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On the Profitability of Innovative Assets

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Abstract

Successful innovative activity is a major contribution to the intangible capital of firms. Although its importance is generally acknowledged, the contribution to companies' profits is a priori unclear. We present the results of an empirical study on the effects of the patent stock on profitability. The database is a representative sample of German manufacturing firms and we use a number of control variables including measures of competition and firm governance. It turns out that the patent stock has a strong and robust effect on profitability.

Keywords: Innovation, Patents, Profitability, Discrete Regression Models

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1 Introduction

Innovation is generally considered as a major cause of economic growth and is one important source (along with human capital) of the wealth of the developed countries (see e.g. the survey by Fagerberg, 1994). Although a significant part of the investment for science and technology is undertaken by governmental agencies, like universities, research institutions or through subsidy grants, the major part is privately financed. Firms invest into research and development in order to maximize their individual profits, but not necessarily economic welfare. However, investments in research and development (R&D) are examples for very high risks of failure of the pursued projects. A large part of all outlays may have no return at all and whether the innovative activity has a positive return on average is a matter that is not clear at the outset.

It is a trivial statement that every investment is risky. However, R&D projects have some peculiarities that render such activities particularly uncertain. R&D is by its definition concerned with a-priori unknown outcomes, and therefore the risk of failure is higher than in the case of conventional investment processes (see e.g. Hall, 2002, for a survey on financing difficulties due to uncertain outcomes). Another feature of innovative activity are the long lags between R&D and the introduction of new products and processes (if they are successful at all). Finally R&D is a classic example of spill-over effects to other firms and therefore imitation is frequently an issue, which clearly reduces the profitability of successful R&D projects (see e.g. Arrow, 1962). Although imitation is not costless, it is clearly cheaper than original R&D and therefore imitation might well be a profit maximizing alternative to innovative activity.¹ At least there seems to be some kind of international division of labour which leads to some countries innovating and others imitating. This reflects, on the one hand, available resources in particular human capital and, on the other hand, production costs namely wages. The risk of imitation is reflected in many models of the new growth literature (see e.g. the textbooks of Aghion and Howitt, 1998, or Barro and Sala-i-Martin, 2004).

Hence it is not clear that innovation has actually a positive impact on a firm's profits. In contrast, as stated at the beginning, the economy usually benefits from innovation as this is

¹ Very few studies are able to compute the costs of imitation. Mansfield et al. (1981) estimate that imitation amounts to about 65% of the costs of innovation.

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3 one major source for productivity increases, growth of a country's gross domestic product
4 (GDP) and finally higher income of the population. Despite the believe that R&D is beneficial
5 for the economy as a whole, it is unclear whether innovative activity is beneficial to the
6 individual firm. R&D projects may frequently fail and spill-overs to competitors may hinder
7 the appropriability of returns. Thus, the social and the private return may differ substantially.
8 This may explain the empirical observation that the majority of firms in industrialized
9 countries chooses not to conduct own internal R&D (see Table 1).

10
11 In this paper, we report the results of an empirical study on the effects of innovation on firms
12 profits. Innovation is measured as the patent stock being the depreciated sum of all past patent
13 applications at the individual firm level. Thus, the patent stock reflects previous R&D
14 investment of a firm and approximates its knowledge capital. Using the patent stock as
15 innovation indicator avoids complicated lag structures of past values of patents.

16
17 This study extends previous research in at least two respects: First, we use a representative
18 sample of firms from which the majority is not required to publish accounting data. This is a
19 major difference to nearly all existing studies, which are based on data from stock
20 corporations. These firms are clearly not representative for an economy as they are on average
21 quite large. Moreover, as they are required to publish their balance sheets, it is not clear how
22 reliable this information is. We use the Mannheim Innovation Panel (MIP) which contains
23 information on a representative sample of German manufacturing firms with more than five
24 employees. The median value of employment is 67 and therefore they are much smaller than
25 the comparable firm of a typical data set previously used for profitability studies.

26
27 Second, aside of standard measures, we use some control variables that are usually neglected,
28 but at least of a potential importance in order to explain profitability. In particular, we
29 consider capital ownership of the top management. It is a long discussed issue whether the
30 managerial-led firm shows the same behavior as the owner-led company. The survey by
31 Shleifer and Vishny (1997) discusses this question in detail (cf. Gugler et al., 2002, for a
32 recent empirical study). Many authors argue that managers favor growth in comparison to
33 profit maximization. If this is true, profitability would be lower in such firms.

34
35 The remainder of the paper is organized as follows: Section 2 discusses the literature on
36 profitability and innovation, and guides our empirical model specification. Section 3 describes
37 the database employed and presents descriptive statistics of the variables used. The fourth
38 section discusses the regression results and the final section concludes.

2 On the profitability of innovation

In the public discussion concerning the competitiveness of an economy figures on innovative activity, like patent statistics play a prominent role. Usually it is assumed that the more innovations are realized, the better it is for the society without taking into account the possibility of wasted resources, if the projects are unsuccessful. In contrast firms do take account of this realistic possibility. Only a part of all firms do actually perform R&D, in fact it is only a minority. Table 1 shows the share of R&D performers in European countries derived from the Third Community Innovation Survey (CIS).² The share of R&D performing firms ranges from 14% in Iceland, Greece, and Spain to 41% in Germany and 44% in Belgium. Apparently the other companies think it is not worthwhile to perform it and produce established products by use of a “well-known” technology.

Table 1: Innovation and R&D activity in European Countries: Manufacturing Sector in 2000

	Belgium	Denmark	Finland	France	Germany	Greece
Share of innovators ^{a)}	59%	53%	49%	46%	67%	27%
Share of Innovators with own internal R&D activity ^{b)}	74%	71%	81%	66%	61%	53%
= Share of R&D performers	44%	38%	40%	30%	41%	14%
	Iceland	Italy	The Netherlands	Norway	Portugal	Spain
Share of innovators ^{a)}	54%	40%	55%	39%	45%	38%
Share of Innovators with own internal R&D activity ^{b)}	26%	37%	61%	62%	39%	38%
= Share of R&D performers	14%	15%	34%	24%	18%	14%

Source: European Commission (2004), Innovation in Europe - Results for the EU, Iceland and Norway, Luxembourg, Notes: a) An innovating firm is defined according to the Oslo-Manual (see Eurostat and OECD, 1997, for the exact definition). In brief, a firm is regarded as an innovator if it has introduced at least one new or improved product or new process within the last three years, or has ongoing activities to do so. b) Firm engaged in intramural R&D activity as defined by the Frascati Manual (see OECD, 1993).

The relationship between innovation and profits is a priori unclear and it is by no means clear that innovative activities really lead to higher returns at the microeconomic level. R&D is clearly a costly and risky process as several projects might fail and the return, if any, will be realized with a long delay. Furthermore, knowledge on innovation may leak out to competitors, which have not had the large expenditures on research and can thus produce at

² Countries that participated in the CIS survey were the 15 European Union (EU) Member states in 2001 plus Iceland and Norway. Countries not reported in Table 1 did not publish the share of R&D-performing firms.

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3 lower costs. It is also questionable, whether patents effectively prevent imitation.³ Imitation
4 may take place on the national level, as an imitating firm may choose a variant of the
5 innovative technology⁴. However it is sometimes argued that the larger problems with
6 imitating arise through international imitation. International intellectual property rights
7 protection seems to be quite problematic in many countries. It might well be the case that the
8 patent protection works on the national level but to much lesser degree internationally. There
9 seems to be some “division of labour” between the highly developed and other countries.
10 Hence some countries are better suited for innovation because of human capital advantages
11 and other specialize in imitation because production costs are lower. Acemoglu et al. (2006),
12 Dinopoulos and Segerstrom (2006), Grossman and Helpman (1991) as well as Segerstrom et
13 al. (1990) consider differences between countries concerning innovation and imitation
14 behavior. Connolly (2003) provides empirical evidence on the impact of trade on imitation (as
15 well as on innovation and growth).

16
17 However, the importance of innovation for economic growth is undisputed and therefore it is
18 indispensable for an economy to make sure that sufficient incentives exist for innovation at
19 the firm level. This question is certainly not only of academic relevance, but also a major
20 concern of policy makers in all industrial countries.

21
22 The importance of innovations for welfare and also the relevance of spillovers are in
23 particular emphasized in the new growth literature. A prominent contribution is Aghion and
24 Howitt (1992) who consider the invention of a new intermediate good, whose use as input
25 allows more efficient methods to be used in producing the consumption good. Hence the
26 innovations affect the productivity level of the production process. Innovators benefit from
27 other earlier innovations in that any innovation raises their productivity if they develop a new
28 innovation. The starting point of any innovation is the value of the preceding innovation and
29 this they call intertemporal spillovers. Aghion et al. (2005) discuss the role of spillovers in the
30 competitive process and their effect on the relation between leaders and followers as well as
31 on the impact of competitive pressure on R&D. Hence it is an interactive feed-back process
32 between innovative R&D and imitation, which determines the return to innovative activity
33 and therewith also the extent of R&D.

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³ This has already been pointed out by Arrow (1962).

⁴ Chen and Yang (2005) provide a recent empirical study on the effects of spillovers.

Another example concerning the interaction between innovation, imitation and growth is presented by Afonso (2006). He considers production of intermediate and final goods where technical progress is the result of a R&D process, which leads with a Poisson arrival rate to successful innovation. The value of the R&D input is assured by a system of intellectual property rights that protect a leading firm's monopoly profits if the innovator is successful. At the same time, however, the acquired technological knowledge disseminates to other firms and leads to better innovation capacity there. The other firms conduct R&D which, if successful, destroys the current leading-edge technology. Hence, the return of an innovation depends on the profits at each time, the interest rate, and on the duration of the technological leadership of the current monopolist. The duration in turn depends on the probability that R&D is successful.

The question of the economic return of innovative activity can only be answered empirically. As said above, one problem is the number of lags between R&D expenditures and the effect on profits. There exist not many studies which explicitly consider the lag structure between R&D expenditures and profits or sales at the firm level. An exception is Ravenscraft and Scherer (1982). They use PIMS⁵ data on individual business lines of 26 and 42 businesses (the number depends on the time periods available). The firms participating in the survey report the typical time lag between the beginning of the development and introduction of the resulting new product. For 45% of all companies this is only one to two years, while 40% express that two to five years are needed and 5% reported of a time lag of more than five years. The empirical results of Ravenscraft and Scherer point to a mean lag of four to six years, but the first returns are realized in the next year after starting the project.

We circumvent the problem of long lag structures by using a patent stock. The patent stock (PS) of firm i in period t is calculated by the perpetual inventory method with a constant depreciation rate as

$$PS_{it} = (1 - \delta) PS_{i,t-1} + PA_{it} ,$$

where PA is the number of patent applications in year t and δ is the constant depreciation rate that is set to 15% (see Griliches and Mairesse, 1984, and Hall, 1990, for more detailed descriptions).

⁵ PIMS means "Profit Impacts of Market Strategy" (see Schoeffler, 1997, for a data description).

The dependent variable is the profit margin. This variable is sometimes called excess return on sales and expresses the following:

$$\frac{\pi}{S} = \frac{S - \text{labor cost} - \text{capital cost} - \text{material cost}}{S}$$

with π denoting profits and S being sales. If firms are in the long-run equilibrium and are operating in the range of their production functions with constant returns to scale, the excess profit return on sales will, on average across all products produced by the firm, equal the Lerner index. With constant returns to scale marginal costs (MC) are equal to average costs (AC). One can therefore write:

$$\frac{\pi}{S} = \frac{pq - ACq}{pq} = \frac{p - MC}{p}$$

with p being the price and q the quantity produced. Hence, our measure is the price-cost margin, where the capital costs have been subtracted and need not to be taken into account by capital divided by sales as an explanatory variable as in other empirical models considering the price cost margin.⁶

The price-cost margin is usually explained by concentration in the industry and the market share of the firm in question. Some studies (e.g. like Geroski et al., 1993) additionally consider the interaction variable concentration times market share. We use the Herfindahl concentration index ($HERF$) in order to take account of imperfect competition. The market share ($SHARE$) is included here as well, because from a theoretical perspective there is a close relationship between the market share and the price-cost margin.⁷ The coefficient of the market share estimated simultaneously with the effect of the concentration variable is also interpreted as a measure on firm efficiency. If, for example, concentration is high in a particular market, all firms should benefit from a high price if concentration implies collusion. However if some firms are more efficient than others, they will receive a larger market share and at the same time will realize higher profits, but not because of collusion. Efficiency advantages will in the long run also lead to a high concentration ratio as the more efficient

⁶ The usual way to estimate price-cost margins was introduced by Collins and Preston (1969). There are numerous studies that follow the same methodology. Below we present results with the variable capital intensity defined as total capital/number of employees. The coefficient of this variable is accordingly not standing for capital costs, but is interpreted as a measure concerning barriers to entry. See our discussion below.

⁷ Cf. among others Cowling and Waterson (1976)

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3 firms will grow faster, have larger market shares than the others, which will possibly have to
4 leave the market. Hence a positive coefficient of the concentration variable is not sufficient
5 for the conclusion that collusion is at work.⁸
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9 Grabowksi and Mueller (1978) as well as Conolly and Hirschey (1984) propose another
10 variable describing imperfect competition. They suggest the use of a R&D variable interacted
11 with concentration (in addition to concentration and R&D). The idea is that in highly
12 concentrated industries, a tendency to cartelistic behavior exists. As it is well known there are
13 incentives to deviate from such collusive settlements and as R&D is especially difficult to
14 coordinate among firms, it may undermine a tendency towards shared monopoly behavior.
15 Thus, a prisoner's-dilemma situation arises where all firms will deviate from cartelistic
16 behavior. Then a negative coefficient of the interaction variable is expected. The rival
17 hypothesis is that in the presence of few competitors imitation problems are smaller and R&D
18 is more valuable. Then a positive coefficient should be estimated. We use the variable
19 $RD*HERF$, where RD is the firm specific R&D intensity (R&D expenditure divided by sales).
20 Additionally, we include the R&D intensity itself (RD).
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31 The R&D intensity must not necessarily have the same impact as patents. R&D is an input to
32 the innovation process, but in many cases R&D projects fail. Then a negative association with
33 profitability would be estimated. The knowledge derived from successful R&D projects might
34 also spill over to competitors, who would be able to imitate at lower cost. Hence, profitability
35 of the innovative firm would also be lower. Patents are, at least at the domestic level, effective
36 in protecting intellectual property rights and therefore there might well exist a difference
37 between their effect and that of R&D intensity on profits.
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44 Of course there are many other potential influences to profitability that should ideally be used
45 as control variables. One important strand of the literature in industrial organization is on the
46 kind of governance of firms. The majority of the usually considered large stock companies is
47 not led by the owner but by a manager. This leads to a principal-agent problem with
48 asymmetric information and it can be doubted that incentives are determined in a way that all
49 problems are efficiently solved. If managers are able to follow their own interests without
50 effective control, many authors conclude that they will pursue growth maximization under the
51 restriction of some expected minimum profit. Jensen and Meckling (1976) as well as Jensen
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60 ⁸ Cf. Uri (1988) for the inclusion of efficiency variables in explaining profitability.

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3 (1986) argue that managers choose to reinvest the free cash flow rather than return it to the
4 owners. This may have two effects: managers may invest more into R&D than owners⁹ and
5 profitability may be lower at the same time. If the managerial firm holds also more patents
6 aside of conducting more R&D, neglecting the governance question might produce an omitted
7 variable bias, which would bias the coefficient of the patent stock downwards. We consider
8 this question by the variable *OWN* that is the percentage of capital ownership held by the top
9 management.

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12 More “conventional” control variables are the share of sales exported (*EXPORT*) at the firm
13 level and imports at the 2-digit industry level j [= imports_{*j*} / (imports_{*j*} + production of
14 domestic firms_{*j*})] (*IMPORT*). International trade is, on the one hand, increasing competitive
15 pressure, as the firm in question is competing not only with domestic companies. Thus,
16 imports and exports supplement the measure of concentration which accounts for domestic
17 competition with international competition. On the other hand the new growth theory
18 emphasises the risk of imitation and spillover effects which may affect negatively the return
19 in general and that of innovative activity in particular. The dummy variable *EAST* stands for
20 firms located in Eastern Germany (the former GDR). If firms are members of a group of
21 companies, the dummy variable *GROUP* controls for synergy (dis)advantages. In addition,
22 the dummy variable *FOREIGN* identifies if the group is led by a foreign parent company.
23 *STARTUP* denotes that the firm in question has been founded during the recent three years.
24 Size effects are considered by the number of employees (*EMP*). In contrast to results from
25 other countries, size disadvantages have been estimated for Germany (see Neumann et al.,
26 1979, 1981) and therefore a negative coefficient is not implausible. In a dynamic world,
27 barriers to entry are crucial in order to explain profitability. We use the capital intensity
28 (*KAPINT*) defined as fixed assets divided by the number of employees as a variable that
29 indicates capital requirements. As at least a part of these capital expenditures is sunk, this
30 variable is expected to represent barriers to entry. Ten industry dummies are included as
31 well.¹⁰

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56 ⁹ Cf. Czarnitzki and Kraft (2004a) for this hypothesis and empirical evidence.

57 ¹⁰ Some other variables would be of interest as well. Lin and Yeh (2005) point to the interaction between foreign
58 direct investment and R&D. However, we have no information concerning foreign direct investment of our
59 firms. In our cross-sectional framework it is also not possible to include the effects of business cycles and
60 uncertainty as it is done by Funk (2006), for example.

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Several of the considered variables are potentially endogenously determined. Profitability might e.g. affect the possibility to finance research and development efforts. Other endogenous relations might as well exist. In order to avoid a possible simultaneous equation bias, we use lagged values of the exogenous variables whenever possible. These variables are predetermined and can thus be applied in the given context. However with respect to R&D we have only information from a limited number of firms so that lags would lead to a much smaller sample. Therefore we abstain from this option.¹¹

There are also plausible interactions among our regressors. E.g. Sutton (1998, 2006) hypothesises and presents empirical evidence for the impact of R&D on concentration. In his model concentration levels can be explained by exogenous and endogenous factors. One endogenous variable is R&D, which is used to improve products and to raise the barriers to entry for present outsiders. This strategy is followed, if it is profitable to do so and hence Sutton's theory offers another reason for finding a positive impact of innovativeness on profitability. Although correlations among the explanatory variables should not affect our coefficients, the estimated standard errors could be inflated due to multicollinearity. Looking at the correlations among the variables did not point to dramatic interactions, though.

Earlier research

One of the earliest studies on this question is Mansfield et al. (1977). They use data from a sample of firms that agreed to provide private data on the returns from innovation. They compare this profitability impact with the social rate of return and found quite large figures for both. However, the social returns were much larger than the private ones. They estimate private returns ranging from negative ones to 214 percent with a median of 25 percent. The social returns range from negative values to a maximum of 307 percent with a median of 56 percent. Conolly and Hirschey (1984) use a sample of 390 "Fortune 500" firms to estimate a simultaneous equation model with R&D intensity (R&D/Sales), advertising intensity, market value in excess of book value of assets and concentration as endogenous variables. They find a positive impact of R&D and a negative one of R&D intensity interacted with concentration. Jaffe (1986) estimates a three equation model with patents, R&D and market value as

¹¹ Another limitation is the cross-sectional character of the data set. Profitability might well be partly determined by management quality or other reasons for unobserved heterogeneity. As we have no data to construct a panel database, this is clearly a limitation of our study.

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3 dependent variables. According to his results the gross rate of return of R&D is 27%. Geroski
4 et al. (1993) consider a sample of British firms and estimate the returns to innovations using a
5 number of control variables.¹² Uri (1988) develops a simultaneous equation model on
6 profitability, concentration and advertising. He finds that R&D expenditures have a positive
7 impact on profits. An indirect way to evaluate the effect of innovation on profitability is to
8 use the market value as dependent variable, because it should represent the discounted future
9 profits of a firm. The seminal study in this strand of literature is Griliches (1981).¹³ The major
10 disadvantage of this approach is its limitation to publicly traded stock companies. This may
11 still be suitable for the US or the UK, but would lead to highly selective samples in
12 continental European countries where the vast majority of firms is privately owned.
13 Czarnitzki and Kraft (2004b) suggest using a credit rating as a proxy variable for market
14 value, because credit ratings are available for almost every firm and they should reflect the
15 wealth and thus profitability of rated companies. In line with the market value studies,
16 Czarnitzki and Kraft find that different innovation indicators including the patent stock
17 exhibit a positive impact on ratings.
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31 **3 Databases, descriptive statistics and econometric method**

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34 In order to receive a database including all the variables mentioned above, we had to link
35 several sources. Most firm level information is taken from the Mannheim Innovation Panel
36 (MIP). The MIP is an innovation survey conducted by the Centre for European Economic
37 Research (ZEW) on behalf of the German Federal Ministry for Education and Research
38 (BMBF) and is carried out annually since 1992. However, the question regarding the return
39 on sales has only been included in the wave concerning the year 2002. Thus, our sample is a
40 cross-section of manufacturing firms with five or more employees.¹⁴ The MIP covers the
41 whole manufacturing sector and is a random sample stratified by firm size classes, industries
42 and region (Eastern and Western Germany). The information to construct the patent stock
43 stems from the patent database of the German Patent and Trademark Office (DPMA) that
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55 ¹² Other relevant studies include Pakes (1986) as well as Schankerman and Pakes (1986).

56 ¹³ See Hall (2000) for a survey on market value studies and Hall et al. (2004) for a recent article on the
57 calculation citation weighted patent stocks in order to improve the approximation of the value of a firm's
58 knowledge capital.

59 ¹⁴ A few firms are actually smaller than five employees due to differences between the population database used
60 for drawing the sample of the MIP and the firms' response in the questionnaire.

includes all patent applications since 1980. The patents were linked to the MIP by assignee names and addresses using a text field search. The initial patent stock in 1980 was set to zero for all firms. As our data concern the year 2002, the bias arising from the initial value of zero in 1980 is vanished over time due to the depreciation rate of the knowledge capital, and is hence negligible. The ownership information of firms is taken from the Creditreform database. Creditreform is the largest German credit rating agency and makes its database available to the ZEW for scientific purposes. The concentration index and the industry sales (in order to compute the market share variable) are taken from publications of the German Monopoly Commission and are based on the 3-digit industry level.¹⁵ The imports are only available at 2-digit industry level and stem from the STAN database of the Organisation for Economic Development and Cooperation (OECD).

The return on sales variable was not surveyed as continuous variable because it was expected that the firms are very reluctant to provide information on their exact profit margin voluntarily; especially, on the background that most firms are usually not required to publish an annual report. For this reason, it was decided to survey the return on sales as categorial variable and classes as shown in Table 2 were defined.

Table 2: Surveyed categories of the return on sales

Return on sales	Class	Return on sales	Class	Return on sales	Class
< 0 %	0	(4 – 7%]	3	> 15%	6
(0 – 2%]	1	(7-10%]	4	don't know	7
(2 – 4%]	2	(10 – 15%]	5		

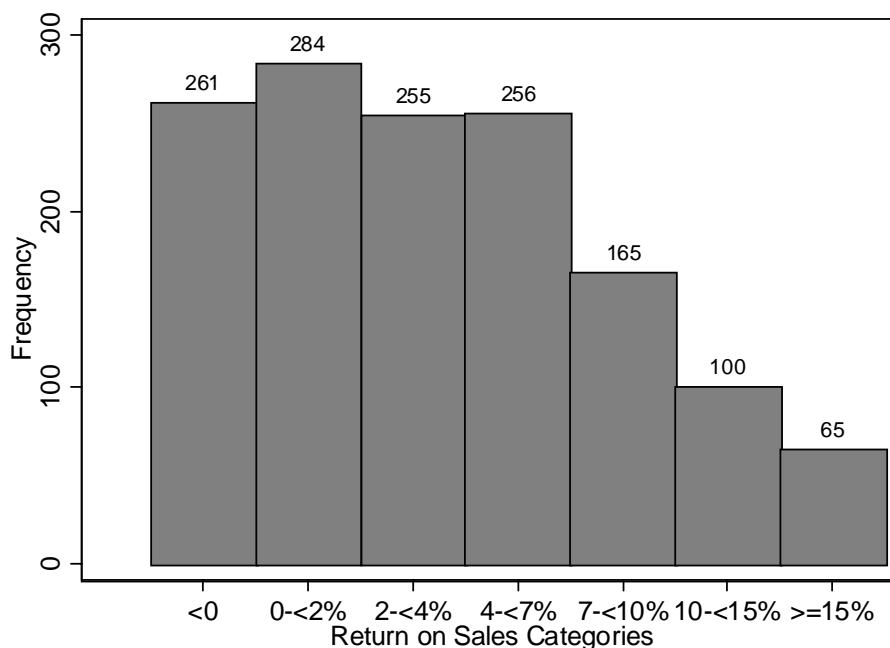
Our initial sample of the MIP wave from 2002 contains 1,649 observations on manufacturing firms (after removal of missing or inconsistent values in explanatory variables).¹⁶ However, 267 interviewees did not respond to the question on return on sales properly: 105 indicated category seven "don't know" and 162 did not respond at all. First, we consider the interviewees responding "don't know" as neutral, that is, those are randomly distributed. For those who did not respond at all, however, we checked for a possible selection bias in the responses by grouping the sample into usable responses and observations with missing values. Then we estimated a probit model on this group variable using our explanatory variables

¹⁵ We use the European standard classification called NACE.

¹⁶ Some missing values in *EXPORT* and *KAPINT* were imputed by mean values defined by industry, firm size and *EAST* in order to lose not to many observations.

described in section 2. The Wald-statistic on joint significance of the coefficients amounts to 27.25 which is distributed chi-squared with 23 degrees of freedom. The corresponding p-value is 0.2457 which leads to the conclusion that there are no systematic differences between respondents and non-respondents and our residual sample with usable information on the return on sales is still random.¹⁷ Of course, this test only accounts for selection on observables. The frequencies of our valid responses are displayed in Figure 1. It is remarkable that almost 19% of firms report a negative return on sales for 2002. The median return is in the category 2, that is, between 2 and 4%.

Figure 1: Distribution of the return on sales



Descriptive statistics of all variables used (except the ten industry dummies) are presented in Table 3. In order to avoid a simultaneity bias, we used lagged values of our variables whenever possible. The patent stock is lagged two periods to take the average delay of innovation returns as shown by Ravenscraft and Scherer (1982) into account. We use the lagged patent stock per employee as regressor to reduce collinearity with other variables due to size effects. Despite indicator variables that hardly change over time (industry dummies, *EAST*, *GROUP*, *FOREIGN*) or definitely refer to a single event in the past (*STARTUP*), all other variables are lagged one period. The only exception is *RD* which is not available in the data for the previous year.

¹⁷ We also carried out t-tests on mean differences for each explanatory variable that led to the same conclusion.

Table 3: Descriptive statistics (1,382 observations)

Variable	Mean	Std. Dev.	Min.	Max.
<i>RETURN ON SALES</i>	2.247	1.721	0	6
<i>PATENT STOCK / EMP</i> *	0.013	0.034	0	0.238
<i>IMPORT</i> *	0.367	0.348	0.065	2.188
<i>HERF</i> *	46.423	68.463	3.213	642.345
<i>SHARE</i> (in %) *	0.807	3.789	0.000	96.611
<i>HERF*SHARE</i> *	65.780	515.267	0.001	16590.540
<i>RD*HERF</i> *	1.783	6.909	0	143.237
<i>EMP/1000</i> *	0.574	2.807	0.001	41.754
<i>RD</i>	0.027	0.056	0	0.403
<i>EXPORT</i> *	0.227	0.243	0	1
<i>EAST</i>	0.334	0.472	0	1
<i>STARTUP</i>	0.033	0.178	0	1
<i>KAPINT</i>	0.095	0.104	0.002	0.923
<i>GROUP</i>	0.390	0.488	0	1
<i>FOREIGN</i>	0.106	0.307	0	1
<i>OWN</i> *, **	0.301	0.419	0	1

* Lagged values;

** Only 834 observations available.

4 Estimation results

We estimate Ordered Probit models to determine the return on sales of the patent stock along with the other regressors. Usually such estimations include unknown threshold values identifying the cut-off points between the different categories. As in binary probit models the variance cannot be identified. Our situation is different in this case, because we exactly know the threshold parameters from the questionnaire and can hence identify the variance. This yields two advantages: we have to estimate less parameters than in the case with unknown parameters and, even more important, we can quantify the marginal effect of the explanatory variables exactly. Given the threshold values, the estimated coefficients directly identify the marginal effects like in a linear regression model and unlike in Probit models with unknown thresholds where the estimated parameters are always scaled by the unidentified variance. Note that there is no need to consider the marginal effects on the probabilities that an observation enters a particular class. We are only interested in the marginal effect in the

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3 underlying "true" latent model (see the appendix for an outline of the Ordered Probit model
4 with known thresholds).¹⁸
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7 We present estimations on two different samples: First, we consider the full sample, and
8 second, only the subsample of Western German firms, because the Eastern German economy
9 is still in transition since the German unification in 1990. Most firms were newly founded
10 since then and are therefore younger than Western German companies, on average. Moreover,
11 Eastern German firms are still highly subsidized in order to foster their catching-up process.
12 Hence, competition indicators like sellers' concentration may play a less significant role in
13 Eastern Germany and as many firms in this region of Germany are still struggling to survive
14 in the market economy, the relationship between profits and the considered indicators might
15 be less informative than in Western Germany where the industry structure has evolved in a
16 framework of a market economy since the Second World-War.
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19 As the variable *OWN* is only available for a subsample of 834 firms, we first run the
20 estimations with the initial sample of 1,382 observations omitting *OWN*, and repeat them for
21 the subsample where *OWN* is available.
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24 In addition to the estimations for different subsamples, we tested for heteroscedasticity using
25 Likelihood Ratio (LR) tests. Multiplicative groupwise heteroscedasticity was considered and
26 modeled by a set of ten industry dummies, five size dummies based on the number of
27 employees and the dummy variable *EAST*. The regression results for the full sample are
28 presented in Table 4. The LR tests rejected homoscedasticity in both samples, and therefore
29 the interpretation of results focuses on the heteroscedastic models. As expected, the
30 relationship between the return on sales and its covariates appears to be stronger in the
31 Western German sample than in the sample including Eastern German firms, too.
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34 The most important result is the positive and significant coefficient of the patent stock. Hence,
35 there is some effect of innovative activity on profits and an incentive for innovation exists.
36 For example, the average profit margin in the sample of Western German firms amounts to
37 3.98%.¹⁹ A Western German firm with an average innovation activity (i.e. mean of the patent
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56 ¹⁸ Verbeek (2000, pp. 192-4) does also present a good example for an Ordered Probit model with known threshold
57 values.

58 ¹⁹ In this case of a categorical variable, this result is obtained by an Ordered Probit estimation with known
59 threshold values including a constant term only.
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3 stock among innovating firms) will ceteris paribus realize a profit margin that is 0.67%-points
4 higher compared to a patent stock equal to zero.
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7 Capital intensity has a positive and significant effect. We interpret this result as evidence on
8 barriers to entry, which have an impact on profitability. In order to compare the impact of
9 capital and patents, we also calculate the effect of the capital stock per employee at the mean
10 (again among innovating firms) versus the hypothetical situation with capital being equal to
11 zero, like in the case of the patent stock mentioned above. This figure amounts to 0.38% for
12 the capital stock and is, hence, approximately half the size of the patent stock variable. A
13 more detailed judgement on the efficiency of patents versus capital would require information
14 on cost of the patent stock, though.
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22 Among our competition variables, the Herfindahl index shows significant coefficients. As
23 *SHARE* is insignificant we find no evidence in favor of the efficiency theory of imperfect
24 competition, but find support for the collusion interpretation. The interaction variable market
25 *SHARE*HERF* is insignificant. In contrast to studies from other countries, the profitability
26 decreases with firm size in our sample. This might be caused by the higher wages that are
27 usually paid in large firms. Apparently, these increases in wages are not matched by
28 productivity differences. *RD*HERF* has a negative coefficient as estimated by Grabowski and
29 Mueller (1978) as well as Conolly and Hirschey (1984). As the two studies used American
30 data, our result seems to be interesting support (although only weakly significant) from
31 another country on the effect of R&D to undermine collusion. Firm size has a negative effect
32 on the profit margin which is in line with the results by Neuman et al. (1979, 1981). The R&D
33 intensity (*RD*) itself has no significant effect. The innovation effect may already be captured
34 by the patent stock indicating that this is a good indicator for valuable innovation activities.
35 We have only data from one year on R&D expenditures and as there will be some lag
36 between these and a possible return we cannot make an exact statement about the profitability
37 of R&D. However, R&D intensity does usually not change very much between different
38 periods as adjustment costs seem to be considerable. Hence if this is (approximately) true, we
39 need no longer lags and in this case R&D has no significant effect on profits aside of the
40 impact on patents. But R&D has also no significantly negative impact on profitability and as
41 successful R&D leads to patents, we find an overall positive effect of innovative activity for
42 profitability.
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Table 4: Ordered Probit regressions – Full sample ^{a)}

Variable	Dependent variable: Return on sales			
	All firms		Western German firms	
	Homosced. model	Heterosced. model ^{b)}	Homosced. model	Heterosced. model ^{b)}
<i>PATENT STOCK / EMP</i> ^{c)}	11.723 *** (4.553)	12.214 *** (4.559)	17.439 *** (5.716)	17.745 *** (5.570)
<i>IMPORT</i> ^{c)}	-0.998 (0.860)	-1.100 (0.890)	-0.723 (1.024)	-0.815 (1.072)
<i>HERF</i> ^{c)}	0.006 ** (0.003)	0.006 ** (0.003)	0.011 *** (0.003)	0.011 *** (0.004)
<i>SHARE</i> ^{c)}	0.062 (0.112)	0.043 (0.105)	0.072 (0.117)	0.069 (0.111)
<i>HERF*SHARE</i> ^{c)}	-0.000 (0.001)	-0.000 (0.001)	-0.000 (0.001)	-0.000 (0.001)
<i>RD*HERF</i> ^{c)}	-0.052 * (0.030)	-0.047 (0.034)	-0.066 ** (0.033)	-0.066 * (0.038)
<i>EMP/1000</i> ^{c)}	-0.125 * (0.067)	-0.118 ** (0.057)	-0.138 ** (0.067)	-0.139 ** (0.058)
<i>RD</i>	1.792 (3.592)	1.556 (3.776)	4.281 (4.554)	4.701 (4.905)
<i>EXPORT</i> ^{c)}	1.399 ** (0.700)	1.363 ** (0.691)	1.341 (0.830)	1.246 (0.820)
<i>EAST</i>	-0.247 (0.316)	-0.384 (0.314)		
<i>STARTUP</i>	-1.035 (0.831)	-1.051 (0.843)	-0.768 (1.066)	-0.986 (1.100)
<i>KAPINT</i> ^{c)}	2.908 ** (1.462)	2.295 (1.406)	4.250 ** (1.838)	3.737 ** (1.847)
<i>GROUP</i>	0.067 (0.346)	0.216 (0.333)	-0.323 (0.421)	-0.151 (0.412)
<i>FOREIGN</i>	0.315 (0.532)	0.394 (0.500)	0.429 (0.604)	0.412 (0.568)
Constant term	2.371 *** (0.596)	2.657 *** (0.513)	2.582 *** (0.712)	2.575 *** (0.616)
LR test on joint significance of ten industry dummies	32.24 ***	28.24 ***	12.79	11.44
$\ln \hat{\sigma}$	1.642 *** (0.024)	1.426 *** (0.093)	1.622 *** (0.029)	1.433 *** (0.117)
# of obs.	1382	1382	920	920
Log-Likelihood	-2594.808	-2573.595	-1714.006	-1701.487

*** (**, *) denote a 1% (5, 10%) significance level;

a) Standard errors in parentheses;

b) Heteroscedasticity term includes ten industry dummies and five size dummies (and *EAST* in the full sample);

c) Lagged values.

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4 Finally, *EXPORT* shows a significant positive coefficient in the full sample only. The other
5 control variables have no impact. Those results are partly unexpected, for example for imports
6 and exports, as international trade has frequently a strong impact. Note that in the sample of
7 Western German firms a test on joint significance of the ten industry dummies does not reject
8 the null hypothesis of all ten coefficients being zero. We conclude that our various
9 competition indicators capture the industry differences well and differences in the return on
10 sales are to a large extent driven by innovation.
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17 The regression for the reduced sample including the firm governance variable *OWN* are
18 presented in Table 5. Once again, we checked for selectivity in this sample. The full sample
19 was grouped according to the variable *OWN*, and we defined one group for non-missing
20 values of *OWN* and the other group where *OWN* is missing. Again, we estimated a Probit
21 model on the group dummy and additionally carried out t-test on mean differences for all
22 explanatory variables. In this case, it turns out that some selectivity is present. As *OWN* is
23 taken from the Creditreform database we have several missing values where we did not find
24 information on the ownership of the corresponding firm in the database. We find that no
25 information is available especially for younger firms and Eastern German firms. Therefore,
26 we omit the variable *STARTUP* from the regression (because there are only very few cases
27 left in the sample) and point out that the regression including Eastern German firms should be
28 interpreted with some care. Unfortunately it is not possible to account for selection within the
29 econometric model as we have no appropriate instruments at hand to model a selection
30 equation. It is important to note that the profitability does not differ significantly between
31 both groups and we therefore conclude that the selectivity problem is not too serious in the
32 upcoming regression analysis.
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Table 5: Ordered Probit - Reduced sample including *OWN*^{a)}

Variable	Dependent variable: Return on sales			
	All firms		Western German firms	
	Homosced. model	Heterosced. model ^{b)}	Homosced. model	Heterosced. model ^{b)}
<i>PATENT STOCK / EMP</i> ^{c)}	14.740 ** (6.642)	14.075 ** (6.263)	19.663 *** (7.603)	18.805 *** (7.140)
<i>OWN</i> ^{c)}	1.089 ** (0.494)	1.036 ** (0.501)	1.567 *** (0.573)	1.646 *** (0.587)
<i>IMPORT</i> ^{c)}	-0.470 (1.163)	-0.889 (1.126)	0.757 (1.386)	0.423 (1.352)
<i>HERF</i> ^{c)}	0.007 * (0.004)	0.007 * (0.004)	0.014 *** (0.005)	0.014 *** (0.005)
<i>SHARE</i> ^{c)}	0.374 ** (0.173)	0.390 ** (0.161)	0.454 *** (0.175)	0.468 *** (0.165)
<i>HERF*SHARE</i> ^{c)}	-0.003 * (0.001)	-0.003 * (0.001)	-0.003 ** (0.002)	-0.004 ** (0.001)
<i>RD*HERF</i> ^{c)}	-0.002 (0.051)	-0.006 (0.048)	-0.027 (0.057)	-0.033 (0.055)
<i>EMP/1000</i> ^{c)}	-0.161 (0.101)	-0.165 * (0.091)	-0.180 * (0.099)	-0.180 ** (0.091)
<i>RD</i>	-3.481 (6.112)	-3.039 (6.270)	5.363 (7.909)	6.288 (8.026)
<i>EXPORT</i> ^{c)}	1.314 (0.916)	1.217 (0.896)	1.244 (1.052)	1.249 (1.031)
<i>EAST</i>	-0.768 * (0.429)	-0.754 * (0.428)		
<i>KAPINT</i> ^{c)}	3.850 ** (1.956)	3.479 * (1.978)	6.900 *** (2.425)	6.701 *** (2.522)
<i>GROUP</i>	0.286 (0.469)	0.378 (0.453)	-0.243 (0.533)	-0.155 (0.526)
<i>FOREIGN</i>	0.039 (0.696)	-0.011 (0.646)	0.445 (0.781)	0.424 (0.737)
Constant term	1.799 *** (0.786)	2.051 *** (0.777)	1.432 (0.918)	1.483 (0.916)
LR test on joint significance of ten industry dummies	21.47 **	23.53 ***	12.39	12.62
$\ln \hat{\sigma}$	1.638 *** (0.031)	1.865 *** (0.076)	1.616 *** (0.036)	1.823 *** (0.092)
# of obs.	834	834	595	595
Log-Likelihood	-1546.525	-1536.661	-1095.855	-1090.282

*** (**, *) denote a 1% (5, 10%) significance level;

a) Standard errors in parentheses;

b) Heteroscedasticity term includes five size dummies

c) Lagged values.

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The LR tests yield that homoscedasticity is rejected again, but in this case it is sufficient to include the five size dummies in the heteroscedasticity term. The results based on the reduced sample show some differences to the ones from the initial sample, but the strong impact of the patent stock is still present. Hence this result is robust to changes in specification and the sample size, but our variables describing the competitive structure have some other effects. Aside of the Herfindahl index, now the market share as well as the interaction term *HERF*SHARE* are significant. Based on these results, we find additionally to the impact of concentration also an effect of the market share, which points to the efficiency interpretation of reduced competition. It is therefore possible that both forces are at work here. But our results are still different from those reported by Ravenscraft (1983), as in his case the market share was the dominating variable and the concentration measure had no significant impact. The interaction variable is negatively significant. This points to inefficiency of the large firms without competitive pressure. Most likely this is due to the missing disciplinary effect of competition. Capital intensity remains significant. Again, the test on joint significance of the ten industry dummies does not reject the null hypothesis in the Western German sample.

Our additional variable *OWN* has the expected positive impact. Owner-led firms have a higher profitability rate, which points to significant principal-agents problems in manager-led firms in Germany. A Western German firm that is led by its owners exhibits a 1.6% points higher return on sales than a firm that is led by managers who do not hold any capital shares. On the background of the distribution of profits in our sample, this 1.6% points represent a substantial difference in firm performance. As studies on the effect of governance are rare in Germany, we think this is a valuable result.

5 Conclusions

We present empirical results on the question whether innovative activity has a significant impact on the profits of firms. Profitability is in our case defined as profits divided by sales and is equivalent to the price-cost margin. Innovation is specified as the patent stock and R&D intensity. All relevant variables are lagged in order to reduce endogeneity problems (except R&D intensity due to data limitations). Our representative sample of German manufacturing firms contains many small and medium-sized firms which are not required to publish their balance sheets. This is a major difference to most other studies conducted in this field, because usually data from large firms is used resulting in a selective sample of companies.

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3 The patent stock has a strong and robust effect on profitability. An innovating firm realizes an
4 about 0.67%-points higher return on sales than a firm not performing innovation activities, on
5 average. Therefore we conclude that an incentive for innovation exists in Germany. In
6 contrast, the R&D intensity has no separate, additional effect. The results with respect to the
7 variables representing the competitive structure are mixed. The Herfindahl concentration
8 index has always a strong positive impact on profits. The market share and the interaction
9 variable market share times the Herfindahl index are both only significant in a subsample of
10 companies for which information on firm governance is available. Hence, we have limited
11 evidence in favor of the hypothesis that a high concentration is the result of efficiency
12 advantages of the larger firms. In contrast, capital intensity has a stable positive impact on
13 profits. We interpret this result as evidence on barriers to entry that have an impact on
14 profitability. Moreover, our results point to the conclusion that owner-led firms have a
15 significantly larger profit rate. There exist governance inefficiencies in German firms and the
16 managers may require better incentives or closer supervision in order to solve the principal-
17 agent problems.
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30 Our result that innovation generates some returns for the firms is just an estimate of the
31 minimal level of the total benefits. Because of the positive externalities connected to the
32 spillover effects of R&D, the social benefits are usually much larger than the private ones.
33 Hence the economy has a considerable advantage from these activities and given the inherent
34 uncertainty of R&D processes in general, information concerning the profitability of
35 innovation seems to be of considerable value for the involved firms and public authorities.
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41 We do not find a similar effect for R&D. The insignificance of the R&D coefficient might
42 reflect the positive impact of innovativeness on profitability but at the same time R&D
43 projects to a high degree fail and, if they are successful, the results may at least partially spill
44 over to competitors. Thus, the positive impact of R&D itself is balanced by the negative ones
45 of wasted R&D and the imitation by rivals. This is supported by our positive effect of the
46 patent stock which measures successful R&D and, at the same time, reflects intellectual
47 property rights that prevent others from imitation to some extent. The joint results concerning
48 R&D and patents point to the relevance of the intellectual property rights system for an
49 economy. Imitation is perhaps largely a problem between but not within countries. Provided
50 this statement would be true, there would be considerable room for political actions on
51 international protection of intellectual property.
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3 Although we find evidence on the positive impact of innovation on profits, this is only one
4 part of the story. The returns have to be compared with the costs, and at present we have only
5 limited information on those. One would need a long times series on R&D expenditures as the
6 input to the innovative process (and not just the data from one year as in the present study).
7 Then the effects of the overall outlays for profits in later years have to be calculated. This
8 would be the “true” test on the profit effects of innovative activity. In such a study, one could
9 also test whether patents have a significant effect on profits aside of past R&D activities as,
10 on the one hand, patents are a measure of R&D output or success and, on the other hand,
11 patents are expected to reduce (or even eliminate) imitation possibilities by competitors.
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Appendix: The Ordered Probit model with known threshold values

The estimations presented in the paper are the results of ordered probit models. Let the latent model be

$$y_i^* = x_i' \beta + \varepsilon_i, \quad \text{with } i = 1, \dots, N. \quad (1)$$

y_i^* is the unobserved dependent variable (the profit-turnover ratio), x_i the set of regressors and ε_i the error term. The observed return on sales is

$$y_i = \begin{cases} 0 & \text{if } y_i^* \leq \mu_0, \\ 1 & \text{if } \mu_0 < y_i^* \leq \mu_1, \\ \vdots & \\ 5 & \text{if } \mu_4 < y_i^* \leq \mu_5, \\ 6 & \text{if } y_i^* > \mu_5. \end{cases} \quad (2)$$

μ_k ($k=0, \dots, 5$) are usually unknown threshold values which have to be estimated. Assuming that the errors are normally distributed yields the following probabilities

$$\begin{aligned} P(y_i = 0) &= \Phi\left(\frac{\mu_0 - x_i' \beta}{\sigma}\right), \\ P(y_i = 1) &= \Phi\left(\frac{\mu_1 - x_i' \beta}{\sigma}\right) - \Phi\left(\frac{\mu_0 - x_i' \beta}{\sigma}\right) \\ &\vdots \\ P(y_i = 5) &= \Phi\left(\frac{\mu_5 - x_i' \beta}{\sigma}\right) - \Phi\left(\frac{\mu_4 - x_i' \beta}{\sigma}\right) \\ P(y_i = 6) &= 1 - \Phi\left(\frac{\mu_5 - x_i' \beta}{\sigma}\right) \end{aligned} \quad (3)$$

The joint likelihood function of these probabilities can be estimated with the familiar Maximum Likelihood technique. Usually the standard deviation σ is – as in binary choice Probit models – not identified. All estimated coefficients are scaled by σ . In this case, however, we are in a situation, where we know the threshold values μ_k . Recall that the profit variable has been categorized in the survey, and we know the threshold values for each class. Using the true threshold values, allows us to identify the variance (and the constant term) and reduces the parameters to be estimated. The coefficients can directly be interpreted as marginal effects in the "true" latent model.

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Finally, the tests on heteroscedasticity allow the variance to vary over industries, firm size and *EAST*. Firm size is specified as five size classes categorized by the number of employees. The homoscedastic standard deviation $\hat{\sigma}$ is replaced by $\hat{\sigma}_i$ with

$$\sigma_i = \exp(\sigma + \omega_i \alpha) \quad (4)$$

where α denotes the vector of additional parameters to be estimated and ω_i are the variables which are considered to model the heteroscedasticity. Although likelihood ratio tests do reject the hypothesis of homoscedasticity, the results concerning the patent stock and most control variables remain similar.

Response to Referee report 1

(report starting with „Referee Report for AE Manuscript “On the Profitability of innovative assets” by Dirk Czarnitzki and Kornelius Kraft”)

Dear Referee,

we would like to thank you for your thoughtful comments and advice. We have revised the paper along the lines of your and two other referee report. Please, see the details with respect to your comments below.

We reprint the original comments and italics and respond below.

1. The introduction needs some additional work (and/or section 2 On the profitability of innovation)

In the second paragraph of the introduction, the authors present the features of R&D activities: (i) the risk of failure in higher (than in the case of conventional investment); (ii) the long lags between R&D and the introduction of new products or processes; (iii) the risk arising from imitation, which reduces the profitability of successful R&D projects. This latter feature needs to be better clarified. That is, R&D activities result in technological-knowledge progress, which, as considered in the first paragraph, is the primary cause of growth. Two major characteristics of technological knowledge are essential for its role as an engine of growth – non-rivalry and partial non-excludability – and they are not explicitly considered in the paper. Technological knowledge is non-rival in the sense that the marginal costs for its use by an additional firm are negligible; and it is partially nonexcludable since the returns to private investment in its production are partly private and partly public. Thus, on one hand, innovations are proprietary – private investment results in a temporary monopoly, if some protection (usually in the form of patents) exists. On the other hand, innovations add to the stock of public technological knowledge – technological knowledge spillovers; and thus the leadership of the firms is only temporary – permanently subject to destruction by new products or processes resulting from new successful R&D –, which, in fact, reduces the profitability of successful R&D projects.

Moreover, in line with these two characteristics – non-rivalry and partial nonexcludability – and bearing in mind that the patent stock reflects previous R&D investments, I consider that some relationship of the work developed with prominent studies of endogenous R&D growth literature is important – e.g., Romer (1986, 1990), Segerstrom et al. (1990), Grossman and Helpman (1991), Aghion and Howitt (1992) and Barro and Sala-i-Martin (2004). This is in order to better understand: (i) why R&D is carried out or supported by private firms in search for profits; and (ii) the process of R&D.

We have added your remarks and literature to the paper. Note that all these issues are not discussed in one paragraph of the paper, but spread out in the introduction, conceptual framework and the discussion of the results.

2. In page 3 the authors state that “It is also questionable, whether patents effectively prevent imitation.” I think that intra-country (domestically) patent effectively prevent imitation, the problem is inter-country (internationally) imitation. In this case, when successful, imitation allows for the diffusion of technological knowledge embodied in

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a good, as the imitator reverse-engineers that good. Since, in the absence of international intellectual property rights (IPRs) protection, imitative R&D is typically cheaper than innovative R&D, the successful imitator can return to international markets and underprice the original innovator.

Thus, considering international imitation – the relevant one – the authors need to consider that the dynamic feedback from imitation to innovation may harm the profits (and, thus, incentives to) innovative R&D – e.g., Grossman and Helpman (1991), Connolly (2003) and Dinopoulos and Segerstrom (2006). That is, in addition to the closed economy Schumpeterian creative destruction effect – challenging innovations destroy the profits of the current state-of-the-art ones –, technological-knowledge diffusion through imitation may bring about further business stealing – challenging imitations, coupled with lower marginal costs in the South, are traded internationally.

We have added a paragraph based on your suggestions and references (on page 4 in the revised manuscript)

3. A final edit for typos and smoothing some of the discussion is necessary. I had no problem following the arguments of the paper, but there were places where discussion was choppy.

We went through the whole paper again and did our best to improve the discussion.

4. A final check of the reference list is also necessary. There is at least one article mentioned in the paper, which is not cited in the reference list: Eurostat (1993) mentioned in table 1 (page 3) – or it is OECD (1993)?!!

All references have been checked again. Yes, indeed, the publication that was cited as Eurostat (1993) should have been /OECD (1993).

5. The authors need to be careful with some abbreviations. For example, what does PIMS data (in page 3) mean? The same is true – but less problematic – for R&D, GDP, EU, OECD and LR tests.

PIMS means “Profit Impacts of Market Strategy”. All abbreviations used are now introduced in the text.

6. In page 5 the authors state that “The price cost margin is usually explained by concentration in the industry and the market share of the firm in question.” They need also to consider that the price margin cost results from the profit-maximisation price of the monopolistic producers of goods that embody designs arising from successful R&D – e.g., Afonso (2006). To manufacture these goods requires a start-up cost of researching a new design and thus the investment in a blueprint can only be recovered if profits at each date are positive for a certain period in the future. This is guaranteed by domestically enforced patents, which protect the firm’s domestic monopoly, while at the same time, almost without costs, disseminating acquired technological knowledge to other domestic firms. Thus, producers are expected to be unwilling to produce under competitive market conditions. It is under these assumptions, that technological knowledge is (or tends to be) public (non-rival and non-excludable) within a country. I think that this is in line with (and thus captured by) the variables RD and patent stock, is that true? But, I think that the variable RD is

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4 *not very appropriate since it represents the 'input' to R&D, and not the 'input' to*
5 *produce goods under imperfect competition. Apparently this opinion is confirmed by*
6 *the results!*
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8 We have discussed this issue on page 5, and cite the reference.
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10 *7. I think that variables in section 2 (pages 5 and 6) must be more in line with the*
11 *related literature; in particular, with recent (omitted) literature.*
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14 We have extended the discussion on the control variables to the best of our
15 knowledge.
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18 *8. In the appendix, the authors start writing in German, which also reflects the need*
19 *of a careful revision.*
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21 This was a command field of the equation editor that we used. We do not know why it
22 suddenly appeared in the text. Apparently this came in when we converted the file
23 into pdf. It has been fixed.
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26 *9. I think that the authors use insufficient detail to comment estimation results (section*
27 *4). In particular, results need to be more related with the results of previous works;*
28 *particularly with results of (ignored) more recent works.*
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30 The results section and the conclusions has been improved.
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Response to Referee Report 2

(report starting with “Comments to the Author”)

Dear Referee,

we would like to thank you for your thoughtful comments and advice. We have revised the paper along the lines of your and two other referee report. Please, see the details with respect to your comments below.

We reprint the original comments and italics and respond below.

· *Microeconometrics based on a cross-section is always subject to unobserved heterogeneity, which, as we know, may be the cause of severe biases in the results. Hence, I would like to see this study conducted in the future in a panel framework;*

We absolutely agree to this point. Actually, we are currently continuing to collect more recent data within the innovation survey so that panel data bases can be constructed in the future.

· *The authors seem to be based on an old structure-conduct-performance approach to empirical industrial organization. Being closer to the Sutton bounds approach, I would be eager to see what the effects would be if Sutton’s methodology was followed.*

Due to the complexity of Sutton’s approach, we are unfortunately not able to test his theory with our data available. However, we acknowledge these important contributions to the topic, and cite Sutton’s work in the discussion.

· *The most serious problem in my view have to do with the implicit assumptions on exogeneity of some variables. That is, I would rather see the results of estimating a system of simultaneous equations: on the one hand, I do believe returns on sales might also explain R&D activities. Furthermore, I believe the market structure as captured by the concentration indices used might well, in a Schumpeterian perspective, be influenced by the innovative activities carried by the firm. Hence, some of the variables the authors treat as exogenous are potentially endogenous, and in future studies I would advise that path to be explored.*

We absolutely agree but currently we only have cross-sectional data at hand which does not allow to account for potential feedback effects. Note, however, that we include all variables as lagged values whenever possible. Thus, at least in technical econometric assumptions, we can treat the variables as predetermined. Even if there were feedback effects present, our model would still consistently estimate the parameter vector. Problems would arise in this model if there was contemporaneous feedback, but that is ruled out by using lagged right-hand side variables.

· *A further point where I would be cautious is in the inclusion of dummies in heteroscedasticity tests. Recent research (see Hendry and Santos, 2005) show that for impulse dummies there is a size distortion in White’s test. I am not sure what would happen with the author’s method.*

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4 In our econometric model the parameters of the industry dummies in the
5 heteroscedasticity term are estimated along with the structural equation using standard
6 ML routines. The heteroscedasticity test is based on a usual LR statistic on joint
7 significance of the parameters. Thus, this problem of the commonly used White test in
8 the Least Squares framework does not apply to our estimations.
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For Peer Review

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3 **Review report on the paper:**
4 *On the Profitability of Innovative Assets*
5

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7 Dear Referee,

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9 we would like to thank you for your valuable comments on our paper. We have
10 revised it along the lines of your and two other referee report. Please, see the details
11 with respect to your comments below.
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14 We reprint the original comments and italics and respond below.
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18 • *The paper might benefit from a better introduction and better conclusions, which*
19 *both give the appearance of being a little rushed. While the introduction is a summary*
20 *of the previous literature to this topic already presented in chapter 2, the conclusions*
21 *are a summary of the estimation results in the paper. Both, introduction and*
22 *conclusions, therefore have no value added for the reader.*
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25 The introduction and conclusion have been edited.

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27 • *The paper lacks a theoretical foundation. The variables that are added to the*
28 *empirical model are derived from previous empirical literature.*
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31 Based on your and another referee's comments we revised the conceptual framework
32 of the paper and also embed the discussion into more recent literature.
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35 • *Estimation method: I am concerned about issues related to endogeneity problems of*
36 *some variables treated as exogeneous in the model. In the literature overview the*
37 *authors cite the papers of Connolly and Hirschey (1984) and Jaffe (1986). In both*
38 *papers multiple equations regressions are applied to cope with problems of*
39 *endogeneity. Why are these problems not addressed in the paper?*
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42 As we do not have panel data at hand, we intended to keep the specification of the
43 model as simple as possible. Panel data would allow us to model feedback effects
44 among the dependent variable and regressors more carefully than we can do with a
45 cross-sectional data structure. Note, however, that all variables enter as lagged values
46 whenever possible, and therefore we can technically treat them as predetermined. In
47 this case, our model estimates the parameter vector consistently even in the presence
48 of feedback effects. A problem would only arise if there was contemporaneous
49 endogeneity, which is, however, ruled out by using lagged values. In panel data,
50 though, the problem would have to be dealt with, as most panel data models require a
51 strict exogeneity assumption and not only a contemporaneous exogeneity assumption.
52 We mention this in the paper now.
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