

Investment in R&D and Corporate Governance

By Valdemar Smith*, Erik Strøjer Madsen* and Mogens Dilling-Hansen**

Summary

The paper investigates the impact of ownership concentration on the likelihood that firms are involved in innovative activities or invest in research and development. We find that more dispersed ownership significantly increases the probability that a firm is engaged in innovation or invests in research and development. Moreover, the effect from ownership concentration is far more important for the incentive to innovate than the effect from product market concentration.

1. Introduction

The development of new products and cost-saving technologies has been an important aspect of economic growth. The innovations may be even more important for the rise in economic prosperity in the future as the effects from accumulation of more capital and other factors of production per capita diminish due to the law of decreasing returns. Today, the rise in total factor productivity already is the most important factor behind economic growth in the developed countries.

The importance of innovation has attracted the interest of researchers who have studied different factors likely to affect the firm's incentive to invest in research and development. Generally, these studies have mainly focused on the effect from the competitive environment of the firm where the Schumpeterian hypothesis of higher innovation activity in big firms or concentrated industries has been tested. However, the studies have also examined the effect of different technological opportunities for the firms, as well as the effect from firm characteristics such as profitability, solvency, age and size.

The interest in different aspects of corporate governance is growing with the spread of performance-related pay of firm executives, and in this area, many of the empirical studies have focused on the relation between corporate governance structure and performance of the firm. However, the question of how different corporate governance systems affect long-term decisions on investment in research and development has not been studied empirically.

This paper contributes to an answer of this question by presenting empirical evidence from 1,780 Danish companies concerning their investment in research and development and engagement in innovation activities.

Large public companies with a highly diffuse ownership structure may have a weak owner control with a less efficient management of the firm as top executives pursue other priorities than shareholder values. However, as shown by La Porta, Lopez-De-Silanes and Shleifer (1999), the large company with a diffuse ownership control is actually non-existing. Even among the 20 biggest companies in each country studied, they found only one or a few big blockholders controlling the firms in all 46 countries except for USA and UK. For all the smaller non-traded companies a few blockholders is common also in the USA and the UK.

Despite the fact that a company with only a few blockholders is the normal ownership structure, most of the available empirical evidence on the governance-performance link is based on data sets with big companies from mainly the USA and the UK. However, Lehmann and Weigand (2000) examined a larger sample of 361 German companies, and contrary to the US/UK results, they found a negative impact on firm profitability from ownership con-

* Department of Economics, Aarhus School of Business, Centre for Industrial Economics, University of Copenhagen.

** Department of Management, Centre for Industrial Economics, University of Copenhagen, University of Aarhus.

centration. We follow this track and look at the number of big blockholders with more than 5% of the shares in Danish companies.

The next section discusses the different theories and hypotheses put forward to explain the innovation activities in firms as well as the latest empirical research in this area. Section 3 presents the cross-section data set of 1,780 Danish firms. Sections 4 and 5 present the empirical findings and section 6 concludes the paper.

2. Determinants of R&D and Innovation

In this section, we go through the different determinants of R&D and innovation and the hypotheses put forward in the literature. The section focuses on effects of ownership structure but it also deals with other factors having proved to affect the likelihood that a firm becomes involved in R&D or innovation activities.

Ownership structure

As mentioned above, the old story with dispersed ownership and therefore weak owners is not common at all. The theory predicts that in firms with weak owners, the managers are tempted to pursue other goals than the maximisation of long-run profit. A typical example is the substitution of short-run profits for R&D investments in order to secure their own salary and job position. The probability of pursuing other goals is expected to increase if the managers' salary depends on the actual performance of the firms and if the period over which managers are evaluated by the board of the firm is shorter than the pay-off period from R&D.

As pointed out by Demsetz and Lehn (1985), this theory cannot explain that most of the companies have more than one owner. The theory is founded on the presumption that the incentive to shirking or free riding increases when the number of owners in the company increases. However, from this point of view the optimal number of owners is only one because in this situation, the whole return from efforts put into monitoring the management belongs to the owner himself, and should not be shared with other owners. Therefore, to explain the fact that the companies generally have more than one owner, the authors suggest that other factors are at work in the decisions among owners about the optimal number of owners.

The first factor is that owners are wealth-constrained, so under some circumstances they have to invite equity capital from outside. This often happens when the founder of the company has several lawful successors and none of them individually could rise the full equity capital of the firm. In this situation, the successor may share the company or invite external ownership from outside the family.

However, also the developments in the company itself can requisite external equity capital if the actual owners do not have deep pockets. This is likely to happen for companies with high growth or high capital requirements and with a low profitability and therefore low retained earnings.

Another factor leading to more owners is that the individual investor or family may want to diversify their portfolio on more than one firm in order to reduce the risk on their total wealth. From this portfolio perspective one would expect the ownership to be more dispersed in firms where the earnings are highly volatile. As investments in R&D are very risky, it is likely that the concentration of ownership will decrease in companies investing in R&D.

The weight to be given to these arguments will depend on the relative strength of the shareholders. If the ownership is highly concentrated in a few large owners, i.e., the shareholders have strong ownership control and the managers are unable to impact information, a positive influence on the effectiveness of the firm is to be expected. Accordingly, a longer time frame involving *inter alia* more R&D investments is expected. On the other hand, if a firm is owned by a large number of blockholders, the owners may be willing to take higher risk and this could have a positive influence on risky R&D investments.

The empirical evidence on R&D/innovation and ownership is rather limited. Battagion and Tajoli (1999) find that firms owned as "società per azioni" (LTDs) — these firms having the most dispersed ownership — affect innovation positively. Yet, even though the effect seems stable, it is only weakly significant.

In this paper, attention is also paid to another aspect of ownership control, i.e. whether the firm is domestically or foreign-owned (by foreign firms). The motive for investing in another country is often a more effective production compared to national firms. These R&D investments must, however, be considered as more risky than R&D investments made in the home country (taking place in a different country with probably less direct control of managers compared to domestic managers). Therefore, it is obvious that an extra premium coming from R&D investments abroad is a precondition for investing in R&D abroad. As a consequence, R&D investments in foreign firms abroad are less likely to take place compared to nationally owned domestic firms (see Bishop, Wiseman, 1999).

Market structure

According to Schumpeter (1942), there will be less innovation in competitive industries. This rejection of perfect competition does not necessarily imply that monopoly is the best market structure for promoting innovation activities as his hypothesis often has been interpreted (see below). Still, Schumpeter emphasised the idea that

large-scale firms were the ideal vehicles for generating technical advances as they can benefit from the scale economies in production, marketing, financing and R&D. Of course, large firms are often synonymous with monopolised industries. Yet, they can also be found in more competitive industries.

Arrow (1962) challenges the Schumpeterian hypothesis by showing that the competitive firms have a stronger incentive to invest in cost-reducing innovations compared to monopolistic firms as they gain the full return from successful innovation including a monopoly rent, which the monopolistic firm already has. Another theoretical argument against the Schumpeterian hypothesis is the general notion of slack or X-inefficiency under monopolistic conditions (see Leibenstein, 1966). Firms in monopolistic market positions may enjoy higher profits and, therefore, be lax and inefficient and fail to pursue the innovation opportunities in their markets.

In oligopolistic industries the relationship between market concentration, market share of the firm and R&D intensity becomes much more blurred. One reason for the complexity is that the R&D intensity not only depends on the firm's demand and costs, but also on its competitors' level of R&D activity. Furthermore, this strategic decision concerning their spending on R&D involves returns from new products in markets that do not yet exist. There are several different theoretical models focusing on different aspects of this strategic competition and they come up with different conclusions.

Some types of models consider innovation as a continuous activity improving the firms' products and their demand in the same way as advertising. Needham (1975) modelled R&D in this product innovation context and showed that the conditions for optimality of the R&D intensity are analogous to the well-known Dorfman-Steiner condition for advertising. This implies that there will be a higher research intensity in less competitive and more profitable industries, i.e. in concentrated industries.

Taking account of rivalry between the firms where the demand for a firm's product also depends on the research intensity in other firms suggests a lower R&D intensity in highly concentrated industries. Thus, if competitors match other firms spending on R&D, there will be a general improvement in product quality. The firm's market share will therefore be unaffected and as a result, the firm will have a lower return on its R&D activities. Firms in highly concentrated industries might therefore collude and lower the amount spent on R&D in order to avoid this offsetting investment in product innovations. As a consequence there will be an inverted U-relation between R&D intensity and market concentration with a low level of research in highly competitive and in very concentrated industries (see Lunn and Martin, 1986).

Other types of models focus on the right timing of innovations. For an early contribution see Scherer (1967). The

key idea in these models is that the return to innovations is higher, the more quickly new products can be developed, as the probability of taking a patent in advance of the competitors rises and with it the reward to the first mover in the market place. Speeding up the research and development process also raises the costs, and the optimal time path thus involves a trade-off between these costs and the first mover benefits. The patent race model points to more rapid innovation in markets where the numbers of sellers are greater. However, the incentive to innovate may level off or fall as the concentration falls further, as the firms may fail to internalise the return from their innovations for a longer period if the number of competitors becomes too large. This dynamic model also implies an inverted U-shape relationship between the concentration ratio and the research intensity.

Several empirical studies have reported a positive correlation between concentration and research intensity.¹ There is some evidence of an inverted U-relationship with maximum research intensity at a four-firm concentration ratio of 50–60%. However, these results depend on whether the empirical analyses are based on industry-level cross-section data or on pooled time-series and cross-section data. In the latter case, when controlling for unobserved heterogeneity, the inverted U-hypothesis typically fails to gain support.²

Firm size

In his work on innovation, Schumpeter also focused on the absolute size of the firm (see above). If larger firms are more innovative, one would expect a positive relationship between firm size and research intensity, as noted by Lunn and Martin (1986) who tested this version of the Schumpeterian hypothesis on US line of business data including a variable for the total asset invested. They found a significant positive coefficient indicating that large firms use more resources on R&D per dollar of sales, especially within the high-tech industries. This result is in accordance with Cohen and Klepper (1996) who find that the firms' R&D expenditure increases more than proportionately with increasing firm size. On the other hand, Vossen (1998), using Dutch data, finds that among firms having decided to invest in R&D, larger firm size leads to lower R&D intensity. Foerre (1997) gets a similar result for Norwegian firms except for the very large firms. Still, in both studies the probability of investing in R&D depends positively on firm size.

¹ See Scherer and Ross (1990), Scott (1984), Levin et al. (1985), Wahlroos and Backström (1982), Lunn and Martin (1986) and Dilling-Hansen et al. (1998).

² See Levin et al. (1985).

Technical entry barriers and other factors

In industries where the optimal plant size is large (minimum efficient scale high) or where capital requirement is high (meaning high sunk cost for potential entrants), entry will probably be impeded and therefore, the existing firms may have less incentive to invest in R&D as a competitive strategy. In general, high barriers to entry may have a negative effect on the research intensity, as noted by Lunn and Martin (1986). However, the empirical evidence is ambiguous. Lunn and Martin (1986) do not detect any significant influence from technical entry barriers, whereas Wahlroos and Backstroem (1982) and Dilling-Hansen et al. (1998) find a stable negative and significant effect of MES on the R&D intensity.

Market conditions

Harris (1988) and Bishop and Wiseman (1999) argue that the proportion of a firm's turnover accounted for by exports is expected to affect innovation positively, i.e. innovation is motivated by the possibility to overcome entry barriers in new markets. Lunn and Martin (1986) and Hughes (1986) argue that the relation between R&D and exports is positive, because the market for exporting firms is much larger. Kleinknecht and Poot (1992) include a dummy variable stating whether the firm has exported more or less than 50% of its sales while Dixon and Seddighi (1996) focus on the distribution of innovative firms compared to the distribution of non-innovative firms on intervals of export. Whereas the latter two analyses do not find a positive and significant relation between export and the innovative or R&D effort of the firm, Bishop and Wiseman (1999) find a clear positive influence of export activity on the likelihood of R&D as well as of innovation.

Profitability, financial solvency

Using a profit maximising model, Lunn and Martin (1986) demonstrate that the first-order conditions with respect to R&D are similar to the Dorfman-Steiner condition of the amount of advertising, i.e. it pays to increase the R&D effort to get a more profitable marginal sale. Thus, a positive relation between the price-cost margin and the research intensity is expected.

In addition, imperfect capital markets often have been mentioned as another reason for positive correlation between profit and R&D (the liquidity constraint hypothesis). As R&D is an intangible (uncertain) asset, raising external funds will take place at higher costs or at more unfavourable conditions than for other investments. Therefore, internal funding (using retained earnings) becomes relatively favourable. In this respect, profitable firms have better opportunities for investing in R&D or innovation.

Empirical analyses of the liquidity constraint hypothesis have typically included the cost-price margin or a similar measure of profit as explanatory variables in the R&D equation. However, a more appropriate measure of the ability to finance R&D investments by using internal funds is the debt/assets ratio of the firm, or alternatively the financial solvency of the firm. For firms with high financial solvency it is easier to finance R&D investments without borrowing funds at all. Further, as noticed by Niininen (1997) firms may prefer internal finance in high-risk investments like R&D, see also Hall (1992). Accordingly, the expected impact of the solvency of the firm on the R&D intensity is positive.

The empirical evidence on the effects of profitability on R&D is somewhat mixed, however. Lunn and Martin (1986) found a significant negative effect of profitability on the R&D intensity that was especially strong in a subsample of high-tech industries. This result is in opposition to Niininen (1997) who states that more long-term debt decreases R&D investments, whereas a high cash flow stimulates R&D investments.

3. Empirical Model and Data

Most of the studies mentioned in the previous section focus on the relation between productivity and either R&D or innovation. In line with Harris (1988) and Bishop and Wiseman (1999), we assume that a recursive model can explain the probability that a firm invests in R&D and the probability that innovation activities takes place within the firm. The R&D and innovation activities are assumed to depend on the factors discussed in the former section. Furthermore, if the firm has R&D activities, the likelihood that it is innovative is expected to increase as being innovative can be seen as the output of the R&D effort.

Starting with the R&D behaviour, the likelihood that a firm invests in R&D depends on market structure, firm size, ownership and the other variables discussed in the former section. Next, innovation is basically a function of the same variables except for the fact that having a R&D function is assumed to increase the likelihood of innovation in itself. Accordingly, the empirical model is specified as follows

$$(1) \text{ INNOVATION}_i = \alpha_0 + \alpha_1 \text{ R\&D}_i + \sum \alpha_j X_{ij} + \sigma_i$$

$$(2) \text{ R\&D}_i = \beta_0 + \sum \beta_j X_{ij} + \varepsilon_i$$

where INNOVATION_i is a measure of the innovative activity for a given firm i . Correspondingly, R\&D_i measures whether the firm invests in R&D or not. X_{ij} represents the variables that are expected to affect the R&D and innovation within the firm.

In line with Bishop & Wiseman (1999), it is assumed that "The coefficients in equation 2 represent the indirect effects of the variables on innovation through their influence on the likelihood of a R&D function." The coefficients in equation 1 account for the direct effect on the likelihood of innovation from the variables over and above the indirect effects via R&D.

Assuming that the causal relationship between R&D and innovation is one way — from R&D to innovation — (1) and (2) can be estimated as two separate equations using single estimation forms.

The data used in this study comes from five different sources. First, general information on the economic performance of firms is taken from The Danish Bureau of Statistics. The basic source of information is firm-specific account figures derived from the legal obligation of companies to publish reports to the authorities.

Next, the data on R&D comes from the official Danish R&D statistics, which is collected every second year. At the empirical level, the concept of R&D comprises creative work undertaken on a systematic basis in order to increase the stock of knowledge of man and society, and the use of this stock in order to devise new applications (see the Frascati-manual, p. 29). The basic reporting unit of the R&D survey is the legal firm unit, which can be identified in the account statistics. In the 1997 R&D survey, the number of respondents was 4,082, of which 3,424 firms returned the questionnaire, giving a response rate of 85%. Of these, 1,013 firms reported having positive intra- and/or extramural R&D expenditure.

The third data source is the Second Community Innovation Survey for Danish firms, CIS II. Firms are defined to be

innovative if they either have introduced new technology or have improved production processes or products or have engaged unsuccessfully in projects aiming at introducing new or improved production processes or products during the period of observation. The CIS II questionnaire has been conducted in the period 1994–1996.

Data on ownership concentration comes from a private company, Koebmandsstandens Oplysningsbureau, which collected firm-specific information from the authorities. According to the Danish Rules and Regulations, private companies must report if they own more than 5% of the shares in a particular company.

Finally, information on foreign ownership is added. This information has been collected from various issues of the yearly publication "Greens – Boersens håndbog om dansk erhvervsliv." The firms included in Greens have either more than 50 employees or a turnover exceeding DKK 50 million in 1994-prices. For this project, only data for a limited number of firms have been completed on foreign ownership.

Merging the different data sources by the firm identification number results in a final data set including 1,755 firms with R&D information and about 600 firms with information on innovation. Table 1 lists the variables used in this study with a summary statistics.

³ The concentration ratio has not been corrected for import/export.

Table 1

Summary statistics of the merged firm data set
1,755 firms in 1997

	Unweighted mean	Standard deviation
Size of firm (number of employees)	238	649
Number of owners with equity share > 5%	1.49	1.11
Product market concentration (CR4)	0.39	0.23
Minimum efficient scale (log Quartilesales, Industry at the 4digit level, NACE-categories)	5.02	1.65
Financial solvency (net capital/total assets)	0.32	0.12
Export intensity (Export/turnover)	0.30	0.34
High-tech intensity (1, else equal to 0)	0.47	–
The firm being R&D active (1, else equal to 0)	0.30	–
The firm being innovative* (1, else equal to 0)	0.84	–
The firm is foreign owned** (1, else equal to 0)	0.15	–
* Data for 1996, 451 observations. Except for information on innovation, the data relates to 1997. ** Only 397 observations.		
Sources: Account data: The Danish Bureau of Statistics; R&D and CIS II data: The R&D statistics collected by Danish Institute for Studies in Research and Research Policy; Ownership information: Koebmandsstandens Oplysningsbureau.		

The table shows that larger firms are over-represented in the sample. Average size corresponds to a firm size of 238 employees, which is relatively high in Denmark, and moreover, the high standard error suggests that there are very large firms included in the sample.

The product market concentration rate is calculated as a standard 4-firm concentration ratio.³ In accordance with other studies, the MES is approximated by the quartile of firm sale in each industry defined at the 4-digit NACE-level.

The definition of financial solvency and export intensity is straightforward, each variable having an average close to one third. However, the variation in financial solvency is much lower than that for the export intensity.

In addition, a dummy variable is included in order to control for different technological opportunities across industries. Thus, high-tech industries are defined according to the standard OECD classification, i.e. firms belonging to NACE 3530,3001/02,2441/42 and 3200-3299.

The ownership variable is defined as the number of blockholders, i.e. owners in possession of at least 5% of the equity capital of the firm. The data on ownership shows that most of the firms have between 1 and 4 owners (in possession of at least 5% of the shares), i.e. the average number equals 1.48 and the standard error equals 1.11. So the number of significant owners is relatively small for the large majority of firms. The ownership variable does not account for different distribution of the

shares among the owners like the Herfindahl-index. However, a blockholder may gain a position in the board, and since you normally cannot vote according to your capital share in the board, the number of blockholders may give a good approximation of the different opinions within the board.

According to the table, 30% of the included firms were R&D active and as expected, a much larger share declared themselves to be innovative, namely 84%. The figures are representative for the Danish R&D and Innovation Statistics.

4. Empirical Results

Table 2 presents the results from five different models of the logistic estimations of the probability of investing in research and development. Generally, the models perform very well with a concordant (or correct prediction) between 65% and 73% of the observations. Also the estimated parameters of the models are very stable across the different model specifications.

³ The concentration ratio has not been corrected for import/export.

Table 2

Logistics estimation of the probability of investing in research and development

	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)
Intercept	-2.155 (0.246)	-2.880 (0.357)	-3.035 (0.367)	-2.929 (0.376)	-2.921 (0.372)
Firm size	0.3498 (0.0369)	0.2773 (0.0396)	0.2649 (0.0402)	0.2248 (0.0419)	0.2768 (0.0408)
Number of blockowners	-0.2933 (0.1652)	-0.2897 (0.1700)	-0.2969 (0.1701)	-0.2880 (0.1747)	-0.2868 (0.1702)
Number of blockowners, squared	0.0583 (0.0257)	0.0591 (0.0264)	0.0602 (0.0264)	0.0580 (0.0271)	0.0589 (0.0265)
Concentration		4.663 (1.052)	4.380 (1.059)	2.8723 (1.1031)	3.9936 (1.0801)
Concentration, squared		-2.749 (1.008)	-2.574 (1.013)	-1.5463 (1.0528)	-2.3309 (1.0248)
Min. efficiency scale		-0.0587 (0.0338)	-0.0611 (0.0339)	-0.0783 (0.0352)	-0.0976 (0.0382)
Financial solvency			0.9438 (0.4622)	0.9730 (0.4799)	0.8644 (0.4656)
Export share				1.6032 (0.1673)	
High-tech industries					0.2773 (0.1311)
-2 log likelihood	2,105	1,989	1,979	1,885	1,974
Concordant	65.1	68.8	69.0	73.4	69.2
Number of observations	1,792	1,761	1,755	1,755	1,755

Note: Numbers in brackets are standard errors of the estimated parameters.

Firm size has a very significant and positive effect on the probability that firms undertake investments in R&D. However, note that this is not enough evidence for the Schumpeterian hypothesis that big firms are more innovative and invest more in R&D. In addition, the hypothesis may require that the share of turnover invested in R&D is increasing with firm size.

The number of block owners has a significant effect on the probability that firms choose to invest in R&D. Generally, the relationship is U-shaped with the lowest R&D probability for firms with 2.4 owners. The result that firms with only one owner or firms with many owners are more likely to undertake R&D activities is in accordance with the theories discussed above. One owner has the full incentive to monitor the management and undertake long-term investments in R&D. On the other hand, from the portfolio view, firms with several block owners can take higher risks and therefore, they are more likely to invest in R&D.

In the experimental phase of the model, variants were estimated by including dummy variables in order to control for foreign ownership and the legal form of the firm LTDs versus personally owned firms. Even though the estimated parameters were correctly signed, i.e. LTDs are more likely to invest in R&D and foreign owned firms are less likely to invest in R&D, the parameters were not significant, at all. In the latter case, this is probably due to the very low number of observations on foreign ownership in the data set, while estimating the influence of company form gave multicollinearity problems with the number of block owners. Most LTDs have more than one owner.

Also the estimated effect from the market competition variables is in accordance with the expected effect. Minimum efficient scale has a significant negative effect on the probability of investing in R&D. This evidence confirms the hypothesis that high barriers to entry reduce the need of developing new products or cheaper production methods.

The estimated effects from industry concentrations indicate an inverted-U relationship with a maximum R&D probability at a four-firm concentration ratio of 0.92. This value is fairly high and shows that absence of incentives to invest in R&D is not a problem in monopolies although the increase in the probability to invest in R&D levels off in highly concentrated industries.

Financial solvency has a significant positive effect on the likelihood that firms undertake R&D activities, see model (3) in table 2. The results confirm the hypothesis of imperfect capital markets, where highly risky and intangible R&D investments have to be financed mainly by equity capital.

The last two models in table 2 successively include the export share and a dummy for the high-tech sectors. Both variables have a significant positive effect on firms' incen-

tive to invest in R&D. The two variables are highly correlated as the high-tech industries have high export shares, and some care may be taken with the interpretation of the estimated coefficient for the two variables. However, the result indicates, that the demand side is important for investments in R&D, where new or big export markets increase the returns from this investment. The dummy for high-tech industries corrects for the higher R&D investment possibilities in these sectors. As can be seen from table 2, it does not change the size of the estimated coefficient for the other variables.

Table 3 presents the results from five different specifications, i.e. model (2) above, of the logistic estimations of the probability of undertaking innovative activities. Generally, the models perform well with a concordant or correct prediction of where a firm has innovative activities in about 70% of the observations. The estimated parameters of the models are also very stable across the different model specifications. The estimated parameters for owner concentration and product market concentration, however, are not significant, but one has to keep in mind that one of the reasons for a less significant model — compared to the R&D model — is the fact that the sample is small compared to the R&D sample.

All the estimated models of the probability of being innovative show that investments in R&D have a significant positive effect on the innovative activity in the firm. Also firm size and export share have positive effects. On the other hand, owner concentration and the competitive environment of the firm do not have any significant direct effect on the innovative activity beside the indirect effect through the R&D variable. These results are in accordance with the findings of Bishop and Wiseman (1999), who found a direct effect from market share but no direct effect from (foreign) ownership.

5. The Importance of the Ownership Structure

Using the estimated model in column (4), table 2, the probability that a firm invests in R&D can be calculated for different kinds of firms. Figure 1 illustrates the probability that an average firm invests in R&D as a function of ownership concentration and product market concentration.

The probability that a firm invests in R&D increases with higher product market concentration reaching the maximum probability at a concentration ratio close to 0.9. However, the absolute variation across various concentration values seems limited, i.e., the difference in probability for the highest versus the lowest value of the concentration ratio is only 0.25, illustrated by the rather flat curves in the figure.

Contrary to product market concentration the number of blockholders seems relatively important. As mentioned

Table 3

Logistics estimation of the probability of undertaking innovation activities

	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)
Intercept	-0.0600 (0.7792)	0.2098 (1.0535)	0.2581 (1.0602)	0.4067 (1.0676)	0.2835 (1.0628)
R&D dummy	0.9663 (0.2992)	1.0002 (0.3087)	1.0011 (0.3089)	0.8664 (0.3150)	1.0089 (0.3100)
Firm size	0.3915 (0.1075)	0.3771 (0.1128)	0.3819 (0.1138)	0.3569 (0.1143)	0.4041 (0.1149)
Number of owners	-0.5820 (0.5625)	-0.5927 (0.6110)	-0.5774 (0.6109)	-0.6512 (0.6386)	-0.5296 (0.6668)
Number of owners, squared	0.0887 (0.1096)	0.1001 (0.1219)	0.0982 (0.1217)	0.1094 (0.1273)	0.0913 (0.1203)
Concentration		-2.0076 (2.6728)	-1.8658 (2.7103)	-2.8540 (2.7591)	-2.0815 (2.7006)
Concentration, squared		1.8113 (2.5410)	1.7131 (2.5607)	2.3468 (2.5732)	1.7405 (2.5511)
Min. efficiency scale		0.0415 (0.0840)	0.0405 (0.0841)	0.0390 (0.0843)	-0.0125 (0.0921)
Financial solvency			-0.3666 (1.0832)	-0.2891 (1.0911)	-0.5675 (1.0931)
Export share				0.9895 (0.4409)	
High-tech industries					0.4462 (0.3155)
-2 log likelihood	366	356	355	350	353
Concordant	70.4	70.7	70.7	72.1	71.3
Number of observations	467	452	451	451	451

Note: Numbers in brackets are standard errors of the estimated parameters.

earlier, the functional form of the influence of ownership ends up being U-shaped with a minimum probability for the number of blockholders close to 3. So changing the number of owners from 1 to 3 only changes the probability of R&D with 2.5 percentage points, but going from 3 to 5 owners has an effect on the estimated probability of approximately 8 percentage points.⁴ Furthermore, increasing the number of owners from 7 to 9 changes the probability with 25 percentage points. The overall variability as a function of blockownership is as high as 53 percentage points, suggesting a notable influence from the owner concentration on the probability that a firm invests in R&D.

Figure 2 presents the results from simulations focussing on the effect from export performance and financial solvency. The probably has been calculated for average values of minimum efficient scale and product market concentration. The number of (+5%) owners has been fixed to 5.

Basically the curves show that the probability of investing in R&D increases with firm size. Thus the likelihood that an average firm with 3,000 employees invests in R&D is 20 percentage points higher than is the case for a firm with 50 employees.

Next, the curves also demonstrate that for a given firm size, higher export share increases the probability that firms invest in R&D. The difference in probability between firms with an export intensity of 100% and the opposite extreme 0% is nearly 40 percentage points.

The influence from financial solvency is more moderate. The absolute difference in the probability that firms invest in R&D is 23 percentage points higher for a firm with a financial solvency of 100% compared to a firm that is 100% financed by debt.

If the results in this section are combined with the estimation results in table 2, noting that the influence from the ownership variable is stable and fairly significant across the various estimations forms, it can be concluded that the ownership concentration seems to be important for firms' incentive to invest in R&D.

⁴ The comparisons are made for product market concentration equal to 0.5.

Figure 1

Simulated probabilities that a firm invests in R&D

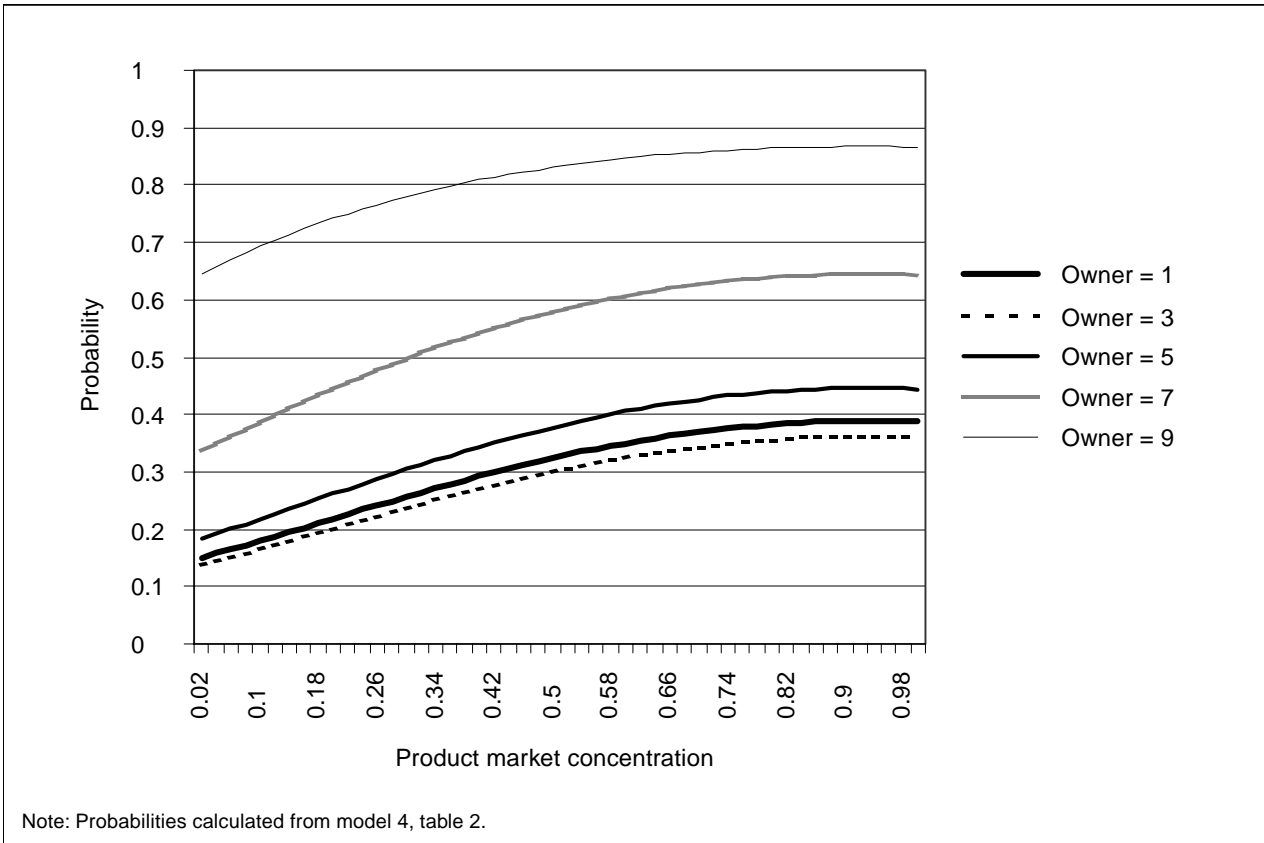
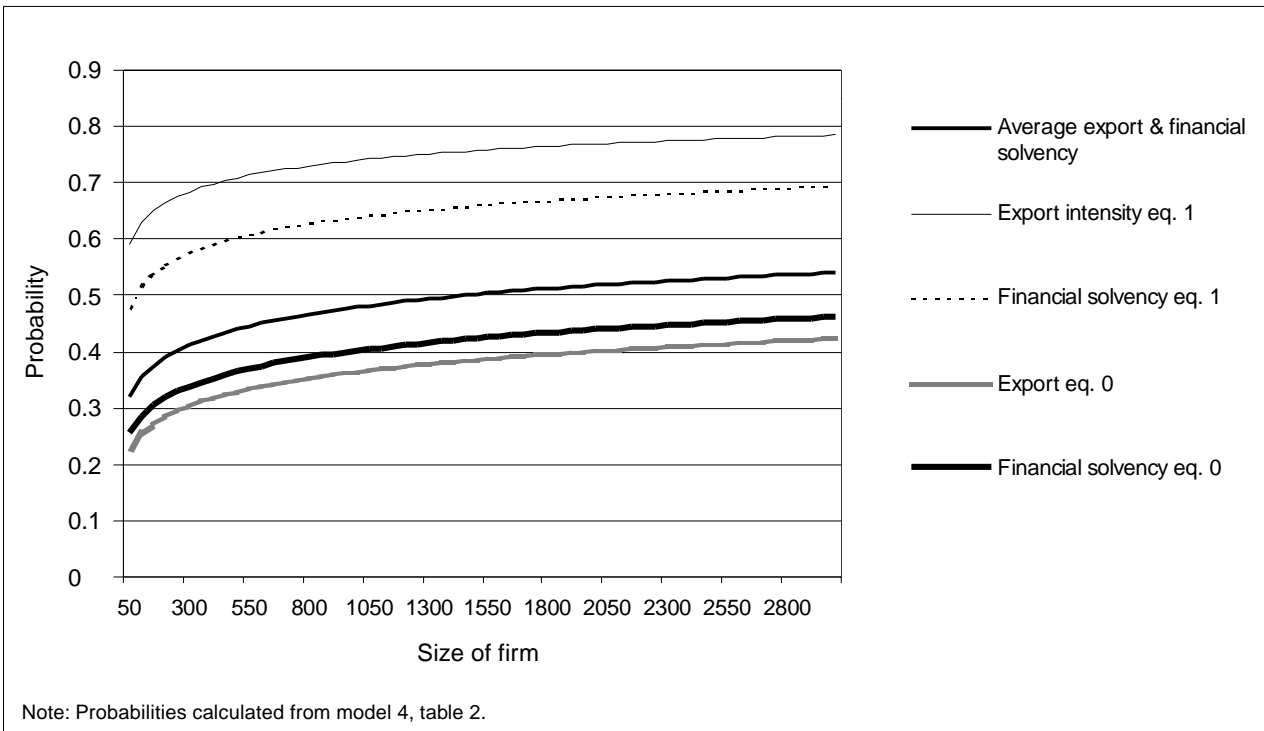


Figure 2

Simulated probabilities that a firm invests in R&D



6. Conclusions

The paper analyses the influence of ownership structure on the innovation behaviour of 1,755 Danish firms. Contrary to many of the existing studies on corporate governance, which are based on samples of very big companies, the sample used in this study also incorporates small companies. Therefore, it is more representative for the total firm population.

Ownership concentration is measured with the number of blockholders, i.e. owners with more than 5% of a firm's equity capital. This variable has a significant positive impact on the probability of investing in R&D. However, we find that the relationship between the number of blockholders and the probability of investing in R&D is U-shaped, with the smallest probability of performing R&D for firms with 2–3 large owners. This result is in favour of the portfolio view that firms with several blockowners can take higher risks and therefore, they are more likely to invest in R&D. Furthermore, this result is consistent with the traditional view that firms with only one owner have the full knowledge (incentive) to pursue long-term strategies, i.e. to invest in R&D projects.

The study shows that the probability that a firm invests in R&D is significantly and positively affected by firm size, financial solvency, export share and market concentration up to a CR_4 value of 90%. Other factors, such as foreign ownership or the legal form of the firm did not have significant effects. Looking at the relative importance of the factors determining the R&D activity, simulations showed that the influence coming from owner concentration is more important than product market concentration or other firm characteristics. Finally, the estimated models for R&D activity did behave quite well being able to predict the observations in the data set close to three-quarters of the time.

The paper also estimates models for the innovative behaviour of the firm and shows that investment in R&D, export share and firm size have significant positive effects on the innovative activity in the firm. However, the influence from owner concentration and product market concentration seems mainly to work indirectly through their influence on R&D. This means that a firm's decision to invest in R&D is the most important factor behind innovation.

References

- Amemiya* (1981): Qualitative Response models: A survey. In: *Journal of Economic Literature*, Vol. XIX, No. 4, 1483–1536.
- Arrow*, K.J. (1962): Economic Welfare and the Allocation of Resources for Invention. In: NBER, *The Rate and Direction of Inventive Activity: Economic and Social Forces*, Princeton.
- Battaglion*, M.R., L. *Tajoli* (1999): Ownership Structure, Innovation Process and Competitive Performance: The Case of Italy. Paper prepared for Corporate Governance and Investment Project Workshop, Aarhus, November 13–14.
- Bishop*, P., N. *Wiseman* (1999): External Ownership and Innovation in the UK. In: *Applied Economics*, 31, 443–450.
- Cohen*, W.M., S. *Klepper* (1996): A Reprise of Size and R&D. In: *Economic Journal*, 106, 925–951.
- Demsetz*, H., K. *Lehn* (1985): The Structure of Corporate Ownership: Causes and Consequences. In: *Journal of Political Economy*, 93 (6), 1155–1177.
- Dilling-Hansen*, M., T. *Eriksson*, E.S. *Madsen*, V. *Smith* (1998): Market Structure, Publicly and Privately Financed R&D Spending. Empirical Evidence for Denmark. Discussion Paper 1998-20, Centre for Industrial Economics, University of Copenhagen and The Danish Economic Journal, 1, 66–80.
- Dixon*, A.J., H.R. *Seddighi* (1996): An Analysis of R&D Activities in North East England Manufacturing Firms: The Results of a Sample Survey. In: *Regional Studies*, 30 (3), 287–294.
- Foerre*, S.E. (1997): Er store foretak mer forskningsintensive? En anvendelse av diagnostiske metoder. Statistiscs Norway, Rapport 97/11.
- Hall*, B. (1992): Investment and Research and Development at the Firm Level: Does the Source of Finance Matter? NBER Working Paper No. 4096, Cambridge MA.
- Harris*, R. (1988): Technological Change and Regional Development in the UK: Evidence from SPRU Database on Innovation. In: *Regional Studies*, 25.5, 361–374.
- Hughes*, K. (1986): *Exports and Technology*. Cambridge.
- Kleinknecht*, A., T.P. *Poot* (1992): Do regions matter for R&D? In: *Regional Studies*, 26 (3), 221–232.
- La Porta*, R., F. *Lopez-De-Silanes*, A. *Shleifer* (1999): Corporate Ownership Around the World. In: *The Journal of Finance*, 54 (2), 471–517.

Leibenstein, H. (1966): Allocative Efficiency vs. X-Efficiency. In: *American Economic Review*, 56, 392–415.

Lehmann, E., J. Weigand (2000): Does the Governed Corporation Perform Better? Governance Structures and Corporate Performance in Germany. Discussion Paper Series, Centre of Finance and Econometrics, University of Konstanz.

Levin, R.C., W.M. Cohen, D.C. Mowery (1985): R&D Appropriability, Opportunity, and Market Structure: New Evidence on Some Schumpeterian Hypotheses. In: *American Economic Review*, 75 (2), 20–24.

Love, J.H., B. Ashcroft, S. Dunlop (1996): Corporate Structure, Ownership and the Likelihood of Innovation. In: *Applied Economics*, 28, 737–746.

Lunn, J., S. Martin (1986): Market Structure, Firm Structure, and Research and Development. In: *Quarterly Review of Economic and Business*, 26, 31–44.

The Danish Ministry of Research (1997): Research and Development in the Business Sector in 1995.

Needham, D. (1975): Market Structure and Firms' R & D Behaviour. In: *Journal of Industrial Economics*, 23, 241–255.

Niininen, P. (1997): Technology Subsidies, R&D Investment and Productivity. In: *Laaksonen, S. (ed.): The Evolution of Firms and Industries. Research Reports*, 223, Statistics Finland, 340–351.

OECD (1994): *The Frascati Manual*.

Scherer, F.M. (1967): Research and Development Allocation under Rivalry. In: *Quarterly Journal of Economics*, 71, 359–394.

Scherer F.M., D. Ross (1990): *Industrial Market Structure and Economic Performance*, Boston.

Scott, John T. (1984): Firm versus Industry Variability in R&D Intensity. In: *Griliches, Zvi (ed.): R&D, Patents, and Productivity*, Chicago/London.

Schumpeter, J. (1942): *Capitalism, Socialism and Democracy*. Harper & Row.

Vossen, R.W. (1998): Strategic and Tactical Decisions, Sunk Costs and Firm Size Effects in R&D. Research Report, 98B19, SOM, University of Gronigen.

Wahlroos, B., M. Backström (1982): R&D Intensity with Endogenous Concentration. In: *Empirical Economics*, 7, 13–22.