-0.51	-1.78 *
TOL_5	-0.49	-1.85 *	-0.49	-1.86 *
TOL_6	-0.50	-1.39	-0.52	-1.44
TOL_7	-0.55	-1.88 *	-0.58	-1.99 **
TOL_8	-0.50	-1.73 *	-0.52	-1.79 *
TOL_9	-0.30	-1.20	-0.35	-1.39
TOL_10	-0.51	-1.82 *	-0.52	-1.83 *
TOL_11	-0.61	-1.67 *	-0.64	-1.74 *
TOL_12	-0.67	-1.89 *	-0.67	-1.87 *
TOL_13	-1.07	-2.69 ***	-1.16	-2.90 ***
TOL_14	-0.71	-2.22 **	-0.70	-2.17 **
WEST	-0.04	-0.63	-0.04	-0.61
EAST	0.04	0.44	0.02	0.22
NORTH	-0.15	-1.54	-0.15	-1.53
REGION	0.06	0.81	0.07	0.86
AGE	-0.03	-1.18	-0.02	-0.96
AGE^2	0.00	0.13	0.00	0.11
EMP	-0.05	-2.48 **	-0.05	-2.34 **
EMP^2	0.00	2.23 **	0.00	2.13 **
HIGHEX	0.01	0.12	-0.04	-0.37
PROFIT(t-1)	0.03	0.30	0.03	0.29
DEBTR	0.01	0.09	-0.02	-0.17
POWER	-0.09	-0.79	-0.07	-0.62
INNO	-0.04	-0.71	-0.05	-0.84
PATENT	-0.06	-0.60	-0.04	-0.39
INTANG	0.19	2.70 ***	0.19	2.67 ***
GROWTH	-0.17	-1.65 *	-0.18	-1.72 *
PERSHARE IV	0.08	2.25 **	0.08	2.06 **
PERSHARE IV^2	0.00	-1.90 *	0.00	-1.71 *
EMPSHARE IV	0.15	1.71 *	0.13	1.51
EMPSHARE IV^2	0.00	-0.99	0.00	-0.76
AUDIT	-0.11	-1.64	-0.11	-1.57
CONSTANT	0.93	3.05 ***	0.91	2.97 ***
No. of obs		617		617
Censored obs		223		223
Log likelihood		-556.46		-550.02
LR Chi2		101.26		102.82
degr of freedom		34		34
significance		0.000		0.000
R2 pseudo		0.083		0.086

* significant at 10%; ** significant at 5%; *** significant at 1%

Table 11. Estimations of employees' ownership share and VC presence

	empshare		empshare2		vc	
TOL_2	0.55	1.58	0.49	1.47	1.30	1.16
TOL_3	1.32	3.06 ***	1.27	3.09 ***	2.93	1.51
TOL_4	1.05	2.64 ***	1.01	2.66 ***	3.09	1.68 *
TOL_5	1.03	2.82 ***	0.98	2.81 ***	3.51	2.06 **
TOL_6	1.29	2.75 ***	1.20	2.68 ***	3.82	1.95 *
TOL_7	1.20	3.02 ***	1.12	2.97 ***	3.66	2.04 **
TOL_8	1.14	2.91 ***	1.08	2.88 ***	3.69	2.05 **
TOL_9	1.02	2.90 ***	0.93	2.79 ***	2.87	1.82 *
TOL_10	1.16	2.99 ***	1.13	3.04 ***	3.17	1.75 *
TOL_11	1.38	2.98 ***	1.26	2.86 ***	2.34	1.11
TOL_12	1.52	3.27 ***	1.45	3.26 ***	4.01	1.97 **
TOL_13	1.52	3.21 ***	1.35	3.00 ***	3.37	1.74 *
TOL_14	1.37	3.17 ***	1.32	3.21 ***	3.89	2.01 **
WEST	0.07	1.02	0.09	1.30	0.10	0.45
EAST	-0.13	-1.06	-0.12	-1.06	0.46	1.46
NORTH	0.09	0.85	0.09	0.89	0.15	0.48
REGION	-0.02	-0.16	-0.02	-0.19	0.50	2.10 **
AGE	0.04	1.42	0.05	1.60	0.20	2.13 **
AGE^2	0.00	1.08	0.00	1.30	0.00	1.64
EMP	0.00	0.16	0.01	0.34	0.06	1.19
EMP^2	0.00	1.26	0.00	1.34	0.00	1.19
HIGHEX	0.01	0.09	-0.02	-0.16	-0.03	-0.12
PROFIT(t-1)	0.02	0.15	0.00	0.02	-0.61	-2.32 **
DEBTR	-0.06	-0.46	-0.09	-0.72	0.37	1.07
POWER	-0.02	-0.13	0.01	0.06	0.23	0.70
INNO	-0.01	-0.09	-0.03	-0.43	0.18	0.86
PATENT	-0.02	-0.20	0.00	0.02	0.27	0.97
INTANG	-0.25	-2.93 ***	-0.23	-2.82 ***	0.41	1.99 **
GROWTH	0.04	0.63	0.02	0.26	0.69	2.67 ***
PERSHARE IV	0.02	0.45	0.01	0.21	-0.11	-1.13
PERSHARE IV^2	0.00	0.78	0.00	0.92	0.00	1.09
EMPSHARE IV	-0.20	-1.89 *	-0.21	-2.06 **	-0.78	-2.25 **
EMPSHARE IV^2	0.00	1.55	0.00	1.77 *	0.02	2.05 **
AUDIT	-0.01	-0.12	-0.01	-0.11	0.45	2.28 **
CONSTANT	-1.12	-2.71 ***	-1.08	-2.72 ***	-5.21	-2.84 ***
No. of obs		617		617		617
Censored obs		336		336		
Log likelihood		-499.88		-475.95		-127.53
LR Chi2		64.12		59.24		92.05
degr of freedom		34		34		34
significance		0.001		0.005		0.000
R2 pseudo		0.060		0.059		0.265

* significant at 10%; ** significant at 5%; *** significant at 1%

5.5.4 Results from IV estimations

The instrumental variable estimations provide results with huge standard errors and no significance for any of the coefficients.[56] The coefficients of the endogenous variables also increase by a factor of about seventy in absolute value. The signs of the coefficients, however, remain the same. Unfortunately, the explanatory power of the first

[56] The results from instrumental regressions (ivreg command in Stata) are shown in the appendix in Table 12 but not much can be deduced from them. Similarly, instrumental tobit regressions (ivtobit command in Stata) were run and the results were very much the same as in the linear IV- regressions (unreported).

stage estimations is low. Although the likelihood ratio test is very significant in each of the estimations, the pseudo R2 values for the entrepreneur's share estimations are around 0.08, and for the employees' share estimations around 0.06. For the VC estimation, the pseudo R2 is 0.27, which indicates a relatively good explanatory power.

It seems that although the interaction terms proposed as suitable instruments became significant in the estimations, they are very weak instruments. Stock and Yogo (2002) provide a method of testing for weak instruments, which is based on the F-values of the first stage equation. The very low F-values of these estimations (F-values are a round 2) indicate that the instruments are weak and thus the results of the two-stage least squares estimation may be biased. Hahn and Hausman (2002) also demonstrate that there can be substantial bias in the 2SLS estimate if instruments are weak. They argue that the correlation between the stochastic disturbances of the structural equation and the reduced form needs to be taken into account when testing for weak instruments. They suggest a specification test that includes all the variables that affect the bias: n, $R^2, K, and\ \rho$ (the correlation between the two error terms σ_{uv}).[57]

5.6 Summary and discussion of results

The descriptive analysis showed that almost half of the firms in the sample were family-owned firms, whereas one sixth were employee-owned. The most growth-oriented and R&D intensive firms were characterised by some outside equity ownership. There was significant variation in the distribution of these two ownership types among industries.

Econometric evidence showed that there exists a significant association between both entrepreneur's ownership and R&D, and employees' ownership and R&D. They had opposing relationships, entrepreneur's ownership a U-shaped, and employees' ownership an inverse U-shaped. Increasing the ownership share of the entrepreneur begins to have a positive effect on R&D after a 51 percent ownership share. This is consistent with what was expected based on the principal-agent model with a risk-neutral entre-

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[57] They consider the "reverse" 2SLS estimator $c_{2SLS} \equiv \frac{\sum_i \hat{y}_{1i}\hat{y}_{2i}}{\sum_i \hat{y}_{1i}^2}$ and use the fact that under conventional (first order) asymptotics the inverse of c_{2SLS} should have correlation one with the "forward" 2SLS estimator b_{2SLS}. Their test is not applied in this paper since its application to more than one endogenous variable appears more complex.

preneur. The higher his ownership, the more effort he will put into managing R&D projects. This result is also consistent with no sign of risk aversion on the part of the entrepreneur. Why R&D intensity initially declines with increasing ownership is difficult to explain. Many firms with no real entrepreneur do show high R&D intensities, and this may mean that there are other aspects of ownership that should have been controlled for.

Increasing the employee ownership share, up to 47 percent, increases firm's R&D, which is consistent with the positive incentive effect due to the managers' income being dependent on the firm's future value. Increasing shares of employee ownership after the 47 percent point seem to decrease R&D intensity. This could be due to risk-aversion of the managers or possible agency conflicts between the managers. The incentive effect dominates any risk-aversion effect at low levels of employee ownership but the risk-aversion effect dominates at higher levels of ownership. We are not able to observe the number of employees among which the ownership is diffused in each firm and do not know an individual's ownership share. Therefore we cannot account for possible principal-agent problems among the employees.

Since the Durbin-Wu-Hausman test showed that the ownership variables are endogenous, the above results cannot imply any direction of causality. IV-estimations did not help in solving the problem. We can try to think of the possible direction of bias in the coefficients of the endogenous variables by speculating on the exact cause of the endogeneity. However, the non-linearity of the relationships complicates the situation, and the potential effects can work in counteracting directions. For example, there can be an unobserved characteristic that affects both R&D and the entrepreneur's ownership the same way. To demonstrate one such potential effect, the entrepreneur's wealth can enable him to hold a large ownership share in his firm while at the same time make him more risk-loving. This would indicate a both higher ownership share and higher R&D being driven by entrepreneur's wealth. In this case, the bias in the Tobit estimates of the entrepreneur's ownership share would most likely be biased upwards. This is, however, only one example and potential opposite effects can be thought of. Alternatively, structural reverse causality can be caused when firm's R&D opportunities make obtaining external funding desirable, and due to the relative low costs of equity in contrast to debt makes it optimal for the firm to reduce the ownership share of the insiders. Here high R&D would imply a lower ownership share of the entrepreneur. If this were the case, the Tobit estimates of the entrepreneur's ownership share would most likely be biased

downwards. Thus there are potential endogeneity issues, the direction of which is hard to establish without empirical evidence. Therefore, controlling for endogeneity successfully is the one and only way of establishing the direction of causality and getting unbiased estimates. Further research in this topic is called for, with substantial effort to be put into solving the econometric problems involved.

6 Conclusions

The aim of this study was to examine both empirically and theoretically how firm ownership structure affects its R&D intensity. To begin with, a principal-agent problem created by the separation of the management of a firm (the agent) and its ownership (the principal) was reviewed. We then discussed how monitoring and contracting, though costly activities, can reduce agency costs but not completely eliminate them. We saw that the nature of innovative activities, being characterised by asymmetric information, a long time frame and high uncertainty, makes them particularly prone to high agency costs.

The focus of this study was on two aspects of ownership that are particularly important from the point of view of agency costs. These were insiders' ownership shares in the firm, measured by the entrepreneur's and his family's ownership share, and the collective ownership share of the employees. The degree of control activities, like monitoring, was measured with a venture capitalist dummy.

Prior empirical literature was reviewed. The results of the studies as well as the econometric methods used varied. We acknowledged that the empirical estimation of effects of corporate governance on firm's activities has various problems: endogeneity, omitted variables, sample selectivity, and measurement errors. These problems were discussed in light of the existing literature and in light of this study.

Most of the prior studies do not manage to solve all the inherent empirical issues. Many studies suffer from sample selectivity, for example samples being selected from large, publicly listed firms. Endogeneity is in most, although not in all, controlled for either through two-stage least squares instrumental estimation or alternatively by three-stage least squares simultaneous equations estimations. The studies also come to different conclusions on whether ownership structure is in fact endogeneously determined. Some of the studies are likely to suffer from an omitted variables bias, as they use only one variable to measure ownership structure. Others that define ownership multi-dimensionally, fail to account for the endogeneity of but one of their ownership variables.

In this study, various alternative measures of ownership structure were used in a number of different specifications. The final specification included three aspects of ownership; entrepreneur's ownership, employees' collective ownership, and the presence of a venture capitalist, and allowed for non-linear effects. Probably the most serious econometric issue concerning this study is that ownership variables are endoge-

nously determined. Thus endogeneity and its causes, as well as the econometric methods that take care of the endogeneity problem, were discussed further.

The Tobit estimations of R&D showed that both the ownership share of the entrepreneur and the ownership share of the employees are related to R&D intensity. They had opposing relationships, entrepreneur's ownership a U-shaped relation with a turning point at 51 percent, and employees' ownership an inverse U-shaped relation, with a turning point at 47 percent. Also the presence of a venture capitalist is positively related to R&D intensity.

Overall, these results are consistent with the prior expectation, based on the principal-agent model, that high levels of entrepreneur's ownership are favourable for R&D. The higher his ownership, the more effort he will put into managing R&D projects. This result is also consistent with no sign of risk aversion on the part of an entrepreneur with high ownership share. The finding that employees' ownership share exhibits an inverse U-shaped relationship with R&D is also consistent with what could be expected. The incentive effect dominates any risk-aversion effect at low levels of employee ownership but the risk-aversion effect dominates at higher levels of ownership.

The results from the Tobit regressions cannot be interpreted as conclusive evidence of the actual causality between ownership and R&D. Endogeneity of the ownership structure variables could have been biasing the results above. This paper showed that the ownership variables are in fact endogeneous to the model, and instrumental variable estimation was used to attempt to solve the problem. However, finding strong instruments for the variables proved to be a difficult task, and the attempts to control for the endogeneity of the ownership structure were largely unsuccessful. Unfortunately only weak instruments were found and the two-stage least squares method gave no interpretable results as the standard errors became huge. Nevertheless, the signs of the coefficients of the ownership variables still remained the same.

Overall, it is clear that the empirical study of corporate governance issues such as the principal-agency theory is a challenging task, and only recently a number of papers have been written that really tackle the issue thoroughly. However, the requirements for data are high, and compromises still have to be made. Future research in this field should focus on attempting to solve the econometric problems involved, and for the most part this can be achieved through better data. Panel data should be collected over several years for a large random sample of firms, and it should include detailed information on ownership and governance structures.

7 References

Anderson, R.C. and Reeb, D.M. Founding-Family Ownership and Firm Performance: Evidence from the S&P 500, Forthcoming Journal of Financial Economics.

Ang, J.S., Cole R.A. and Lin J.W., 2000, Agency Costs and Ownership Structure, Journal of Finance, 55: 81-106.

Baldwin, J.R., Gellatly, G. and Gaudreault, V., 2002, Financing Innovation in New Small Firms: New Evidence From Canada, Research Paper Series, Analytical Studies Branch, No. 190.

Berger, A. N. and Bonaccorsi di Patti, E., 2002, Capital Structure and Firm Performance: A New Approach to Testing Agency Theory and an Application to the Banking Industry, Federal reserve.

Bhagat, S., Welch, I., 1995, Corporate research & development investments, International comparisons. Journal of Accounting and Economics 19 (1995) 443-470.

Bitler, M.P., Moskowitz, T.J., and Vissing-Jorgensen, A., 2002, Why Do Entrepreneurs Hold Large Ownership Shares? Testing Agency Theory Using Entrepreneur Effort and Wealth, CRSP Working Paper No. 544.

Börsch-Supan, A. and Köke, J., 2000, An Applied Econometricians' View of Empirical Corporate Governance Studies, ZEW Discussion Paper No. 00-17, Centre for European Economic Research, Mannheim, German Economic Review, Vol. 3, pp. 295-326, 2002.

Cong, R., 1999, Augmented regression, www.stata.com.

Cui, H. and Mak, Y.T., 2002, The Relationship Between Managerial Ownership and Firm Performance in High R&D Firms, Journal of Corporate Finance 8: 313-336.

Czarnitzki, D. and Kraft, K., 2002, Management Control and Innovative Activity, Centre for European Economic Research, Mannheim.

Demsetz, H and Villalonga, B., 2001, Ownership Structure and Corporate Performance, Journal of Corporate Finance, Vol. 7, pp. 209-233.

Demsetz, H. and Lehn, K., 1985, The Structure of Corporate Ownership: Causes and Consequences, Journal of Political Economy 93: 1155-1177.

Dougherty, C., 2002, Introduction to Econometrics, Second edition, Oxford University Press.

Francis, J. and Smith, A., Agency costs and innovation, Some empirical evidence, Journal of Accounting and Economics 19 (1995) 383-409.

Gompers, P.A., 1995, Optimal Investment, Monitoring, and the Staging of Venture capital, The Journal of Finance, Vol. L, No.5, December 1995.

Gompers, P and Lerner, J., 1999, The Venture Capital Cycle, The MIT Press.

Hahn, J. and Hausman, J., Weak Instruments: Diagnosis and Cures in Empirical Econometrics, http://econ-www.mit.edu/faculty/?prof_id=hausman.

Hart, O., 2001, Financial Contracting, Harvard Institute of Economic Research, Discussion Paper Number 1924.

Holmstrom, B., 1989, Agency Costs and Innovation, Journal of Economic Behaviour and Organization 12 (1989) 305-327.

Hyytinen, A. and Pajarinen, M., 2003, Small Business Finance in Finland: A Descriptive Study, in Hyytinen and Pajarinen, 2003 (eds.), Financial Systems and Firm Performance: Theoretical and Empirical Perspectives, The Research Institute of the Finnish Economy (ETLA) B:200.

Jensen, M.C. and Meckling, W., 1976, Theory of the Firm: Managerial Behavior, Agency Costs, and Capital Structure, Journal of Financial Economics 3: 305-360.

Kaplan, S.N., and Strömberg, P., 2001, Venture Capitalists as Principals: Contracting, Screening, and Monitoring, Financial Intermediaries, AEA Papers and Proceedings, Vol 91. No. 2.

Mueller, E. and Spitz, A., 2002, Managerial Ownership and Firm Performance in German Small and Medium-Sized enterprises, Centre for Economic Performance, London School of Economics and Political Science.

Stock, J.H. and Yogo, M., 2002, Testing for Weak Instruments in Linear IV Regression, National Bureau of Economic Research, Technical Working Paper 284.

Wooldridge, J., 2002, Econometric analysis of cross section and panel data, the MIT press.

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APPENDIX

Table 9. Durbin-Wu-Hausman test

RDINT	Coef.	Std. Err.	t	P>t	[95% Conf.	Interval]
EMPSHARE	424.3	147.5	2.88	0.004	134.5	714.1
EMPSHARE^2	-454.4	157.6	-2.88	0.004	-764.0	-144.8
PERSHARE	-502.7	173.3	-2.90	0.004	-843.2	-162.3
PERSHARE^2	509.3	174.8	2.91	0.004	165.9	852.7
VC	-23.11	10.57	-2.19	0.029	-43.87	-2.34
TOL_2	-4.47	1.76	-2.53	0.012	-7.94	-1.00
TOL_3	4.28	1.42	3.00	0.003	1.48	7.08
TOL_4	5.53	1.81	3.05	0.002	1.96	9.09
TOL_5	6.41	2.20	2.92	0.004	2.09	10.73
TOL_6	4.53	1.61	2.81	0.005	1.36	7.70
TOL_7	16.31	5.56	2.93	0.004	5.39	27.23
TOL_8	12.38	4.26	2.91	0.004	4.02	20.74
TOL_9	14.94	5.12	2.91	0.004	4.87	25.00
TOL_10	14.36	4.81	2.99	0.003	4.91	23.81
TOL_11	-0.70	0.97	-0.72	0.471	-2.60	1.20
TOL_12	6.13	2.02	3.04	0.002	2.17	10.10
TOL_13	2.69	1.34	2.01	0.045	0.06	5.33
TOL_14	6.28	2.08	3.02	0.003	2.20	10.36
WEST	6.11	2.12	2.88	0.004	1.94	10.28
EAST	12.02	4.32	2.78	0.006	3.53	20.50
NORTH	0.51	0.28	1.83	0.067	-0.04	1.06
REGION	-2.09	0.70	-2.98	0.003	-3.47	-0.71
AGE	-0.17	0.05	-3.17	0.002	-0.27	-0.06
AGE^2	0.00	0.00	3.05	0.002	0.00	0.00
EMP	0.00	0.01	-0.16	0.872	-0.03	0.02
EMP^2	0.00	0.00	-2.54	0.011	0.00	0.00
HIGHEX	12.83	4.49	2.86	0.004	4.00	21.66
PROFIT(t-1)	-6.88	2.51	-2.73	0.006	-11.82	-1.93
DEBTR	2.80	1.15	2.45	0.015	0.55	5.05
POWER	0.93	0.51	1.84	0.066	-0.06	1.93
INNO	-3.82	1.30	-2.93	0.004	-6.38	-1.26
PATENT	-0.05	0.22	-0.23	0.817	-0.48	0.38
INTANG	8.45	3.17	2.67	0.008	2.23	14.67
GROWTH	-6.49	2.64	-2.46	0.014	-11.67	-1.31
EMP_RES	-422.1	147.5	-2.86	0.004	-711.9	-132.4
EMP2_RES	452.4	157.6	2.87	0.004	142.8	761.9
PER_RES	501.0	173.3	2.89	0.004	160.5	841.5
PER2_RES	-507.3	174.8	-2.90	0.004	-850.7	-163.9
VC_RES	23.39	10.56	2.21	0.027	2.64	44.15
CONSTANT	1.51	2.31	0.65	0.514	-3.03	6.04
No. of obs	518					
F(39, 478)	7.37					
Prob>F	0.000					
R^2	0.375					
Adj. R^2	0.324					

Notes: EMP_RES is the residual from the estimation of empshare, EMP2_RES the residual from the estimation of its square. Similarly, PER_RES is the residual from the estimation of pershare and PER2_RES the residual from the estimation of its square. VC_RES is the residual from the estimation of VC.

Stata (ivendog command) reports the following output for tests of endogeneity of pershare, pershare2, empshare, empshare2, and vc:

H0: Regressors are exogenous
Wu-Hausman F test: 3.58102 F(5,478) P-value = 0.00344
Durbin-Wu-Hausman chi-sq test: 18.70284 Chi-sq(5) P-value = 0.00218
Therefore, H0 is rejected and regressors are endogeneous.

Table 12. Results from IV- estimation (2SLS)

RDINT	Coef.	Std. Err.	t	P>t	[95% Conf.	Interval]
EMPSHARE	-142.1	725.1	-0.20	0.845	-1566.9	1282.7
EMPSHARE^2	147.4	751.1	0.20	0.845	-1328.4	1623.2
PERSHARE	134.9	691.0	0.20	0.845	-1222.7	1492.6
PERSHARE^2	-151.2	765.8	-0.20	0.844	-1655.9	1353.5
VC	10.40	50.83	0.20	0.838	-89.46	110.27
TOL_2	-2.38	13.75	-0.17	0.863	-29.39	24.63
TOL_3	4.20	21.46	0.20	0.845	-37.95	46.36
TOL_4	3.63	18.49	0.20	0.845	-32.71	39.97
TOL_5	2.52	14.32	0.18	0.860	-25.61	30.65
TOL_6	2.45	15.08	0.16	0.871	-27.18	32.08
TOL_7	5.78	31.20	0.19	0.853	-55.53	67.09
TOL_8	4.55	24.48	0.19	0.852	-43.55	52.66
TOL_9	5.93	31.43	0.19	0.850	-55.84	67.69
TOL_10	6.46	32.40	0.20	0.842	-57.20	70.13
TOL_11	0.46	11.79	0.04	0.969	-22.71	23.62
TOL_12	4.15	21.82	0.19	0.849	-38.72	47.02
TOL_13	3.98	16.88	0.24	0.814	-29.20	37.16
TOL_14	4.10	21.69	0.19	0.850	-38.53	46.72
WEST	1.36	7.69	0.18	0.860	-13.76	16.47
EAST	1.07	8.32	0.13	0.898	-15.28	17.42
NORTH	-0.19	3.46	-0.06	0.955	-7.00	6.61
REGION	-2.56	13.15	-0.19	0.846	-28.40	23.28
AGE	-0.12	0.59	-0.20	0.843	-1.29	1.05
AGE^2	0.00	0.01	0.18	0.857	-0.01	0.01
EMP	0.02	0.14	0.14	0.887	-0.25	0.29
EMP^2	0.00	0.00	-0.08	0.936	0.00	0.00
HIGHEX	3.55	20.26	0.18	0.861	-36.26	43.36
PROFIT(t-1)	0.63	5.91	0.11	0.915	-10.99	12.25
DEBTR	8.78	47.65	0.18	0.854	-84.86	102.41
POWER	0.36	4.54	0.08	0.938	-8.57	9.28
INNO	-2.05	9.56	-0.21	0.830	-20.84	16.74
PATENT	0.35	3.21	0.11	0.912	-5.95	6.65
INTANG	1.25	10.53	0.12	0.906	-19.45	21.94
GROWTH	-4.10	25.65	-0.16	0.873	-54.50	46.30
CONSTANT	-4.15	32.90	-0.13	0.900	-68.79	60.49
No. of obs	518					
F(35, 483)	0.05					
Prob>F	1					
R^2	.					
Adj. R^2	.					

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