Non-technical Summary

This paper discusses the different incentives of managers versus firm owners to invest in innovative activities. Economic theory proposes different incentives in owner-led firms and manager-controlled firms. In the first place, the impact of risk on the incentive to invest in R&D are compared for the capital-led and the managerial firm. On the one hand, the risk of dismissal for the manager implies less innovative investment than in the "traditional" capital-led firm. On the other hand, innovative activity will most likely increase the growth rate and therefore the size of a firm. This is a positive stimulus for R&D in the managerial firm.

We present empirical analyses on the determinants of the R&D intensity of firms. We use a sample of 3,978 observations from the Mannheim Innovation Panel. Aside of more conventional measures like competition, size and other variables, we explain the R&D activities by the leadership and the ownership of firms. On the one hand, we distinguish manager-led firms from owner-led firms. On the other hand, we hypothesise that the R&D expenditures of manager-led firms depend on the control exerted. We take that into account by a Herfindahl index of capital dispersion.

We estimate Tobit models and it turns out that the management control has a significant impact on the R&D intensity of firms. If the capital shares are widely dispersed and the managers are thus not intensively controlled by the owners, they invest more into R&D than others. In contrast, there is no significant difference in R&D intensities among owner-led firms and managers who are strongly controlled.

Management Control and Innovative Activity[1]

by

Dirk Czarnitzki* and Kornelius Kraft**

Decembre 2000

Abstract

This paper discusses theoretically the different incentives of managers versus firm owners to invest in innovative activities. There are opposing effects concerning R&D intensity in the manager-controlled firm. Our study on the determinants of R&D intensity presents empirical results concerning this question. A sample of German firms with 3,978 observations is used and it turns out that the owner-led firms invest less into R&D than the managerial firms. With respect to the manager-led firms, expenditures on R&D depend on the control exerted. If capital shares are widely dispersed and managers are thus only controlled a little by owners, they invest more into R&D. Owner-led firms and managers who are strongly controlled have a very similar R&D intensity.

Keywords: Innovative Activity, Managerial versus Owner-led Firms, Incentives, Tobit Regression

JEL-Classification: O32, O31, D21, C24

* Centre for European Economic Research, Mannheim, Germany
** University of Essen, Germany

---

[1] We are grateful to the members of the MIP-Team for providing the data, i.e. Thorsten Doherr, Günther Ebling, Sandra Gottschalk, Norbert Janz and Hiltrud Niggemann. Especially, we thank Jürgen Moka for maintaining the VVC database with the information on capital dispersion and leadership of the firms. Additionally, we thank Georg Licht for helpful discussions and Heide Crawford for proof reading.

1 Introduction

The importance of technological progress for the wealth and long-term growth of nations has been acknowledged by scholars from very different schools of thought. In the 1970s and 1980s several studies reported the decline in productivity growth (see, e.g. Dertouzos et al. 1989) and discussed the effect of R&D in this context (see, e.g. Fagerberg 1987). Clearly, productivity growth is the most important determinant of income improvement and thus the wealth development of an economy.

There are interesting questions concerning the reduced growth rates: Are they a result of less successful innovation policies in modern firms? At the same time, the importance of large firms in contrast to small ones with respect to innovation is an important topic (Acs and Audretsch 1988, 1990). Evidence from case or industry studies point to the view that large firms mainly pursue established technological trajectories and that really revolutionary innovations come from outside (Henderson 1993).

Since the beginning of the discussion on innovation, a major emphasis has been given to the central role of the entrepreneur for this process. For example, Kirzner (1985) in line with the view of Mises (1951) emphasizes that

a) the market is an entrepreneurial process,
b) a learning process is central to the market and
c) entrepreneurial activities are creative acts of discovery.

In stark contrast to these statements on the entrepreneurs, nowadays big firms are led by managers which leads to a classical principal agent problem. Managers are mainly paid on the basis of a fixed salary and it is rather questionable whether they always act in the interest of the capital owners. According to Mises (1951) an entrepreneur is defined by the following criterion: "There is a simple rule of thumb to tell entrepreneurs from non-entrepreneurs. The entrepreneurs are those on whom the incidence of losses on the capital employed falls." If this definition is used, the vast majority of the leading firms in all developed capitalist countries are not led by entrepreneurs. It remains to be investigated which consequences this has for the innovation process.

The topic is not really new. Kraft (1989) discusses this among other determinants of innovative activity. It is empirically demonstrated that managerial firms show less innovative activity than owner-led companies. However, Kraft (1989) provides no deeper theoretical analysis concerning this result and has only a very small sample for the empirical test. Recently, some theoretical contributions have elaborated on this issue. Holmström (1989) discusses the principal agent problem in the context of innovation. Zwiebel (1995) uses a two-period model with the expected remuneration of managers and considers the incentives for innovation if a manager is dismissed, provided the performance is below some level. Aghion, Dewatripont and Rey (1997) apply an intertemporal model to demonstrate that managers will invest less in innovation than others. They assume that the managers have private costs connected with innovations that determine their results. Schmidt (1997) examines the impact of product market competition on managerial incentives within a static model with uncertain profits. All papers assume risk-neutral agents, which can be criticized as a very restrictive assumption in principal-agent situations like managerial remuneration.[2]

The incentives of managers and the optimal payment structure have been discussed in many articles. The present paper deals with the role of managerial leadership of large firms in innovative activity in comparison to owner-led firms, i.e. the "classical" entrepreneurial firm. Furthermore, we investigate the effect of capital share dispersion: we consider the question whether close capital market control has the same, a similar, or no impact on management behavior in comparison to owner-led firms. At first, the incentives for a managerial-led firm in contrast to the entrepreneurial firm are discussed. This discussion demon-

---

[2] We omit the literature on capital structure and management incentives as these contributions consider a quite different problem. Cf., among others, Dewatripont and Tirole (1994) and Hart and Moore (1995).

strates that opposing effects are at work here. Subsequently, we present the results of an empirical study concerning this question. We analyse whether the leadership of firms (managers versus owners) and the dispersion of capital shares have an effect on investment in R&D. For this purpose, we use data collected by the Mannheim Innovation Panel (MIP) of the Centre for European Economic Research (ZEW). In total, we have information on 2,223 German firms for the years from 1992 to 1996, which leads to 3,978 observations. We have information on whether management has a significant share of the capital and thus the firm is led by at least one of the owners. Additionally, we use the capital share dispersion as a measure of capital market control. The MIP has information on small and medium-sized firms, which are often controlled by a single owner as well as on large firms with several owners. The dispersion of the capital ownership is measured as a Herfindahl index which is added as an explanatory variable to more conventional variables that explain innovation.

2 Theoretical Considerations

2.1 Risk

Investment in R&D is clearly a risky project. Actually, one of the most important tasks when innovative activity is analyzed is the consideration of the effect of risk. In the given context firm ownership has essentially two effects:

1. the attitude towards risk, in particular risk-aversion versus risk-neutrality and
2. the effect of uncertain returns on the expected income of a capital owner in comparison to that of a manager.

The first aspect is of potential interest, but the effects are quite obvious and need no further analysis.[3] The second effect will be considered more in detail.

In most cases managers are paid on the basis of a fixed part and a profit-related component. Of course the capital owner only receives profits. However, in contrast to the owner, who cannot be dismissed, managers face the risk of

[3] A standard model is Holmström and Milgrom (1987). A good exposition of the whole issue is Milgrom and Roberts (1992).

dismissal if the performance of the firm is below a certain level. As innovative projects are necessarily risky and in most cases more risky than investment into capacity enlargement, for example, managers have the specific risk of being dismissed if a project fails completely. This is essentially the point of Zwiebel (1995).

2.2 Firm Size

For some time now it has been discussed whether and, if so, why managerial firms are size oriented.[4] It seems to be an accepted “stylized fact” that managers’ salaries depend largely on firm size and only to a small degree on returns on capital. For example, Baker, Jensen and Murphy (1988) cite evidence that as a general rule the salary of top executives increases by 3% when the firm’s sales increase by 10%. This will clearly lead to a growth orientation of managerial firms. Non-monetary determinants of managers’ utility-like status, power and prestige are most likely more closely related to firm size than to profitability. Perhaps the capital market realizes the financial success, but the public opinion is more impressed by employment figures and thus the personal influence increases with firm size.

The pursuit of increasing size as an aim in addition to, or at the expense of, profit is at least a widely discussed hypothesis. If time enters the analysis, it is natural that growth maximization is considered. Firm growth will, among other things, be determined by innovation. New products in particular, but also superior new processes will lead to larger sales figures. Of course, not every innovation project will lead to a success, but higher expenditures for R&D and more projects will increase the probability of one or more successful results. Certainly, there are less risky ways to increase firm size, in particular mergers. These are intensively investigated and their average negative impact for overall profits is well established. Perhaps as a substitute for this now critically discussed strategy, managers pursue other ways to increase size. The public

---

[4] Cf. among many others Marris (1964), Williamson (1964), Baumol (1962).

usually views innovative activity positively and a higher rate will hardly be criticized by anybody. Therefore, this might be a better strategy than mergers and acquisition. However, we do not claim that R&D activities are the only alternative to mergers.

Risk aversion by managers and their growth orientation are opposing arguments if the managers' incentives are investigated. Risk will most likely reduce the degree of R&D expenditures, but growth orientation and the positive valuation of innovation in the public is a stimulus for it. The net effect seems to be unclear a priori. In Appendix B we present a simple model for the opposing incentive effects for managers.

It is also necessary to mention that the effects discussed above can only be realized if the top managers are not closely controlled. If a dominant shareholder exists, for example an owner family that has a large capital share, in most cases the behavior of the managers is closely investigated. With a wide dispersion of the capital shares the managers have more freedom. For the single capital share a change of the total return on capital does not have much absolute effect. Additionally, in a modern stock company the management control is quite difficult, perhaps impossible, for an individual shareholder. The necessary information on exerting control is hardly available. For this reason we check for the impact of capital share dispersion on the behavior of managerial firms.

3 Empirical Study

Some theoretical articles deal with the impact of managerial leadership on innovation. However, there is very scant empirical evidence on this quite fundamental question, given the dominance of the large manager-led firms in all developed countries. The only empirical study that we are aware of is Kraft (1989). Actually, Kraft finds a lower level of innovative activity for managerial firms. His sample, however, only has 58 firms and is therefore quite small. Although useful as a first indication, a broader and more representative study is needed for an analysis of this question.

The theory deals with the difference between classical entrepreneurial firms and modern managerial firms. We have information on whether one or more dominant firm owners exists and in addition, whether one or more of them are also the top managers. Thus we intend to differentiate between the managerial and the owner-led firm based on this information. The owner-led firm is presumably more in line with the classical entrepreneurial firm than the managerial firm and we want to investigate the effect of this differentiation on R&D.

There is extensive literature on the control exerted by capital owners and the behavior of the firms, in particular profitability and management compensation.[5] We follow this literature in that we assume that a narrow control of the capital owners reduces the discretionary power of the managers. An efficient control leads to an efficient level of R&D and, perhaps more importantly, if the capital owners have a close look at the development of the firm and the environmental conditions, the asymmetric information problem is reduced or does not exist at all. This means that the capital owners know whether a good or bad profit situation is due to managerial slack or caused by bad luck. If this is true, the managers must not fear being dismissed if the profits are below a certain level because it is recognized that this is not their personal fault. Our hypothesis is that risk and size effects should have no effect or only a small effect if a dominant capital owner exists.

The control exerted by the capital will be a positive function of the concentration of the capital stock. If capital is widely dispersed, the returns from effective control are small for the individual capitalist and will therefore hardly be exerted. This is a classical public goods problem. In accordance with the literature on capital control (applied to other problems than innovation) we use the dispersion of capital shares as the measure for control exerted from the capital owners. We have quite detailed information on this and are able to calculate a Her-

[5] As representative examples, see Leech and Leahy (1991) as well as Kraft and Niederprüm (1999).

findahl index on capital dispersion. This variable is used in connection with more conventional ones to explain the R&D intensity in firms.

3.1 Data

This study uses data from the Mannheim Innovation Panel (MIP) conducted by the Centre for European Economic Research (ZEW) on behalf of the German Federal Ministry for Education and Research (bmb+f). This survey was launched in 1992 and collects information from about 2,500 firms of the manufacturing sector every year. It represents the German part of the Community Innovation Survey (CIS) of the European Commission. Additionally, we used some information given in the database of the "Verband der Vereine Creditreform" which represents the sampling frame for the MIP. We use data from the years 1992 to 1996. However, the response rate to some questions is limited and, overall, data concerning 2,223 innovating firms are used. The Mannheim Innovation Panel defines innovators according to the Oslo-Manual's guidelines (OECD 1997, p. 47):

> "Technological product and process (TPP) innovations comprise implemented technologically new products and processes and significant technological improvements in products and processes. A TPP innovation has been implemented if it has been introduced on the market (product innovation) or used within a production process (process innovation). TPP innovations involve a series of scientific, technological, organisational, financial and commercial activities. The TPP innovating firm is one that has implemented technologically improved products or processes during the period under review."

It is important to note that we only use firms with limited liability and stock companies because in Germany only firms with these legal forms are able to split management and ownership. This yields an unbalanced panel of about 3,978 observations. We pool the data for our regression analyses because less than 3% of the firms participated in all observed years. More than 50% of firms were observed only once (see Table 2 in the appendix A).

The study analyzes the activity of firms specified as the expenditures for R&D divided by sales (multiplied by 100). This is a standard variable and it is named R&D/SALES. For 3,018 observations R&D/SALES is greater than zero. The other firms did not engage in R&D activities at all.

The focus of our analysis is the impact of the structure of firms' ownership on innovation activities. Therefore, we create a variable HERF which is a concentration index of owners' shares. Actually, this is calculated like the Herfindahl index. Thus, HERF takes values between zero and one. It is close to zero if a firm has many owners who all hold a small share. However, if one owner holds the whole capital, it takes the value one. Additionally, we create the dummy variable OWN. This is one if a firm is owner-led, i.e. the manager(s) hold any capital shares. OWN is zero otherwise. Finally, we consider the degree of management control by CONTROL=(1-OWN)*HERF. If a manager leads the firm this variable takes the value of our capital dispersion index HERF and it is zero otherwise. Using the variables OWN and CONTROL we can describe three types of management: 1. An owner-led firm (OWN=1, CONTROL=0), 2. A strongly controlled manager (OWN=0, CONTROL=1 or close to one), 3. A less strongly controlled or even uncontrolled manager (OWN=0, CONTROL=0 or close to 0).

Additionally, we use the following explanatory variables: The market share (SHARE) is measured at the three-digit industry level.[6] The share of sales exported (EXPORT) is measured on the individual firm level and describes the participation to international competition. A related variable is the share of sales of foreign firms compared to total shares of both foreign and domestic firms in an industry, which is called IMPORT. This variable is expected to express the competitive pressure from other countries and is, of course, quite important for an open economy like Germany.[7] The next variable is the concentration ratio (CONC), which is defined as the Herfindahl index at the three-digit industry level. It is the sum of squared market shares of the firms operating in the three-digit industry (and then multiplied by 1,000). In addition we use the change of the index from period to period (DCONC). We assume that the consideration of international trade, the concentration index, the change of this index, and the

[6] As industry classification we use the European standard called NACE.
[7] Unfortunately, for some industries IMPORT was only available at a two-digit level.

individual market share make it possible to identify the degree of competitive pressure with which a firm is faced.

Firm size is specified by seven size classes for the number of employees. These dummy variables control whether innovative activity varies with firm size. This takes into account another classical hypothesis by Schumpeter, namely that larger firms show more innovation activity. The size classes are expected to check for possibly non-linear size effects in a more variable way than, for example, employment and employment squared. However, the results are insensitive to the particular size variable. It is possible that the younger firms are also the more innovative ones, as the foundation of a firm usually goes hand in hand with the introduction of one or more innovations. The established firms are often reluctant to introduce “fundamental” innovations and these are launched by newly founded companies. In order to account for the effect of the age of a firm, we include the inverse of the age of a firm in question (1/AGE). We use the inverse in order to account for a probable non-linear relationship between age and innovative activities. The variable capital intensity (KAPIN) is defined as tangible fixed assets per employee in millions DM and is included in order to control for differing technologies as well as for barriers to entry.

The data cover firms that are located in both western and eastern Germany (the former GDR). In the 1990s, eastern German firms received many tax incentives and direct subsidies from the government in order to support their development. Hence, it is possible that eastern German firms behave differently from western German ones. We include a dummy variable (EAST) that has unit value for companies operating in eastern Germany. It is well known that technical opportunities differ considerably among industries. We include 13 two-digit industry dummies in order to control for specific effects. Furthermore, four time dummies indicate whether an observation is from 1993, 1994, 1995 or 1996. The year 1992 is the basis in this case. Descriptive statistics of the variables used can be found in the Appendix.

Due to the censorship of the distribution of the dependent variable R&D/SALES we estimate Tobit models. As is frequently the case in microeconomic data, heteroscedasticity occurs. We computed LM-Tests as suggested in Greene (1997, p. 969). Thus, we consider a Tobit model with groupwise heteroscedasticity. The heteroscedasticity term contains industry and size dummies as well as year dummies and our regional indicator EAST.

Initially, we use data of all firms. In order to test for the robustness of the results, we then consider only managerial firms. The results are shown in Table 1.

Both the owner-led firms and the management-led firms with large capital owners have fewer expenditures for R&D than the other firms. The Herfindahl-index for the capital share dispersion has no significant independent effect. These results are somewhat surprising, as the growth effect dominates the risk aspect that is perhaps unexpected. The results are just the opposite of what Zwiebel (1995) and Aghion et al. (1997) suppose. We explain the difference by the dominance of the firm size with respect to the growth argument for managerial incentives. Zwiebel (1995) and Aghion et al. (1997) do not discuss this aspect. On the one hand managers get “punished” for insufficient profits by a dismissal, but on the other hand they get a “reward” for high growth rates via increased salaries.

Table 1: Determinants of R&D/SALES - Tobit regressions

	Complete Sample		Only manager-led firms	
	Tobit	Tobit with Heteroscedasticity	Tobit	Tobit with Heteroscedasticity
KAPINT	.49 (.26)	.05 (.06)	-1.18 (-.48)	-.56 (-.62)
20-49 employees#	-.17 (-.29)	2.49 *** (3.36)	-2.88 (-2.30)	1.50 (.63)
50-99 employees#	-.55 (-.95)	2.65 *** (3.65)	-2.48 (-2.05)	2.88 (1.22)
100-199 employees#	-1.37 ** (-2.28)	2.70 *** (3.79)	-3.63 ** (-3.10)	2.71 (1.16)
200-499 employees#	-.58 (-.96)	3.02 *** (4.25)	-2.79 (-2.40)	2.98 (1.28)
500-999 employees#	.013 * (.02)	3.00 *** (4.15)	-2.20 (-1.84)	3.03 (1.30)
1000 and more employees#	.96 (1.26)	3.54 *** (4.66)	-1.23 (-.99)	3.40 (1.45)
EXPORT	.05 *** (7.57)	.02 *** (7.92)	.05 *** (5.97)	.02 *** (5.75)
SHARE	.06 (1.27)	.05 * (1.66)	.06 (1.14)	.06 * (1.85)
IMPORT	.14 *** (5.68)	.07 *** (5.27)	.15 *** (4.59)	.10 *** (5.54)
CONC	-.01 (-1.33)	-.01 ** (-2.07)	-.01 * (-1.91)	-.01 *** (-3.26)
DCONC	.07 *** (2.63)	.04 *** (2.78)	.05 (1.46)	.05 ** (2.20)
1/AGE	1.39 (1.03)	-.04 (-.05)	5.57 *** (2.75)	.03 (.04)
EAST	3.61 *** (8.96)	1.56 *** (6.80)	2.82 *** (5.00)	1.48 *** (5.68)
OWN	-1.72 *** (-3.79)	-.41 ** (-2.30)		
CONTROL	-2.11 *** (-3.27)	-.70 ** (-2.41)	-1.60 *** (-3.84)	-.43 *** (-2.70)
HERF	.55 (1.13)	.18 (.78)		
Constant	-5.17 *** (-4.72)	-4.60 *** (-5.57)	-2.52 (-1.55)	-5.10 ** (-2.12)
Log Likelihood	-11,262.92	-9,928.82	-6,364.38	-5,472.80
Number of observations	3,978		2,133	
Share of censored obs.	.32		.23	

Notes: All estimations include 13 industry dummies and 4 time dummies. The results are not reported. The heteroscedasticity was modeled groupwise (see Greene 1997, p. 967). The heteroscedasticity term contains size dummies, industry dummies, time dummies and EAST. The t-values are given in parentheses.
*** (**, *) denotes a significance level of 1% (5%, 10%).
# The reference class consists of firms with 5 to 19 employees.

A test of the hypothesis that the coefficients of the owner-led dummy OWN and the interaction variable CONTROL are equal shows that these are not significantly different. Hence, the delegation of tasks to managers instead of leadership by the owners themselves has no effect on the R&D intensity if the managers are closely controlled.

The evaluation of the result on R&D expenditures is most likely different from the firm owner and the society's point of view. We have no information on the rentability of the R&D expenditures, but since the owner-led and the efficiently controlled firms show fewer expenditures, we assume that the management controlled firms have too much R&D if profit maximization is the aim. The capital owners will most likely disapprove of this apparent waste of resources. However, the individual evaluation must not be equivalent to the society's total welfare effect. Given the importance of spillovers from R&D expenditures to other firms, positive external effects of innovative activity exist and then the firm's individual incentives might be too low from the society's viewpoint. Hence, the larger expenditures of the managerial firms might be welfare superior. Given that the literature discusses the problematic aspects of managerial leadership more frequently, our result concerning R&D is perhaps one of the few instances in which managerial firms have a positive aspect.

The other results are of interest as well. The control variables work quite well. A strong effect comes from the share of exported sales. The import ratio also has a strong positive impact on R&D activity. Apparently, these firms are forced to be innovative in order to be successful in international competition. In line with these results on international competition is the negative and significant coefficient of the concentration variable. However, in contrast, DCONC is significant and positive, which points to another conclusion.

The time dummies 1994 and 1995 (which are not reported) are significant. Additionally, we find strong differences between the individual industries, which does not come as a surprise. Firm size also has an effect, but only the differences with respect to the smallest firm class are large. The size classes with

200 to 499 employees and with 500 to 999 employees have about the same coefficients, but otherwise expenditures for R&D divided by sales increase with firm size.

4 Conclusion

We investigate the impact of the leadership of a firm on the incentives for innovative activity. In the first place, the impact of risk on the incentive to invest in R&D are compared for the capital-led and the managerial firm. On the one hand, the risk of dismissal for the manager implies less innovative investment than in the “traditional“ capital-led firm. On the other hand, innovative activity will most likely increase the growth rate and therefore the size of a firm. This is a positive stimulus for R&D in the managerial firm.

Furthermore, the results of an empirical study are reported. We compared whether owner-led firms differ from managerial firms in general. Additionally, we consider the impact of capital market control. Capital control is defined as the dispersion of capital shares and is measured by use of a Herfindahl index. The more dispersed capital ownership is, the more the firm invests in R&D. The capital share concentration has about the same effect as if one or more of the capital owners were also the top managers: They invest less in R&D. If profit maximisation is concerned then it is not necessary to “make everything oneself”, but a close control suffices. However, if R&D activities have large spillovers to other firms, it is questionable whether the private optimal expenditures are also the socially desirable ones.

At first glance this result seems to be in contrast with case studies like Henderson (1993) and with the a priori expectations of most economists. Many stories exist in which established firms rejected offers from inventors regarding new products. The inventors frequently had to found a new enterprise themselves because otherwise the inventions would never be commercialized. The recent attention that newly founded small enterprises have attracted in the public and by the politicians in many countries is perhaps motivated by such cases.

Apparently, our results contradict these case studies. However, this must not necessarily be true. Perhaps managerial (uncontrolled) firms pursue the more established and less risky projects with their R&D activities. It is possible that really revolutionary (and very risky) innovations are not developed by the large firms but come from the small capital-led ones. It is still a possibility that large managerial firms have incremental innovations, but not the really new inventions. However, this is speculative and in order to say something about this question, we need more detailed information on the innovative output.

Appendix A

Table 2: Panel Structure

Observed Patterns							
1992	1993	1994	1995	1996	Firms	Percent	Cum.
X					500	22.49	22.49
				X	239	10.75	33.24
	X				237	10.66	43.90
		X			196	8.82	52.72
X	X				146	6.57	59.29
X	X	X			90	4.05	63.34
	X	X			78	3.51	66.85
X		X			69	3.10	69.95
X	X	X	X	X	67	3.01	72.96
Other Patterns					601	27.04	100.00
					2,223	100.00	

Table 3: Descriptive Statistics

Variable	Mean	Std. Dev.	Min.	Max.
R&D/SALES	3.55	7.37	0	92.11
KAPINT	.08	.08	.0018	.67
Employees/1000	.46	1.68	.005	40.98
EXPORT	21.06	23.31	0	100.00
SHARE	.63	3.09	.00037	90.39
IMPORT	20.11	9.20	5.53	54.43
CONC	47.84	34.01	2.10	234.87
DCONC	.37	5.02	-30.56	66.77
1/AGE	.15	.15	.0042	1.00
EAST	.36	.48	0	1.00
OWN	.46	.50	0	1.00
CONTROL	.39	.49	0	1.00
HERF	.50	.50	0	1.00

Appendix B

R&D and Growth in the Owner-Led Firm

In this section the level of innovative activity is derived on the basis of the following assumptions:

- Innovative activity is specified as expenditures for R&D and is called i.
- It is assumed that R&D expenditures improve the product quality and lead to the introduction of new goods. We consider something like "standard sales volume" S, which has the same value, if no innovation activities are pursued. With positive R&D expenditures the expected growth rate μ is also positive and increases in i, however, at a decreasing rate.
- In addition it is assumed that risk also increases in R&D expenditures and therefore the variance σ^2 is a positive function of investment in R&D. These assumptions lead to

  $$\frac{\partial \mu}{\partial i} > 0, \frac{\partial^2 \mu}{\partial i^2} < 0 \text{ and } \frac{\partial \sigma^2}{\partial i} > 0, \frac{\partial^2 \sigma^2}{\partial i^2} > 0.$$

The term σ^2 stands for the expected variance of the expected growth rate μ of the firm. These specifications[8] appear to be quite plausible concerning the effects of R&D projects. For example the assumptions can be motivated by the intention of the firm to invest in projects with low risk in the first place, but with larger investments more risky projects are also started. The decreasing returns to innovative activity are standard and necessary to have equilibrium. In sum, it also follows that if R&D expenditures are above some critical value, the standard deviation increases by a larger rate than the growth rate and hence

$$\frac{\partial \frac{\mu}{\sqrt{\sigma^2}}}{\partial i} < 0.$$

As usual, we assume a risk-neutral firm owner and the utility of this person depends only on profits. The expected profit of the firm in this case is

$$V = \int_0^\infty E_t\left(S\right)e^{-(r-\mu)(s-t)}ds - i = E\left(\frac{S}{r-\mu}\right) - i$$

with the interest rate r. The interest rate might also reflect the risk of bankruptcy if nothing or not enough is invested in R&D (a larger value of *r* implies a higher risk of bankruptcy). We also assume $r-\mu>0$ in order that the integral is bounded. Profit maximization by a risk-neutral firm owner at date 0 implies:

$$\frac{\partial E(V)}{\partial i} = E\left(\frac{S}{(r-\mu)^2}\frac{\partial \mu}{\partial i}\right) - 1 = 0\,.$$

The decreasing returns to R&D with respect to growth guarantee that the maximization problem is strictly concave in R&D investment and has an internal solution.

R&D in the Managerial Firm

The managerial firm does not necessarily choose the same solution as the owner-led firm. In order to interpret the behavior of the manager, the incentives to managers must be considered. In Germany, managers are usually paid on the basis of a large fixed component and a smaller flexible and profit-dependent part.

Most empirical studies of managerial compensation schemes find that performance has a surprisingly small impact on remuneration. In an examination of US companies, Jensen and Murphy (1990) found that a one dollar increase in the total wealth of capital owners (stock value and dividend) leads to only a three cent increase in management's total compensation.

---

[8] In order to exclude uninteresting corner solutions it is also assumed that $\lim_{i\to 0}\frac{\partial \mu}{\partial i} \to \infty$ is true.

In the first place, this dominant remuneration rule is applied to determine the innovation strategy in this case and to compare it with the solution in the case of unrestricted profit maximization without an explicit derivation of it. In the next section the remuneration rule is endogenously determined.

The model is based on the Principal-Agent paradigm with moral hazard. There are two economic actors: the informed party (Agent) whose information is relevant for the common welfare and the uninformed party (Principal). The Principal proposes a contract and the Agent accepts or rejects the offer.

B.1 Risk

Assumption: If the manager does not meet a certain performance level, she or he is dismissed and incurs a utility loss[9] (compare for a similar assumption Schmidt 1997). This means that in the case of dismissal the manager must incur search costs to find a new job. She or he may become unemployed for some time and may have to move for an adequate position. These losses could also reflect the loss in firm-specific human capital. Most important is probably the loss in reputation, i.e. the dismissed manager has the stigma of being a loser and of being rather incompetent. Their future income and also prestige will generally be lower than it used to be.

Assumption: For simplicity, the value of income in the case of dismissal is adjusted to zero without any loss of generality (for a similar assumption, cf. Zwiebel 1995).

The required performance level is defined as a ratio ν of the expected growth rate $\hat{\mu}$. The expected growth rate as a function of R&D investment is assumed to be public knowledge, as it may, for example, be based on forecasts by economic research institutes, estimations by banks and investment institutes, on

---

[9] Several studies besides Jensen and Murphy (1990) have examined the dependence of management compensation on performance [c.f. Gibbons and Murphy (1990), Main (1991), Kaplan (1994a,b)] as well as "punishment" in the case of management failure [Weisbach (1988); Warner, Watts and Wruck (1988); Gilson (1989); Fizel and Louie (1990)].

announcements by competitors, or projections of the industry average. The project-specific risk, however, is not known. If the firm in question has a growth rate below $\nu\hat{\mu}$, the manager is dismissed[10]. Hence, the manager must first take into account the effects of R&D investment on expected growth and, second, the impact on risk. The probability θ of not meeting the given standard is defined as $\theta(\tilde{\mu} < \nu\hat{\mu})$, with the realized value $\tilde{\mu}$ of the growth rate. The probability of not reaching this level clearly depends on the standard deviation of the innovation process. Assuming a normal distribution the ex ante probability of $\tilde{\mu} < \nu\hat{\mu}$ can be expressed as

$$\theta\left(\frac{\nu\mu - \hat{\mu}}{\sigma}\right) = \Phi\left(\frac{\nu\mu - \hat{\mu}}{\sigma}\right)$$

where Φ stands for the cumulative distribution function.

B.2 Firm Size

There is extensive literature that discusses whether and why managers' salaries depend on firm size and not on profits alone (cf. the classical references Marris 1964, Williamson 1964, Baumol 1962). Fershtman (1985), Fershtman and Judd (1987) and Sklivas (1987) have given an explanation for this phenomenon. In oligopoly, it might be optimal to commit managers to follow apparently non-profit maximizing behavior by relating salaries to firm size. The firm will then grow and become a Stackelberg leader in an oligopolistic setting. The incentives are a credible commitment to reach for size. If the other firm does not follow such a strategy, the firm maximizing growth will realize larger profits. If, however, the other firm follows the same strategy, both will have lower profits and a classical prisoner's dilemma emerges.

In oligopoly the owner-led firms have the same incentive to become the Stackelberg-leader as the manager-led firms. Hence, if managerial firms are com-

[10] The hat stands for the expected value of growth and clearly $0 < \nu < 1$. For example, it could be 50% but any value below one will have the same effect.

pared with owner-led ones, there can only be a difference if the owner-led firms are for some reason unable to commit to the output increasing strategy. This is indeed a possibility, as a written contract is a credible commitment, which cannot be replicated by an owner-led firm.

Rosen (1992) offers another explanation for the orientation of salaries at firm size. The leader of a larger organization has a greater responsibility and if he or she is successful, the marginal product will be higher than at the top of a smaller company (Rosen 1992). Thus the mere observation of higher salaries paid by larger firms says nothing about the incentive structure. Zábojník (1998) explains sales maximization as a possibility to solve the problem of underinvestment into specific human capital.

There might as well be other reasons at work for the dependence of salaries on sales. Sales are easy to implement as an aim, while profits can be measured in many different ways. Accounting profits may have only a loose relation to economically meaningful profit measures. Irrespective of being risk-neutral or risk-averse, managers[11] will dislike incentive schemes based on profit rates that are not very reliable and subject to idiosyncratic and accidental fluctuations.

The simultaneous consideration of profit and sales orientation of the incentives is included by adoption of the Fershtmen and Judd (1987) and Sklivas (1987) remuneration scheme, (which is also suited for an analysis of managerial behavior outside of oligopolistic interdependence). In accordance with Fershtman (1985), Fershtman and Judd (1987) as well as Sklivas (1987) managers are assumed to be risk-neutral here. The manager is paid at the margin in proportion α_i to a linear combination of profits π_i and sales S_i :

$$O_i = \alpha_i \pi + (1-\alpha_i) S_i$$

[11] Risk aversion is not considered by Fershtman (1985), Judd and Fershtman (1987) as well as Sklivas (1987).

The manager's remuneration, however, will in general not be O_i but $E(M) = F + \gamma O_i$, with F standing for the fixed component of remuneration and γ representing the share of profits and/or sales that goes to the managers. Since the reward is linear in profits and sales and she or he is risk-neutral, the manager acts to maximize O_i and the values of F and γ are irrelevant. In order to adjust the Fershtman/Judd/Sklivas salaries rule to our dynamic innovation problem the manager is paid on the basis of intertemporal profits and sales volume.

In order to satisfy the participation constraint, the expected income has to be greater or equal to the outside option $\bar{u}$. The manager's maximization problem at date 0 is now:

(15)

$$E(M) = (1-\theta)\gamma\left\{\alpha\left(E\left(\frac{S}{r-\mu}\right)-i\right)+(1-\alpha)E\left(\frac{S}{r-\mu}\right)\right| + \theta*0 + F$$

$$= (1-\theta)\gamma\left\{E\left(\frac{S}{r-\mu}\right)-\alpha i\right\}+F \geq \bar{u}.$$

with $\theta = \theta\left(\frac{\hat{\mu}(1-\nu)}{\sigma}\right.$.

Maximization of this relation leads to:

(16)

$$\frac{\partial E(M)}{\partial i} = (1-\theta)\gamma\left\{E\left(\frac{S}{(r-\mu)^2}\frac{\partial \mu}{\partial i}\right)-\alpha\right.$$

$$-\frac{\partial \theta}{\partial\left(\frac{\hat{\mu}(1-\nu)}{\sigma}\right)}\frac{\partial\left(\frac{\hat{\mu}(1-\nu)}{\sigma}\right)}{\partial i}\gamma\left\{E\left(\frac{(S)}{r-\mu}\right)-\alpha i\right\} = 0$$

The assumptions concerning R&D guarantee that the manager's optimization problem is globally concave and has a unique solution.[12] The first term is only identical to unrestricted profit maximization if $\alpha = 1$ and $\gamma = 1$. There are two opposing effects at work, namely size and risk: Given the growth orientation of management, the marginal unit of R&D is only evaluated at the ratio $\alpha < 1$ and therefore the management invests more than the owner firm. The ratio $\gamma < 1$ does not play a role here. However, the second effect is that as long as the risk of dismissal θ increases with innovative activity, the manager will invest less in R&D than the owner-led firm. In addition, the managers will invest more in less risky projects in order to minimize their personal risk of being dismissed. Hence, the manager-led firm is expected to invest more in conventional projects rather than in really "revolutionary" products and processes. Casual evidence seems to support the view that fundamental innovations are not developed by the large manager-led firms, but by smaller owner-led ones. The large firms buy a license or even a whole firm if an innovation turns out to be successful. It is unclear, which one of the two opposing effects is the stronger one, and it remains a question that can only be answered by use of an empirical study. In the absence of the threat of dismissal, the derivative

$$\frac{\partial \theta}{\partial \left(\frac{\hat{\mu}(1-\nu)}{\sigma} \right)} \frac{\partial \left(\frac{\hat{\mu}(1-\nu)}{\sigma} \right)}{\partial i} = 0$$

and the optimization leads to larger R&D expenditures in comparison to the owner-led firm.

[12] Clearly R&D must be above the critical level necessary for a decreasing ratio of the growth rate to the standard deviation, but this condition is obviously implied from the first order condition.

References

Acs, Z.J. and D.B. Audretsch (1988), Innovation in Large and Small Firms, *American Economic Review* 78, 678-690.

Acs, Z.J. and D.B. Audretsch (1990), *Innovation and Small Firms*, Cambridge.

Aghion, P., M. Dewatripont, and P. Rey (1997), Corporate Governance, Competition Policy and Industrial Policy, *European Economic Review* 41, 797-805.

Baker, G.P., M.C. Jensen and K.J. Murphy (1988), Compensation and Incentives: Practice versus Theory, *Journal of Finance* 43, 593-616.

Baumol, W. (1962), On the Theory of the Expansion of Firms, *American Economic Review* 52, 1078-1087.

Dertouzos, M.L., R.K. Lester, R.M. Solow and the MIT Commission on Industrial Productivity (1989), *Made in America*, New York.

Dewatripont, M. and J. Tirole (1994), A Theory of Debt and Equity: Diversity of Securities and Manager-Shareholder Congruence, *Quarterly Journal of Economics* 109 ,1027-1054.

Fagerberg, J. (1987), A Technology Gap Approach to Why Growth Rates Differ, *Research Policy* 16, 87-99.

Fershtman, C. (1985), International Organizations and Managerial Incentives as Strategic Variables in Competitive Environment, *International Journal of Industrial Organization* 3, 245-253.

Fershtman, C. and K.L. Judd (1987), Equilibrium Incentives in Oligopoly, *American Economic Review* 77, 927-940.

Fizel, J.L. and K. Louie (1990), CEO Retention, Firm Performance and Corporate Governance, *Managerial and Decision Economics* 11, 167-176.

Garen, J.E. (1994), Executive Compensation and Principal-Agent Theory, *Journal of Political Economy* 102, 1175-1199.

Gibbons, R. and K. Murphy (1990), Relative Performance Evaluation for Chief Executive Officers, *Industrial and Labor Relations Review* 43 (supplement), 30S-51S.

Gilson, S.C. (1989), Management Turnover and Financial Distress, *Journal of Financial Economics* 25, 241-262.

Greene, W.H. (1997), *Econometric Analysis*, 3rd ed., New York.

Hart, O. and J. Moore (1995), Debt and Seniority: An Analysis of the Role of Hard Claims in Constraining Management, *American Economic Review* 85, 567-585.

Henderson, R. (1993), Underinvestment and Incompetence as Responses to Radical Innovation; Evidence from the Photolithographic Alignment Equipment Industry, *RAND Journal of Economics* 24, 248-270.

Holmström, B. (1989), Agency Costs and Innovation, *Journal of Economic Behavior and Organization* 12(3), 305-327.

Holmström, B. and P. Milgrom (1987), Aggregation and Linearity in the Provision of Intertemporal Incentives, *Econometrica* 55, 303-328.

Jensen, M.C. and K.J. Murphy (1990), Performance Pay and Top-Management Incentives, *Journal of Political Economy* 98, 225-264.

Kaplan, S.N., (1994a), Top Executives, Turnover, and Firm Performance in Germany, *Journal of Law, Economics & Organization* 10, 142-159.

Kaplan, S.N. (1994b), Top Executive Rewards and Firm Performance: A Comparison of Japan and the United States, *Journal of Political Economy* 102, 510-546.

Kirzner, I.M. (1985), *Discovery and the Capitalist Process*, Chicago.

Kraft, K. (1989), Market Structure, Firm Characteristics and Innovative Activity, *Journal of Industrial Economics* 37, 329-336.

Kraft, K. and A. Niederprüm (1999), Determinants of Management Compensation with Risk-Averse Agents and Dispersed Ownership of the Firm, *Journal of Economic Behavior and Organization* 40, 17-27.

Leech, D. and J. Leahy (1991), Ownership Structure, Control Type Classifications and the Performance of Large British Companies, *Economic Journal* 101, 1418-1437.

Main, B.G.M. (1991), Top Executive Pay and Performance, *Managerial and Decision Economics* 12, 219-229.

Marris, R. (1964), *The Economic Theory of the "Managerial" Firm*, London.

Mehran, H. (1995), Executive Compensation Structure, Ownership, and Firm Performance, *Journal of Financial Economics* 38, 163-184.

Milgrom, P. and J. Roberts (1992), *Economics, Organization and Management*, Prentice Hall, Englewood Cliffs.

Mises, L. (1951), *Profit and Loss*, *Consumers-Producers Economic Services*, South Holland.

OECD (1997), *Oslo-Manual – Proposed Guidelines for Collecting and Interpreting Technological Innovation Data*, Paris.

Rosen, S. (1992), Contracts and the Market for Executives, in: L. Werin and H. Wijkander (eds.), *Contract Economics*, Oxford, 181-211.

Schmidt, K.M. (1997), Managerial Incentives and Product Market Competition, *Review of Economic Studies* 64, 191-213.

Sklivas, S.D. (1987), The Strategy Choice of Managerial Incentives", *RAND Journal of Economics* 18, 452-458.

Warner, J.B., R.C. Watts and K.H. Wruck (1988), Stock Prices and Top Management Changes, *Journal of Financial Economics* 20, 461-492.

Weisbach, M.S. (1988), Outside Directors and CEO Turnover, *Journal of Financial Economics* 20, 431-460.

Williamson, O.E. (1964), *The Economics of Discretionary Behavior: Managerial Objectives in a Theory of the Firm*, Englewood Cliffs, N.J.: Prentice-Hall

Zábojník, J. (1998), Sales Maximization and Specific Human Capital, *RAND Journal of Economics* 29, 790-802.

Zwiebel, J. (1995), Corporate Conservatism and Relative Compensation, *Journal of Political Economy* 103, 1-25.