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Bargaining in Vertical Relationships and Suppliers' R&D Profitability

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Das Wichtigste in Kürze

Investitionen in Forschung und Entwicklung (FuE) sind eine der Triebfedern für Produktivitätswachstum und somit auch für Wachstum und Wohlstand. Es ist jedoch nicht klar, wie profitabel FuE – Investitionen sind, da FuE-Projekte typischerweise mit hohen Kosten sowie hoher Unsicherheit hinsichtlich ihres Erfolgs verbunden sind. Zudem fallen Gewinne im Vergleich zu anderen Investitionsformen erst mit einer erheblichen zeitlichen Verzögerung an.

Ein wichtiger Faktor für die Profitabilität von FuE-Investitionen – der in bisherigen Studien noch nicht betrachtet wurde – ist die Verhandlungsmacht eines FuE treibenden Zulieferers gegenüber seinen Kunden. Da FuE-Investitionen des Zulieferers nicht nur auf der Zuliefererseite sondern auch auf der Käuferseite in neuen Produkten oder niedrigeren Produktionskosten resultieren können, ist es wahrscheinlich, dass Verhandlungen über die Verteilung des entstehenden Gesamtgewinns eintreten. Hat der Käufer eine starke Verhandlungsposition, d. h. verfügt er über Käufermacht, so ist es möglich, dass er sich Teile des Gewinns aus den FuE-Investitionen des Zulieferers aneignet. Umgekehrt ist es möglich, dass sich der Zulieferer, wenn er über die stärkere Verhandlungsposition verfügt, Teile des anfallenden Gewinns auf Käuferseite aneignet. Der Beitrag dieser Studie liegt darin, dass Verhandlungsmacht in die Analyse von FuE-Profitabilität integriert wird.

Diese Untersuchung beschäftigt sich mit zwei Fragen. Erstens, welche Faktoren bestimmen die Verhandlungsmacht des Zulieferers und wie beeinflussen diese die Profitabilität? Bestehende Studien zeigen, dass die die Marktposition des Zulieferers sowie der Grad der Käuferkonzentration entscheidende Faktoren sind. Hinsichtlich der FuE-Profitabilität lässt sich somit erwarten, dass eine starke Marktposition die Erlöse aus eigenen FuE-Investitionen erhöht, wohingegen eine hohe Käuferkonzentration die Erlöse senkt. Zweitens wird untersucht, wie die identifizierten Determinanten der Verhandlungsmacht eines Zulieferers die Profitabilität seiner FuE-Investitionen beeinflussen. Diese Frage wird empirisch mit einem Datensatz von 472 deutschen Unternehmen aus dem Verarbeitenden Gewerbe untersucht. Es zeigt sich, dass die Effekte beträchtlich sind. Eine Erhöhung der FuE-Intensität in 2010 um einen Prozentpunkt würde die Umsatzrendite eines durchschnittlichen FuE-treibenden Zulieferers im Jahr 2012 um ca. 14 % reduzieren, wenn dieser Zulieferer komplett von seinen größten drei Kunden abhängt und einen durchschnittlichen Marktanteil besitzt. Im Gegensatz dazu könnte ein FuE-treibender Zulieferer, der über ein Monopol und über eine durchschnittliche Käuferkonzentration verfügt, seinen Gewinn im Jahr 2012 um 10 % steigern.

Diese Ergebnisse haben wichtige Implikationen. Manager von FuE-treibenden Unternehmen im Verarbeitenden Gewerbe können das Unternehmensergebnis verbessern, wenn die Käuferstruktur diversifiziert wird. Zudem kann es sinnvoll sein kleinere Märkte zu bedienen, wenn dies mit höheren Marktanteilen einhergeht. Dies erhöht die Verhandlungsmacht und verbessert somit die Profitabilität von FuE-Investitionen. Die Ergebnisse sind auch für Wettbewerbsbehörden relevant. Die Bewertung von Zusammenschlüssen bei Käuferunternehmen sollte berücksichtigen, dass die FuE-Profitabilität von Zuliefererunternehmen dadurch beeinflusst wird, um nachteilige Effekte auf die Innovationsanreize der Zulieferer zu vermeiden.

Non-technical summary

Research and development (R&D) investments are considered to be one of the most important drivers of firm productivity and consequently of economic growth and welfare. It is by no means clear however, whether R&D investments are profitable since the costs are high, the outcome is uncertain, the risk of failure is considerable and profits accruing from these investments typically have a significant time lag compared to other types of investment.

It is well known that the profitability of R&D strongly depends on the market environment of the firm, e. g. market concentration and entry barriers. An important factor for the profitability of R&D – which has been neglected in existing studies – is bargaining power that an R&D performing firm possesses in negotiations with its buyers. As R&D translates into new products or lower costs of production not only on the supply side but also on the buyer side, bargaining over the distribution of the accruing profits along the supply chain may occur. On one hand, if the buyer has the stronger bargaining position, i. e. he has buyer power, it is possible that large parts of the gains from a supplier's R&D activity will be appropriated by the buyer. On the other hand, if the supplier has the stronger bargaining position it is likely that he can extract significant shares of the buyer's profit. To the best of my knowledge, there is no study dedicated to the analysis of R&D profitability however, taking account of these opportunities. Hence, the main contribution of this paper is the integration of bargaining in vertical relationships into the analysis of a suppliers' R&D profitability.

This paper deals with two major research questions. First, which factors determine the bargaining power of a supplier in a vertical relationship and how do these factors affect a supplier's profitability? Building on theoretical and empirical evidence about the effects of bargaining in vertical relationships, the crucial determinants of a supplier's bargaining power are identified as the market position and the degree of concentration in the buyer portfolio. With respect to R&D profitability the latter is expected to diminish returns from R&D, while the former is expected to increase it. Second, how do the identified determinants affect the profitability of supplier's R&D investments? This question is explored empirically using a dataset of 472 German manufacturing firms which contains information on the relationship to their buyers and find considerable effects of suppliers' bargaining power on their R&D profitability. An increase of R&D intensity in 2010 by a percentage point would reduce profits of an average R&D performing supplier by about 14 % in 2012 given the supplier depends completely on the largest three buyers and does hold an average market share. Contrastingly, a monopolist R&D performing supplier with average buyer concentration would experience a profit increase by 10 % in 2012.

The results provide several implications for practitioners. Managers of R&D performing supply firms in the manufacturing sector may find it beneficial to diversify the buyer structure as this increases bargaining power and allows for a higher profitability of R&D activities. In addition, the results show that it is more profitable to serve smaller markets if this leads to an increased market share. Again, this translates into a stronger bargaining position and spurs R&D profitability. The results also have relevance for competition authorities. Merger decisions should take into account how upstream R&D profitability is affected by downstream mergers to avoid adverse effects on suppliers' innovation incentives.

Bargaining in Vertical Relationships and Suppliers' R&D Profitability

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Abstract

This paper explores the effect of bargaining in vertical relationships on the profitability of suppliers' R&D investments. Studies on the relationship between R&D and firm profitability mostly concentrate on the impact of horizontal market structure and neglect vertical interactions. Building on theoretical and empirical evidence about the effects of bargaining in vertical relationships, the crucial determinants of a supplier's bargaining power are identified as the market position and the degree of concentration in the buyer portfolio. With respect to R&D profitability the latter is expected to diminish returns from R&D, while the former is expected to increase it. The hypotheses are tested using a sample of 472 German manufacturing firms. The empirical findings support all hypotheses and highlight the importance of taking a supplier's bargaining power into account when estimating R&D profitability. The estimated effects are considerable: for an average R&D performing supplier an increase of R&D intensity in 2010 by a percentage point would reduce profits by about 14 % in 2012 given the supplier depends completely on the largest three buyers and does hold an average market share. Contrastingly, a monopolist R&D performing supplier with average buyer concentration would experience a profit increase by 10 % in 2012.

JEL-Classification: D22, L22, O32

Keywords: Bargaining, Firm performance, Vertical relationships

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1. Introduction

R&D is considered to be one of the most important drivers of firm productivity and consequently of economic growth and welfare. Thus, considerable amounts of public spending are directed towards programmes promoting R&D investment on firm level. It is by no means clear however, whether R&D investments are profitable since the costs are high, the outcome is uncertain, the risk of failure is considerable and profits accruing from these investments typically have a significant time lag compared to other types of investment.

It is well known that the profitability of R&D strongly depends on the market environment of the firm. Traditional industrial organization literature emphasizes the importance of market concentration and entry barriers for firm profitability (for an overview see Schmalensee, 1989) and this has been shown to be important for the profitability of R&D as well (Grabowski and Müller, 1978; Conolly and Hirschey, 1984; Czarnitzki and Kraft, 2010). Another factor that may be important – and which has been neglected in existing studies – is the relative bargaining power that an R&D performing firm possesses in negotiations about prices and quantities with its buyers. Such vertical relationships between suppliers and buyers receive growing attention from economists, especially since it has become accepted that larger buyers may benefit from buyer power. Often, the emergence of buyer power is attributed to concentration processes among buyer firms (see e. g. Chipty and Snyder, 1999, Inderst and Wey, 2007). Such processes however are not sufficient for generating buyer power. In Germany for instance, one can observe that for a third of all firms the three largest customers account for 50-100% of their sales (Aschhoff et al., 2007). Such a concentrated customer structure may lead to buyer power as well, notably if the supplier is small and the buyer large. The execution of buyer power is seen as predominantly negative, since it lowers the profit of the suppliers, thereby lowering their investment incentives (OECD, 1998; European Commission, 1999).

As R&D translates into new products or lower costs of production not only on the supply side but also on the buyer side, bargaining over the distribution of the accruing profits along the supply chain between supplier and buyer may occur and affect the profitability of suppliers' R&D investments considerably. On one hand, if the buyer has the stronger bargaining position, i. e. he has buyer power, it is possible that large parts of the gains from a supplier's R&D activity will be appropriated by the buyer. On the other hand, if the supplier has the stronger bargaining position it is possible that he can extract significant shares of the buyer's profit. To the best of my knowledge, there is no study dedicated to the analysis of R&D profitability however, taking account of these opportunities. Hence, the main contribution of this paper is the integration of bargaining power in vertical relationships into the analysis of a suppliers' R&D profitability.

This paper deals with two major research questions. First, which factors determine the bargaining power of a supplier in a vertical relationship and how do these factors affect a supplier's profitability? Building on theoretical and empirical evidence about the effects of bargaining in vertical relationships, the crucial determinants of a supplier's bargaining power are identified as the market position and the degree of concentration in the buyer portfolio. With

respect to R&D profitability the latter is expected to diminish returns from R&D, while the former is expected to increase it. Second, how do the identified determinants affect the profitability of supplier's R&D investments? This question is explored empirically using a dataset of 472 German manufacturing firms which contains information on the relationship to their buyers and find considerable effects of suppliers' bargaining power on their R&D profitability. An increase of R&D intensity in 2010 by a percentage point would reduce profits of an average R&D performing supplier by about 14 % in 2012 given the supplier depends completely on the largest three buyers and does hold an average market share. Contrastingly, a monopolist R&D performing supplier with average buyer concentration would experience a profit increase by 10 % in 2012.

The next section presents existing empirical literature on the profitability of R&D while the third section reviews theoretical and empirical findings on the impact of bargaining in vertical relationships and derives empirically testable hypotheses. The empirical approach is described in section 4, while results are presented in section 5. Concluding remarks are given in section 6.

2. Literature overview

Empirical studies dedicated to the analysis of the relationship between R&D or innovation activities and firm profitability provide mixed results on the relationship between R&D, innovation and firm profitability. Most of these studies include to some extent measures capturing the horizontal market structure which is in line with traditional industrial organization literature that emphasizes the importance of market concentration and entry barriers for firm profitability (for an overview see Schmalensee, 1989). Vertical relations and the possible consequences on suppliers' bargaining power are not considered however.

Among the studies using US data, Mansfield et al. (1977) assess the private and social returns of seventeen industrial innovations. They find pre-tax private returns ranging from negative values to 214% with a median of 25%. In 30% of the cases though, the private returns were so low that no firm in hindsight would have invested in that project. Nevertheless the social returns exceeded the private ones considerably, ranging from negative values to 307% with a median of 56%. Grabowski and Müller (1978) find a positive impact of R&D on adjusted profit rates of US firms. They also consider market concentration in order to test the hypothesis that R&D in combination with high concentration may act as a catalyst of competition. They suggest that while there is a tendency of cartelistic behaviour in concentrated industries, R&D delivers an incentive to deviate from collusive agreements because it is difficult to coordinate between the cartelists. Hence, R&D can induce rivalry in otherwise cartelistic markets. This is supported by the empirical results. More evidence for this hypothesis is provided by Conolly and Hirschey (1984) who estimate a simultaneous equation model with R&D intensity, advertising intensity, firm profitability and the concentration ratio as endogenous variables. With respect to the impact of R&D on firm profitability they find a positive effect of R&D. Jaffe (1986) estimates a three-equation model using a dataset of 432 US firms with patents, profit measured as the operating income before depreciation and market value as dependent variables. The results show that the average gross rate of return of R&D is 27%. The

concentration rate measured as the four firm concentration ratio is negatively affecting firm profits.

Evidence for Europe is provided by several papers employing data from the Community Innovation Survey (CIS). Recent papers of Czarnitzki and Kraft (2010, 2012) use a sample of German manufacturing firms and explore the effect of patent stocks, R&D intensity and spillovers on firm profitability. Czarnitzki and Kraft (2010) find a positive effect of patent stock but no effect of R&D intensity. With regards to the competition variables they find that concentration is positively affecting firm profitability while market share is insignificant. In addition they estimate a negative coefficient for the interaction between R&D and concentration thereby supporting the hypothesis of Grabowski and Müller (1974). In contrast, Czarnitzki and Kraft (2012) test for a non-linear relationship between firm profitability and R&D. They find evidence for an upward sloping curve with decreasing marginal returns. What is more, an effect of concentration on firm profitability cannot be detected. Mata and Woerter (2013) explore the impact of external and internal R&D on price-cost margins for Swiss firms. They do not consider any market structure at all and find firms with both external and internal R&D activities to be more profitable than firms with merely internal R&D. Rexhäuser and Rammer (2014) also use a dataset of German firms but find no effect for the magnitude of the patent stock and the introduction of market novelties or cost saving innovations on firm profitability. In line with Czarnitzki and Kraft (2012) they do not find an effect of horizontal concentration. Their results show however a strong negative effect on profitability for a competition dummy variable which is a composite competition index taking unit value if the firm indicates that at least one of the following characterizations apply to their main product market: entry of new competitors, products and services are quickly outdated, the firm's products can be easily substituted by competitors' products, strong competition from abroad and uncertainty in demand or competitors actions.

Geroski et al. (1993) use a panel of 721 British firms observed during the period 1972 to 1983. They do not consider R&D but innovative outputs and assess the impact of the latter on firm profitability. They find a positive effect of an additional innovation on firm profitability. Moreover, the results provide evidence that differences in profitability between innovators and non-innovators are persistent with innovators exhibiting a higher profitability. In addition, Geroski et al. (1993) are the first to hint at the importance of vertical relationships when assessing the profitability of a firm in combination with its innovative efforts. They note that innovations in their dataset "have had a far greater impact on users' productivity growth than on producers' productivity (e.g., Geroski, 1991), and there is no reason not to think that this might also be true with profitability" (p. 208).

This statement reflects exactly why the distribution of bargaining power in vertical relationships may be an important factor in determining a supplier's profitability. Given that a supplier's innovative product or process does have a greater impact on downstream profitability, he may extract a share of the downstream profit through bargaining. How much of the downstream profit can be extracted depends on the strength of the supplier's bargaining position relative to the bargaining position of the buyer. Conversely, if the buyer does have a stronger bargaining position compared to the supplier, the former can reduce the profits of the latter by extracting a large part of the upstream profit.

To the best of my knowledge, there is no existing study however, taking account of these opportunities. Hence, the main contribution of this paper is taking account of bargaining power in vertical relationships when analysing the profitability of suppliers' R&D.

3. Theoretical framework

In this section I study how the profitability of suppliers' R&D investments is affected by bargaining power. To this end, theoretical and empirical findings are reviewed. Subsequently hypotheses are derived that can be tested empirically.

First, I will consider how a supplier's profitability is affected by bargaining power. Major determinants of bargaining power in vertical relations are firm size and market concentration. Theoretical literature on vertical interactions frequently predicts a negative effect of buyer concentration on supplier profitability due to buyer power (e. g. Dobson and Waterson, 1997; Inderst and Wey, 2007, Smith and Thanassoulis, 2012). Usually this finding is derived from Nash bargaining models applying different assumptions on efficiency of the outcome, upstream and downstream market structure, uncertainty over output quantities as well as a supplier's cost function. In most of these models it is assumed that there is one supplier negotiating simultaneously with numerous buyers over the split of a joint profit *v*. The joint profit *v* is the sum of the upstream and the downstream profits generated by the contract between supplier and buyer, which I will refer to as "incremental profits" in the following. In a given negotiation the outcome of all other negotiations is taken as given, hence the negotiations with a certain buyer are over the last units of the intermediary product.

Assuming inefficient Nash bargaining, i. e. bargaining over linear unit prices, buyers can reduce upstream profits if downstream concentration increases (Dobson and Waterson, 1997). This is due to the fact, that the outside option of the supplier, i. e. the prices and quantities he can sell to all other downstream firms in case the negotiations with a certain buyer fail, is devaluated since there are less alternative buyers available. If in addition downstream firms are very competitive (i.e. their products are perceived to be close substitutes) and behave in a Bertrand manner, supplier's profits are driven down even further as the incremental downstream profit is close to zero and consequently the joint profit *v* decreases.

In the case of efficient Nash bargaining, i. e. contractors maximize the joint profit and can settle on non-linear prices, similar results occur. Given the supplier can be certain over the final upstream quantity demanded, input prices are a function of average costs of supplying the buyer. Consequently a large order in combination with increasing marginal costs of the supplier implies lower input prices (Chipty and Snyder, 1999; Inderst and Wey, 2007). To derive this result it is necessary that downstream firms are considered as monopolists on symmetric but separate markets with marginal costs of transforming the intermediate product of zero. In this case the optimal quantity provided by the downstream firm is independent of the market size and hence the downstream price is constant over all downstream markets. It follows then that only the incremental upstream profit is relevant for the emergence of buyer power and ultimately lower supplier profitability. Relaxing the assumption that downstream prices have to be constant across markets, Björnerstedt and Stennek (2007) derive buyer dis-

counts also for the case of multiple upstream and multiple downstream firms. They argue that the relation of a buyer's marginal revenue and a supplier's marginal cost determines whether there is a quantity discount or a quantity premium for buyers. If marginal cost of the supplier is steeper than marginal revenue of the buyer, an increase in quantity for the buyer reduces incremental cost of supply more than it increases downstream revenues, ultimately leading to a quantity discount for the buyer.

In the presence of uncertainty over upstream final output, a supplier's profitability decreases if there are large buyers, i. e. buyers who account for large share of the supplier's sales, and decreasing marginal costs of supply (Smith and Thanassoulis, 2012). This is due to the fact that a supplier now attaches a probability of losing a contract to volumes negotiated with a buyer. The average costs of supplying the buyer are now not calculated over the final units but over all possible output realizations. Hence larger buyers imply larger expected output, lower expected marginal cost and thus lower input prices.

In line with the presented results from theoretical literature one can argue that increased buyer concentration is likely to have a negative effect on supplier's profitability. Accordingly, the first hypothesis reads:

Hypothesis 1: *The profit of the supplier is decreasing the more concentrated the buyer portfolio.*

Next I will show how a supplier's bargaining position is affected by his market position and which effect this will have in turn on his profits. A supplier's market position is defined on one hand by the market structure in the horizontal market and on the other hand by the substitutability of the supplied product. A monopoly in the supply market does not allow for an outside option of the buyer which in turn should result in a more powerful bargaining position of the supplier in comparison to a supplier with a high number of competitors. Such a beneficial market position is for instance obtainable by product differentiation thereby making the own product less substitutable.

Empirical studies dedicated to the analysis of manufacturer-retailer relationships in the food sector hint in the direction, that lower substitutability increases supplier margins. This is shown for yoghurt and peanut butter in the US (Sudhir, 2001), antibiotics in the US (Ellison and Snyder, 2010) and coffee in Chile (Noton and Elberg, 2013). If downstream product markets are very competitive because the products are easy to substitute, there is evidence for the existence of buyer power. For instance, for a yoghurt market in a particular region of the US with a considerable market share of private labels, there is support for the existence of two-part tariffs with zero wholesale margins (Villas-Boas, 2007).[1] A two-part tariff is characterized by the feature, that the manufacturer sets the wholesale price equal to marginal cost, so the retailer can claim all the profit for the product. The manufacturer is able to extract part of this wholesale profit in the form of a fixed fee the retailer has to pay. If wholesale profits are

[1] Two-part tariffs are considered to be the optimal contract whenever there is downstream market power. This holds for certain demand or asymmetric information (Tirole, 1988) and uncertain demand (Rey and Tirole, 1986). If there are multiple retailers and multiple manufacturers however, two-part tariffs are no longer the optimal contract (Schmalensee, 1981).

zero however, this implies that all the profit remains with the retailer. Hence suppliers' profitability is reduced.

Another way to achieve a monopoly position is patent protection. For antibiotics without patent protection, i.e. if competition with generic products is prevailed, large buyers (chain drugstores) receive discounts when compared to smaller buyers (Ellison and Snyder, 2010). Again, this implies a lower profitability on the supply side if substitutability is high. Against the background of these empirical results, it is obvious that suppliers' profitability positively depends on the strength of their market position. Consequently, the second hypothesis is stated as follows:

Hypothesis 2: *The profit of the supplier is increasing in the strength of the market position.*

The theoretical results this section builds on, typically consider negotiations over price and quantity of a good to be traded between supplier and buyer with rational agents. Williamson (1975) however, does acknowledge that agents may be boundedly rational, i. e. they have incomplete information about market opportunities and future occurences for instance (Alchian and Woodward, 1988) and are prone to failure. What is more, agents can behave opportunistic in a way, that they disclose information selectively and / or distortedly or simply give false promises regarding future conduct (Williamson, 1975). Such behaviour gives rise to transaction costs which may have an adverse impact on vertical relationships.[2] In the context of R&D, transaction costs may be substantial if R&D is sourced out or performed within an alliance (Aghion and Tirole, 1994). Under such circumstances, suppliers of R&D services can have several motives to behave opportunistically: "increasing the profits by reducing the efforts, preparation of own competitive activities and selling non-specific parts of the generated knowledge to a competitor (Kloyer and Scholderer, 2012; p. 347)". The buyer may also be tempted to behave opportunistically. That is, after the R&D supplier carried out necessary investments to fulfil contracted obligations, the buyer may enforce ex-post negotiations leading to conditions which reduce the supplier's profit margins or even lead to losses. Such behaviour is known as hold-up (Klein et al., 1978).

This paper considers internal R&D investments of suppliers, i. e. investments that aim at the development or the significant improvement of production technologies or products to own benefit. Hence, problems of information asymmetries between supplier and buyer and subsequent opportunities for moral hazard or hidden actions may not be as severe as in contractual R&D relationships. If there are opportunities for one party to behave opportunistically however, it should be the party in possession of the stronger bargaining position. This implies that even in the presence of opportunistic behaviour, suppliers' profitability should be positively (negatively) affected by a stronger (weaker) bargaining position.

Regardless of bargaining power, it has been shown frequently in empirical work that R&D activities are a main driver of firm productivity (e. g. Griliches, 1994; Crepon et al., 1998; Griffith et al., 2006; Peters, 2008). This is due to the fact that R&D translates into new prod-

[2] Transaction cost economics have been applied not only to vertical relationships but to a wide range of economic matters, e. g. "transfer pricing, corporate finance, marketing, the organization of work, long-term commercial contracting, franchising, regulation, the multinational corporation, company towns, and other contractual relationships, both formal and informal" (Shelanski and Klein, 1995; p. 336).

ucts and/or new production processes, thereby offering the opportunity to charge higher prices (for new products) or to benefit from lower cost of production for a given output. Of course, among firms there may be different strategies of performing R&D. That is, some firms carry out R&D incrementally, i. e. they alter existing technology; while some others concentrate on developing new-to-the-market products and/or technologies. No matter which strategy is applied, R&D will at some point result in an innovation which gives a firm a competitive advantage.

In addition to the positive effects of R&D on suppliers' profitability, there are also positive effects to be expected on the profitability of buyers. Using industry data from the UK, Geroski (1991) shows that the biggest impact on productivity growth came from innovations used rather than innovations produced. Scherer (1982) distinguishes the allocation of R&D expenditure by industry of use and industry of origin and explores the relationship to productivity growth in the US. In line with the results of Geroski (1991) he finds the R&D expenditure allocated to industry of use to have a larger effect on productivity growth. Hence, it seems plausible to assume that supplier's R&D can enlarge the joint profit which is to be split between supplier and buyer by bargaining. On one hand, if bargaining power of a supplier carrying out R&D activities is weak it is not possible to appropriate a large share of the joint profit (Farber, 1981; Lunn and Martin, 1986; Peters, 2000). On the other hand, if bargaining power of a supplier is high, he may be able to extract parts of the downstream profit that accrue due to an innovative product, for instance. The corresponding hypotheses for the effect of bargaining power in vertical relationships on the profitability of suppliers' R&D activities read:

Hypothesis 3: *The profitability of R&D investment increases with the strength of a supplier's market position.*

Hypothesis 4: *The profitability of R&D investment decreases with the concentration of a supplier's buyer portfolio.*

4. Empirical study

4.1. Data

In order to test the hypotheses empirically I employ firm level data from the Mannheim Innovation Panel (MIP) which provides information on enterprises from both manufacturing and services located in Germany and employing at least 5 employees. The data is annually collected by the Centre for European Economic Research (ZEW) on behalf of the Federal Ministry of Education and Research. The survey focuses on enterprises' innovative activities but also includes questions on their competitive environment.[3]

The 2011 wave of the MIP provides valuable information on supplier-buyer relationships and enterprises' market environment. Since the question regarding the supplier-buyer relationship is not part of the regular questionnaire, it is not possible to construct a panel dataset. The wave 2011 also contains general information, e. g. the profit over sales, the number of employees or

[3] For a more detailed description of the MIP see Peters (2008) and Rammer and Peters (2013).

the sales, but also information on the innovation behaviour and R&D spending. In order to have a lag between the dependent profit variable and the explanatory variables the wave 2011 is merged with the wave 2013 since the question regarding the profit is included biannually. I restrict the sample to manufacturing firms because services comprise rather heterogeneous industries. Additionally, R&D does more frequently occur in manufacturing. There are 1,411 firms for which the merge was successful representing Nace 2-digit industries 10-17 and 20-33.[4] To avoid outlier problems I drop all three observations with an R&D intensity of larger than 2, i. e. a firm's R&D expenditures exceed the sales by 100 % leading to an initial sample of 1,408 firms. The further steps of data cleaning are described in the next section.

4.2. Variables[5]

Dependent variable

The dependent variable is a supplier's profit over sales (*PROFIT*). This variable is available for both years 2012 and 2011 and thus provides an interesting opportunity to check if the impact of R&D investments in 2010 on supplier's profitability does have a time lag as suggested by Ravenscraft and Scherer (1982).[6]

The profit over sales variable was surveyed as categorical variable. Table 1 provides an overview of the different categories. Although provided with a category "don't know", some of the participating firms did not answer the question at all.

Table 1: Surveyed categories of the return on sales

Return on sales	Class	Return on sales	Class	Return on sales	Class
< -5%	1	[2, 4%)	5	>15%	9
[-5, -2%)	2	[4, 7%)	6	Do not know	10
[-2, 0%)	3	[7, 10%)	7		
[0, 2%)	4	[10, 15%)	8		

From the initial sample of 1,408 firms, 111 answered "don't know" to the profit in 2011 while 120 firms did so to the profit in 2012. Another 238 firms did not respond at all to the profit in 2011 (2012: 249 firms). Since the profit over sales variable is sensitive information and firms may be reluctant to provide information on it, I follow Czarnitzki and Kraft (2010, 2012) and perform an analysis if there are systematic differences between respondents and non-respondents. The detection of systematic differences would indicate that the estimations presented in next subsection suffer from a selection bias. Therefore I generate two dummy variables: the first takes unit value if the firm did not respond to the question at all while the second indicates if a firm did not respond or checked the "don't know" category. Then, Probit models are estimated for each year separately, regressing the dummy variables on all explana-

[4] The Nace codes refer to the Nace Rev. 2. The breakdown of industries is presented in Table A 1 in the Appendix.

[5] Detailed variable descriptions are presented in Table A1 in the Appendix.

[6] Using US data they find a mean lag of 4 to 6 years.

tory variables presented below. After deleting all observations with missing values in the explanatory variables, I eventually arrive at a sample of 570 observations, of which 472 do report profit over sales in both years 2011 and 2012.[7] I perform Wald-Tests to check if the coefficients are jointly significant. The test statistics take the value 19.79 (2011) and 21.59 (2012) for the model using the first and 16.52 (2011) and 18.08 (2012) for the model using the second dummy variable. All test statistics are distributed with 23 degrees of freedom. The corresponding p-values are 0.60, 0.49, 0.83 and 0.75 respectively, implying that there are no systematic differences between responding and non-responding firms. Obviously, this procedure controls for selection on observables. Given the various control variables which were applied, I conclude however that selection is not a concern in the final sample.

The profit over sales represents the excess return on sales and expresses the profits (sales – labour cost – capital cost – material cost) over sales. Czarnitzki and Kraft (2010, 2012) show that under certain assumptions the return on sales represents the Lerner index.[8] As the return on sales is net of capital costs, there is no need to include an additional explanatory variable controlling for the costs of capital.

Explanatory variables

The goal of this study is to explore the relationship between profitability and R&D investments taking into account the distribution of bargaining power in vertical relationships. Hence, R&D investments are measured by R&D intensity (*RDINT*) of the supply firm in 2010 which is defined as R&D expenditure over sales. It is unclear though if the effect of *RDINT* can be expected to be positive or negative (see subsection 2.1.2). The latter can occur if it is true that R&D performing firms face difficulties to find external capital lenders (see e. g. the survey of Hall and Lerner, 2010 and the references cited therein). As a result, risky and uncertain R&D projects are predominantly financed with internal financial means, implying a reduction of the supplier's profitability.

The bargaining power of the supplier is represented by the supplier's market position and the concentration of his buyer structure. The concentration of the buyer structure (*BUYCON*) is derived from a question regarding the share of sales generated by the largest three buyers in 2010, which could be filled in by respondents directly. Obviously, it would be preferable to have the share of each single buyer in the supplier's sales but the measure still allows testing of hypothesis 1 as a large value of *BUYCON* should indicate also large shares for single buyers.[9] In addition, the questionnaire included a check box which could be ticked if the share of sales with the largest three buyers is below 1 %. I chose to drop all observations with a sales

[7] Missing values in the dependent and explanatory variables would have led to a final sample of 676 observations. I decided however to exclude another 204 firms which indicated to have a market share of less than 0.1 % or a share of sales generated by the largest three customers of less than 1 %. The reasons are explained when describing the variables buyer concentration and market share.

[8] These assumptions are that firms are in the long-run equilibrium and produce with constant returns to scale. Then the returns on sales of a firm represent on average across the product portfolio the Lerner index since average costs equal marginal cost when returns to scale are constant.

[9] Note that the observed share reflects the share of sales generated by three customers. If firms have less than three buyers, the share equals 100 %.

share of the largest three buyers below 1 % as I am interested in intermediate markets and I assume that these firms rather work on final product markets.

A supplier's profitability should be also affected by the concentration in the downstream market as a high concentration does not allow for easy switching of buyers. Since the dataset contains only limited information about the buyers, I cannot observe the product markets they are active in. This is clearly a limitation of this study. However, downstream concentration should be captured at least partly by industry dummies controlling for differences in suppliers' industry characteristics, if suppliers in a particular industry are affected equally by downstream concentration.

The market position of the supplier which was identified as determining the supplier's bargaining power is captured by several variables. Recall that the market position depends on the switching costs of buyers and reflects market structure and the substitutability of the supplied product. For instance, switching costs should be low if the intermediate good is homogenous and durable and numerous suppliers produce it. In contrast, they should be high if the good is very customer-specific. Hence, the number of a supplier's competitors (*COMP*) is included to control for switching opportunities of buyers. *COMP* is a dummy variable indicating whether the number of competitors is within the range of 1 to 5.[10] The reference category thus is to have no or more than 5 competitors.[11] In order to control for substitutability, I use the assessment of the supplier whether the firm's product is easy to substitute by competitors' products on a 4-point-Likert-scale.[12] I construct a dummy variable (*SUBSTIT*) taking unit value if the firm agrees or fully agrees to the above statement.

The main variable reflecting a supplier's market position is the supplier's market share in the main product market (*MSHARE*). Firms were asked directly for their market share with the most important product in 2010 and could check a box, if it was below 0.1 %. The share of responding firms in the initial sample with a market share below 0.1 % was about 30 % which seems remarkably high. Further inspection showed that some quite large firms were within this group.[13] This is surprising as larger firms should report larger market shares. As the questionnaire did not provide an option to answer "don't know" for the market share, it seems reasonable that a significant share of firms ticked the threshold box because they did not know how large their market share is. Hence, as a measure of precaution and since I do not have the opportunity to cross check the information with other data, I excluded all firms reporting market share below 0.1 %.

Apart from the fact that market share is a more objective measure, it is also more detailed compared to *SUBSTIT* and should in addition capture factors like buyer loyalty or the strength of a brand which have impact on the substitutability of a product. However, the choice of the

[10] The corresponding question asks for the number of competitors on the main product market and provided the categories "None", "1 to 5", "6 to 10", "11 to 15", "16 to 50" and "more than 50" to answer.

[11] I also experimented with the inclusion of a dummy variable indicating if the supplier is a monopolist. The estimated coefficient of the variable was however highly insignificant while all other results were unchanged. Hence, I refrain from using this variable.

[12] The respondent could assess the statement with "do not agree", "somewhat disagree", "somewhat agree" and "fully agree".

[13] About 10 % of these firms reported to have more than 100 employees.

market share as measure of a supplier's bargaining power deserves further discussion. The underlying assumption is that if a supplier's market share is large, then – from the perspective of a buyer – there are fewer alternative suppliers to turn to in case the negotiations with the supplier fail. Hence, the supplier has higher bargaining power compared to a supplier with low market shares. What is more, the market share can also be interpreted as a sign of higher efficiency. This interpretation goes back to the "Chicago School" (see e. g. Demsetz, 1973 or Peltzman, 1977) and builds on the assumption that there are productivity differences between firms within a market. Competition between these firms leads to a reallocation of market shares from inefficient to efficient firms. Hence productive firms grow, increase their market share and are more profitable while less productive firms shrink and eventually exit the market. That is, the efficiency argument would imply a stronger bargaining position for a supplier with a high market share since the outside option for a buyer would be to turn to a supplier operating on a higher cost curve.

Using the market share as a measure of a supplier's bargaining power comes with a caveat though. According to the simple Cournot model with homogenous goods, the market share determines the price-cost margin of a firm, i. e. the higher the market share, the higher a firm's profitability (see e. g. Belleflamme and Peitz, 2010). This would imply a relationship between market share and firm profitability which is detached from bargaining. However, the model neglects at the same time both vertical interaction and the existence of transaction costs. As I have shown in the previous section transaction costs may play an important part in vertical relationships. Also an overwhelming part of the transactions on intermediate markets are sealed by bargaining.[14] Hence, the interpretation of the market share as a determinant of bargaining power seems to be reasonable.

Even though I consider *BUYCON* and *MSHARE* to be the main variables of interest in measuring suppliers' bargaining power, there are other factors affecting the contractors bargaining position and thereby influencing a supplier's profit. The elasticity in demand may be an important factor as a supplier could make up the loss of a buyer or concessions in prices with increasing the prices for remaining buyers.[15] The leeway for such price increases should be the larger, the less price elastic demand. To control for that, three dummy variables are included in the estimation equation, indicating to what extent the supplier agrees with the statement, that an increase in prices leads to an immediate loss of customers on a 4-point-Likert-scale. If they strongly agree, I assume the price elasticity of demand to be high (*ELAST_H*), while it is assumed to be medium, if the supplier somewhat agrees (*ELAST_M*). The price elasticity of demand is assumed to be low if the supplier somewhat disagrees (*ELAST_L*). Consequently, the reference category consists of firms which strongly disagree with the above statement and therefore face a relatively inelastic demand. Finally, a high degree of product diversity offers more outside options to the supplier compared to a single-product-supplier. In the questionnaire firms where asked for the share of sales with their most important product. In order to control for a firm's product diversity, I include a variable (*DIVERS*) that is defined

[14] Björnerstedt and Stennek (2007) cite an estimation of *The Economist* that about 80 to 90% of all intermediate goods are traded through extended term contracts and that spot markets play a fairly minor role.

[15] The observation of low prices for large or powerful buyers while the remaining buyers' prices increase, is described as "waterbed effect" (see Inderst and Valletti, 2011, Smith and Thanassoulis, 2012).

as 100 minus the share of sales with the most important product. *DIVERS* thus reflects the share of sales a firm generates with others than its most important product.

Further firm specific characteristics that may affect a supplier's profitability are also considered. Firms involved in international trade are likely to be more competitive as they are able to enter foreign markets. Moreover, after entering they serve presumably larger markets. Thus a variable indicating the export intensity (*EXPORT*) is included which is defined as the share of exports in sales. To capture size effects the firm size (*SIZE*) measured as the log of the number of employees in full time equivalents is included. Another dummy variable is included in order to control if the firm is part of a multinational enterprise group (*FOREIGN*). Further control variables are whether the firm is located in Eastern Germany (*EAST*) and 10 industry dummies (*IND*) with the furniture/sport/toys industry as reference.

4.3. Estimation strategy[16]

Given the theoretical framework and the variables identified in the previous section, the empirical strategy is formulated according to equation (1).

$$PROFIT_{i,t+2} = \beta_0 + \beta_1 RDINT_{it} + \beta_2 MSHARE_{it} + \beta_3 BUYCON_{it} + \delta X + \varepsilon_i \qquad (1)$$

Vector *X* includes all variables which were identified to affect the bargaining power of the supplier and thus profitability, i. e. the substitutability of the supplier's product (*SUBSTIT*), the price elasticity of the demand (*ELAST_H, ELAST_M, ELAST_L*), the number of competitors (*COMP*) and the supplier's degree of diversification (*DIVERS*). In addition, vector *X* contains further variables capturing firm characteristics, i. e. *EXPORT*, *SIZE*, *FOREIGN*, *EAST* and the industry dummies.

Since the dependent variable is categorical, an ordered Probit model is estimated to obtain the influence of R&D investments and the supplier's bargaining power on profitability. Hence, equation (1) defines our latent model of the unobserved dependent variable $PROFIT_i^*$. The observed profit over sales relationship is defined by:

$$PROFIT_i = \begin{cases} 1 \text{ if } PROFIT_i^* \leq \mu_1 \\ 2 \text{ if } \mu_1 < PROFIT_i^* \leq \mu_2 \\ \vdots \\ 8 \text{ if } \mu_7 < PROFIT_i^* \leq \mu_8 \\ 9 \text{ if } \mu_8 < PROFIT_i^* \leq \mu_9 \\ 10 \text{ if } \mu_9 < PROFIT_i^* \end{cases} \qquad (2)$$

The values of μ_i with $i = 1, \ldots, 9$ define the thresholds of the respective categories. Such models are commonly used for dependent categorical variables with unknown thresholds values. The fact that the questionnaire provides observable threshold parameters allows the identification of the variance which is usually unidentified. Consequently we can exactly quantify

[16] A similar approach is used by Czarnitzki and Kraft (2010, 2012) who use the MIP wave of 2003 to analyze the relationship between firms' patent stocks and their profitability (2010) and the same data to study the effects of incoming and outgoing knowledge spillovers on profitability (2012).

the marginal effects of the explanatory variables (Verbeek, 2004). This is in contrast to an ordered Probit model with unknown threshold values or a binary Probit model in which the estimated parameters are always scaled with the unidentified variance.[17]

I also test for additive groupwise heteroscedasticity within the sample using a likelihood ratio (LR) test. Heteroscedasticity may lead to inconsistency of the estimated coefficients. Therefore I model a heteroscedasticity term allowing the variance to vary by location in East Germany and industry affiliation. The location of the firm is captured by *EAST* while 10 industry dummies (*IND*) control for a firm's industry affiliation. The LR tests reject the hypothesis of homoscedasticity. Therefore, I will only present the estimation results of the heteroscedastic models.

Endogeneity issues may be of concern for the explanatory variables R&D intensity, market share and size as they may be determined simultaneously with profitability. I could not identify suitable instruments for these variables which would allow elimination of endogeneity. However, I can rule out short-term endogeneity as I lag the explanatory variables by 2 periods. Longer time lags or instruments would be needed in order to take account of long-term endogeneity, which are unfortunately unavailable.

In addition, I analyse correlations among the explanatory variables which should not affect the estimated coefficients, but may inflate the estimated standard errors. Both pair-wise correlations and variance inflation factors are calculated but there is no indication for multicollinearity issues when applying conventional standards from the relevant literature (Chatterjee and Hadi, 2006).[18]

5. Results

5.1. Descriptive Statistics

Descriptive statistics of the full sample differentiated by a firm's R&D status are shown in Table 2. The share of R&D performers in the full sample is 59 %. It is apparent that in many aspects the group of R&D performers is similar to the non-R&D performers.

The mean profit of all groups of suppliers is between the categories 5 and 6 which imply return to sales between 2% to lower than 7%. The means for both groups are slightly higher in 2011 than in 2012. Between the groups there is however no large gap, even though the difference between R&D performers and non-performers is significant for 2011. The R&D performers have an average R&D intensity of 3.8 %. Taken together with the non-R&D performers the average R&D intensity drops to 2.3 % which is close to the 2.7 % reported in Czarnitzki and Kraft (2010) who use a similar dataset.

[17] See Verbeek (2004, pp. 205-207) for an illustrative example of an ordered Probit model with known threshold values.

[18] The correlation matrix and the variance inflation factors can be found in Table A 5 in the Appendix.

Table 2: Descriptive statistics differentiated by suppliers' R&D status

	Full Sample		R&D performer		Non-R&D performer		T-test	
	Mean	SD	Mean	SD	Mean	SD		
PROFIT 2012	5.42	2.04	5.51	2.14	5.29	1.89	-1.15	
PROFIT 2011	5.69	1.97	5.85	2.03	5.46	1.86	-2.08	**
RDINT	2.26	5.20	3.81	6.31	0.00	0.00	-8.37	***
MSHARE	26.35	27.28	26.38	24.86	26.31	30.54	-0.03	
BUYCON	36.91	24.08	36.50	23.58	37.52	24.85	0.45	
SUBSTIT[a]	0.59	0.49	0.55	0.50	0.65	0.48	2.28	**
ELAST_L[a]	0.35	0.48	0.36	0.48	0.34	0.47	-0.49	
ELAST_M[a]	0.45	0.50	0.45	0.50	0.46	0.50	0.37	
ELAST_H[a]	0.11	0.32	0.11	0.31	0.11	0.32	0.13	
COMP[a]	0.49	0.50	0.52	0.50	0.44	0.50	-1.61	
DIVERS	33.20	24.59	36.18	24.06	28.86	24.77	-3.21	***
EXPORT	29.88	28.25	36.99	29.05	19.52	23.52	-6.92	***
SIZE	239.79	591.55	331.49	741.89	106.06	169.24	-4.14	***
FOREIGN[a]	0.10	0.31	0.12	0.32	0.08	0.28	-1.21	
EAST[a]	0.28	0.45	0.29	0.46	0.25	0.43	-1.02	
N	472		280		192			

[a] Dummy variable. Columns with heading SD display standard deviations. The last two columns display t-statistics whether a T-test on mean difference between the group of R&D performers and non-R&D performers rejects the Null hypothesis of no difference. The asterisks indicate the corresponding level of significance (* 10 %, ** 5 %, *** 1 %). The variable SIZE is presented in original values. Descriptive statistics of the remaining variables are presented in Table A 2 in the Appendix.

Non-R&D performers do not exhibit significantly lower market shares with the average market share being about 26 %. Also both groups do not differ in respect to the share of sales with the three largest customers. Across both groups the share of sales generated with the largest three buyers is between 37 and 38 %. The group of R&D performers exhibits a significantly lower share of firms indicating easy substitutability while there are no differences to non-R&D performers in the measures of the demand elasticity. This implies that even though the products of R&D performers are less easy to substitute, the demand elasticity limits the scope for quasi-monopoly pricing as otherwise buyers will go elsewhere. There is also no indication for R&D performers to be more frequently active in an oligopolistic market. Instead they are significantly more diversified, generate a much higher share of sales by exports and are also considerably larger compared to non-R&D performers. Both groups do not show any differences with respect to foreign ownership and location in Eastern Germany. The high overall share of firms located in East Germany (28%) is due to oversampling of these firms in the MIP.

Regarding the industries there are no surprises in the differences between R&D and non-R&D performing firms. The share of non-R&D performers is significantly higher in the Food/Tobacco, Textiles and Wood/Paper/Print industries while R&D performers constitute a significantly higher share in Chemicals, Machinery, and Electronics.

5.2. Regression results

I estimate equation (1) and present the results of the heteroscedasticity consistent ordered Probit model in Table 3. Columns I and II report estimation results for the profit in 2011 and the profit in 2012, without taking account of the interaction effects between R&D intensity and the variables indicating a supplier's bargaining power (*BUYCON* and *MSHARE*). The estimation results including interaction effects are presented in columns III and IV for the profit in 2011 and the profit in 2012 respectively.

Let us first have a look at the results without interaction terms in order to check how the buyer variables affect suppliers' profit (see Table 3, column I and II). The most important result is that a supplier's bargaining power does indeed affect his profitability significantly. As expected, the market share, as a measure of the strength of a supplier's market position and thus stronger bargaining power, exerts a positive effect on profitability. The share of sales with the largest three buyers, as a measure of buyer concentration and thus lower supplier bargaining power, does exert a negative effect on a supplier's profitability. The effects remain constant regardless the dependent variable. This supports the hypotheses 1 and 2, which state that higher buyer concentration should affect profits negatively, while a higher market share should have a positive effect on suppliers' profits.

Let us now turn to the results of the model including interaction terms between the variables reflecting the bargaining power of a supplier and R&D intensity (see Table 3, column III and IV). The results clearly show a positive relationship between bargaining power of the supplier and R&D investments. First, a higher market share, as a measure of the strength of a supplier's market position and thus its bargaining power, is related to larger R&D investments. Second, higher buyer concentration which indicates lower bargaining power of a supplier is connected with lower R&D investments. The highly significant interaction terms take explanatory power from the direct measures of *RDINT*, *MSHARE* and *BUYCON*. This demonstrates that profitability of R&D investments strongly depends on a supplier's bargaining position. A Wald-Test on the joint significance of *RDINT*, *MSHARE*, and *BUYCON* and their interactions rejects the hypothesis of all coefficients being jointly zero at the 5 % confidence level for the profit in 2011 and at the 1 % significance level for the profit in 2012. These findings support hypotheses 3 and 4.

Table 3: Estimation results of heteroscedasticity consistent ordered Probit models

	Dependent variable: Profit over sales							
	2011		2012		2011		2012	
	I		II		III		IV	
RDINT	-0.078		-0.104	*	-0.030		0.017	
	(0.062)		(0.060)		(0.110)		(0.108)	
MSHARE	0.023	***	0.023	***	0.016	*	0.015	*
	(0.008)		(0.008)		(0.009)		(0.009)	
BUYCON	-0.019	*	-0.021	**	-0.010		-0.008	
	(0.011)		(0.010)		(0.011)		(0.011)	
MSHARE x RDINT					0.007	***	0.007	***
					(0.002)		(0.002)	
BUYCON x RDINT					-0.007	**	-0.009	***
					(0.003)		(0.003)	
SUBSTIT[a]	-1.388	***	-1.379	***	-1.363	***	-1.358	***
	(0.514)		(0.499)		(0.512)		(0.496)	
ELAST_L[a]	-2.042	**	-2.811	***	-1.897	*	-2.592	***
	(0.995)		(0.978)		(0.989)		(0.971)	
ELAST_M[a]	-2.641	***	-2.880	***	-2.606	***	-2.782	***
	(0.982)		(0.954)		(0.979)		(0.948)	
ELAST_H[a]	-3.153	***	-3.626	***	-3.108	***	-3.510	***
	(1.137)		(1.122)		(1.129)		(1.107)	
COMP[a]	0.959	**	1.203	**	0.940	**	1.187	**
	(0.483)		(0.486)		(0.477)		(0.480)	
DIVERS	-0.013		-0.026	**	-0.013		-0.027	***
	(0.011)		(0.010)		(0.010)		(0.010)	
EXPORT	0.019	*	0.018	*	0.017	*	0.016	
	(0.010)		(0.010)		(0.010)		(0.010)	
SIZE	-0.151		-0.377	*	-0.133		-0.376	*
	(0.199)		(0.197)		(0.198)		(0.196)	
FOREIGN[a]	-0.51		-1.469	*	-0.444		-1.402	*
	(0.826)		(0.813)		(0.821)		(0.809)	
EAST[a]	0.447		0.236		0.629		0.439	
	(0.538)		(0.528)		(0.535)		(0.520)	
Constant	7.427	***	9.406	***	7.240	***	9.152	***
	(1.681)		(1.598)		(1.666)		(1.584)	
$ln\hat{\sigma}$	1.390	***	1.298	***	1.347	***	9.152	***
	(0.151)		(0.152)		(0.153)		(1.584)	
Industry dummies included	yes		yes		yes		yes	
Wald - Test: joint significance of industry dummies	31.45	***	39.97	***	33.60	***	43.64	***
$R^2_{McFadden}$	0.81		0.81		0.80		0.80	
N	472		472		472		472	
Log likelihood	-919		-916		-915		-910	
LR-test on heteroscedasticity	LRχ2 (11) = 49.95	***	LRχ2 (11) = 54.79	***	LRχ2 (11) = 50.91	***	LRχ2 (11) = 54.41	***

[a] Dummy variable. Standard errors are shown in parentheses. Asterisks indicate significance levels of 10% (*), 5% (**) and 1% (***) respectively. Heteroscedasticity term includes East and 10 industry dummies. Estimation results of the industry dummies are presented in Table A 3 in the Appendix.

To get an idea about the magnitude of the effect of *RDINT*, *MSHARE*, and *BUYCON*, let us consider an average supplier among the group of R&D performers with group averages of market share (value equals 26 %) and buyer concentration (37 %). As a benchmark, uncondi-

tional profits over sales in the manufacturing sector are estimated, which were 5.5% in 2011 and 4.7% in 2012.[19] On average, an increase in R&D investments 2010 by one percentage point would reduce the average supplier's profit by 0.11 percentage points in in 2012.

In contrast, let us now consider the profitability of the same supplier if the largest three buyers account for 100 % of the sales. Then an increase in R&D investments in 2010 would reduce profitability in 2012 by 0.67 percentage points. Given the average profit of 4.7% in 2012 a reduction by 0.67 percentage points would decrease the profit over sales by about 14 %. This result highlights the substantial negative effects that may result from buyer concentration on supplier profitability. It indeed seems that suppliers facing low bargaining power in vertical relationships cannot fully appropriate the returns of their R&D investments.

For comparison let us consider the effect if the supplier is a monopolist, i. e. his market share is 100 %. Then an increase in R&D investments in 2010 would increase profitability in 2012 by 0.49 percentage points. This corresponds to an increase in profit over sales by 10 %.

With respect to the other explanatory variables influencing a supplier's profitability, I find across all specifications negative results for the substitutability of the produced good, the strength of the demand elasticity and oligopolistic competition which is in line with microeconomic theory. Given the results of the columns III and IV, if a supplier's product is easy to substitute, the return on sales is on average 1.4 percentage points lower when compared to suppliers who state that their products are not easy to substitute, all else equal. Similarly, an increase in demand elasticity from relatively inelastic to highly elastic implies ceteris paribus a reduction in profitability about 3.1 percentage points in 2011 and 3.5 in 2012. The profit in 2012 of suppliers which face oligopolistic competition in 2010 is on average 1.2 percentage points higher compared to suppliers who face more or less competitors.

For the variables indicating the degree of diversification, the export intensity, the firm size and affiliation to a foreign enterprise group the results are not significant across all model specifications but the coefficients point into the same direction. All else equal suppliers with a more diverse product portfolio exhibit lower profits while exporters have larger profits. Firm size does negatively affect profitability as does the affiliation to a foreign enterprise group. The estimated coefficients of *EAST* are insignificant throughout all estimations.

Robustness Tests

It has been argued before that larger firms are likely to be more efficient, to have higher market shares and thus to be more profitable (see also subsection 4.2). In addition, as R&D intensity is defined as R&D expenditure over sales, smaller firms tend to have higher values of *RDINT* since their sales numbers are smaller compared to larger firms. This would result in higher values of *RDINT* for a given amount of R&D expenditure. Small sales numbers also promote high sales shares with the largest three customers. Therefore, one could presume that the negative effect of *RDINT* and *BUYCON* on profitability and also the negative interaction term between *RDINT* and *BUYCON* are mainly driven by small firms. In order to test for this, all firms having fewer employees than the firm on the 25 % quantil (value equals 23 employ-

[19] That was done by estimating an ordered Probit model with a constant only.

ees) are excluded from the sample. As this reduces the small sample further to 357 firms, the explanatory variables *COMP*, *EXPORT* and *SIZE* are dropped since a Wald-test on joint significance could not reject the Null hypothesis of these coefficients being jointly zero. Moreover, the presentation of the results is restricted to the estimations using the profit in 2012 as dependent variable in Table 4 for reasons of simplicity.

The results show that in the model specification without interaction terms the coefficients of *RDINT* and *BUYCON* turn insignificant. In contrast, all variables indicating substitutability and demand elasticity are highly significant and in about the same magnitude as in the estimations with the full sample. Inclusion of the interaction terms shows however that the interaction term of *BUYCON* and *RDINT* loses statistical significance as well, while the interaction term of *MSHARE* and *RDINT* more than triples in magnitude from 0.007 in Table 3 (column IV) to 0.023 in Table 4 (column II).

Therefore it seems that small firms indeed have a strong impact on the empirical analysis of bargaining power and the profitability of R&D. However, excluding them from the sample still shows the effect of bargaining power on R&D profitability. The Wald-Test on joint significance of *RDINT* and both interaction terms is rejected to the 0.1 % confidence level. For the average R&D performing supplier this implies that with a buyer concentration of 36 % and a market share of 26 %, a one percentage point increase in R&D investments in 2010 would now increase profitability by 0.68 percentage points whereas the estimate with the full sample predicted a reduction of 0.36.

The average of the unconditional profit distribution in this sample of firms equals 4.5 %. The increased coefficient of the interaction between *RDINT* and *MSHARE* implies, that a percentage point increase in R&D intensity in 2010 would increase profitability for the average R&D performing supplier in 2012 by 0.18 percentage points. The corresponding effect for a monopolist with average buyer sales share is 1.9 while the fully dependent supplier with an average market share experiences a drop in profits by 0.3 percentage points. This corresponds to an increase in profits of 43 % and a decrease of 7 % respectively.

Strongly related to the size of a firm is the likelihood of being a R&D performer. Hence one could argue in a similar vein, that non-R&D performing firms drive the results from the full sample since they are less competitive and therefore hold lower market shares. Hence, the positive effect of *MSHARE* on profitability could be caused by non-R&D performers which in addition may also affect the positive slope of the interaction term between *MSHARE* and *RDINT* since they have a R&D intensity of zero.

To check this, all non-R&D performing firms are dropped. As the number of observations drops to 280, the number of explanatory variables is reduced. *COMP*, *FOREIGN* and *SIZE* are excluded after the Wald-Test rejected that all three coefficients together are jointly significant. The results are presented in Table 4 columns III and IV.

Table 4: Estimation results of heteroscedasticity consistent ordered Probit models for a sample excluding small firms and a sample of R&D performing firms

	Dependent variable: Profit over sales 2012							
	Small firms excluded				R&D performing firms			
	I		II		III		IV	
RDINT	0.036		-0.166		-0.070		0.097	
	(0.080)		(0.131)		(0.069)		(0.129)	
MSHARE	0.037	***	0.014		0.054	***	0.040	**
	(0.009)		(0.010)		(0.014)		(0.016)	
BUYCON	-0.013		-0.005		-0.012		0.013	
	(0.012)		(0.013)		(0.014)		(0.017)	
MSHARE x RDINT			0.023	***			0.006	**
			(0.004)				(0.003)	
BUYCON x RDINT			-0.007	**			-0.009	***
			(0.003)				(0.003)	
SUBSTIT[a]	-1.57	***	-1.507	***	-1.629	***	-1.472	**
	(0.528)		(0.510)		(0.614)		(0.618)	
ELAST_L[a]	-2.547	**	-2.485	**	-0.629		-0.921	
	(1.052)		(1.018)		(1.434)		(1.444)	
ELAST_M[a]	-2.983	***	-3.119	***	-1.422		-1.877	
	(1.026)		(0.988)		(1.322)		(1.345)	
ELAST_H[a]	-3.077	**	-3.391	***	-2.713	*	-3.049	*
	(1.232)		(1.185)		(1.627)		(1.651)	
DIVERS	-0.025	**	-0.025	**	-0.034	**	-0.031	**
	(0.011)		(0.011)		(0.014)		(0.014)	
EXPORT					0.024	**	0.022	**
					(0.011)		(0.011)	
FOREIGN[a]	-1.673	*	-1.862	**				
	(0.861)		(0.858)					
EAST[a]	-0.672		-0.255		0.227		0.398	
	(0.561)		(0.539)		(0.725)		(0.716)	
Constant	8.439	***	8.824	***	4.589	**	4.354	**
	(1.547)		(1.513)		(2.117)		(2.121)	
$ln\hat{\sigma}$	1.543	***	1.493	***	2.262	***	2.148	***
	(0.177)		(0.178)		(0.363)		(0.352)	
Industry dummies included	yes		yes		yes		yes	
Wald - Test: joint significance of industry dummies	26.02	**	32.28	**	21.44	**	20.73	**
R^2 McFadden	0.52		0.75		0.59		0.65	
N	357		357		280		280	
Log likelihood	-687		-670		-530		-526	
LR-test on heteroscedasticity	LRχ2 (11)= 38.56	***	LRχ2 (11) = 37.49	***	LRχ2 (16) = 68.91	***	LRχ2 (16) = 66.64	***

[a] Dummy variable. Standard errors are shown in parentheses. Asterisks indicate significance levels of 10% (*), 5% (**) and 1% (***) respectively. Heteroscedasticity term for the sample in columns I and II includes East and 10 industry dummies while it includes 5 size dummies, East and 10 industry dummies for the sample in columns III and IV. Estimation results of the industry dummies are presented in Table A 4 in the Appendix.

In the specification without interactions the same pattern emerges as if all small firms were dropped. That is, *RDINT* and *BUYCON* turn insignificant. If the interaction terms are included, the interaction between *RDINT* and *MSHARE* loses a level of significance while the other cross term is strongly significant but does not substantially increase in magnitude. Notice instead, that the exclusion of the non-R&D performing firms drove the confidence levels of the demand elasticity coefficients either insignificant or close to insignificance. Hence, it seems

that within the group of R&D performers demand elasticity is not as important in determining profitability as in a sample including non-R&D performers as well. In this sample the average estimated unconditional profit over sales in 2012 is 5 %. A percentage point increase in R&D investments 2010 would decrease profitability of the average R&D performing supplier with a buyer concentration of 36 % and a market share of 26 % by 0.05 percentage points on average. This corresponds to a 1 % decrease in profits. This is considerably lower than in the full sample. The effect for a monopolistic supplier is again positive. A percentage point increase in R&D intensity 2010 would increase profitability by 0.4 percentage points and corresponds to an increase in profits by 8 %. Contrastingly, a fully dependent supplier, i. e. with a share of sales by the largest three buyers of 100 %, would experience a drop in profitability 2012 by 0.61 percentage points due to a percentage point increase in R&D intensity 2010. This implies a profit loss of about 12 %.

6. Concluding remarks and further research

This paper explores the effect of bargaining in vertical relationships on the profitability of suppliers' R&D investments. Studies on the relationship between R&D, innovation and firm profitability mostly concentrate on the impact of horizontal market structure which follows traditional industrial organization literature that emphasizes the importance of market concentration and entry barriers for firm profitability. While providing inconclusive results, none of the existing studies takes vertical interactions of R&D performers into account.

Building on theoretical and empirical evidence about the effects of bargaining power in vertical relationships on a supplier's profitability, the crucial determinants of a supplier's bargaining power are identified as the market position and the degree of concentration in the buyer portfolio. With respect to R&D profitability the latter is expected to diminish returns from R&D, while the former is expected to increase it.

The hypotheses are tested using a sample of 472 German firms from manufacturing sectors. The empirical findings support all hypotheses and therefore highlight the importance of taking bargaining power occurring in vertical relationships into account when measuring R&D profitability. The estimated effects are considerable: for an average R&D performing supplier an increase of R&D intensity in 2010 by a percentage point would reduce profits by about 14 % in 2012 given the supplier depends completely on the largest three buyers and does hold an average market share. Contrastingly, a monopolist R&D performing supplier with average buyer concentration would experience a profit increase by 10 % in 2012. What is more, the findings support the hypothesis of a lagged impact of R&D investments on a supplier's R&D profitability (Ravenscraft and Scherer, 1982).

The findings are an important contribution to the existing literature for several reasons. First, because this is the first study that analyses the effects of supplier's bargaining power on the profitability of R&D. Second, the sheer magnitude of the effects indicates that further research with respect to the R&D incentives for suppliers facing bargaining power is needed.

Moreover the results provide several implications for practitioners. Managers of R&D performing supply firms in the manufacturing sector may benefit from a more diversified buyer

structure as this increases bargaining power and allows for a higher profitability of R&D activities. In addition, the results show that it is more profitable to serve smaller markets if this leads to an increased market share. Again, this translates into a stronger bargaining position and spurs R&D profitability. The results also have relevance for competition authorities. Merger decisions should take into account how upstream R&D profitability is affected by downstream mergers to avoid adverse effects on suppliers' innovation incentives.

There are opportunities for improvement – both theoretically and empirically – which are left to future research. From a theoretical point of view, it would be useful to have a model explaining how R&D incentives are shaped by bargaining. Therefore, R&D should be integrated in the existing bargaining framework as it was pioneered by the model of Inderst and Wey (2007). Having said this, bargaining models concerned with buyer power are often limited to monopoly in the supply market and separate downstream markets. It would be useful for empirical purpose – and especially for the question how bargaining power affects R&D profitability – if upstream competition is introduced. Empirically, it would be worthwhile to gather information for each of the suppliers' buyers instead using aggregated shares. In contrast to this study, it would allow the generation of buyer-specific outside option values. In addition, it would help to have information on all products which are supplied to the buyer and the respective market share of the supplier in all according markets. With that information it would be possible to render a suppliers' outside options even more precisely. Moreover, it would be interesting to collect information about factors which are likely to determine the buyers' outside options, e. g. the share of inputs sourced from a particular supplier, product markets the buyers are active in, the concentration level in the respective market and so on. Thus, more information on the nature of the buyers would be invaluable and would allow for the analysis of countervailing power for instance (Galbraith, 1956).

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Appendix

Table A 1: Industry breakdown

Variable	Industry group	Nace Code[a]
IND1	Food/Tobacco	10-12
IND2	Textiles	13-15
IND3	Wood/Paper	16-17
IND4	Chemicals	20-21
IND5	Synthetics	22
IND6	Glass/Ceramics	23
IND7	Metal	24-25
IND8	Machinery	28, 33
IND9	Electronics	26-27
IND10	Automotive	29-30
IND11	Furniture/Sport/Toys (Reference group)	31-32

[a] Nace Code Rev. 2

Table A 2: Descriptive statistics differentiated by suppliers' R&D status (continued from Table 2)

	Full Sample		R&D performer		Non-R&D performer		T-test	
	Mean	SD	Mean	SD	Mean	SD		
IND1	0.066	0.248	0.025	0.156	0.125	0.332	4.39	***
IND2	0.053	0.224	0.029	0.167	0.089	0.285	2.88	**
IND3	0.057	0.232	0.018	0.133	0.115	0.319	4.53	***
IND4	0.091	0.288	0.125	0.331	0.042	0.200	-3.12	**
IND5	0.083	0.276	0.068	0.252	0.104	0.306	1.41	
IND6	0.074	0.262	0.071	0.258	0.078	0.269	0.27	
IND7	0.140	0.347	0.143	0.351	0.135	0.343	-0.23	
IND8	0.161	0.368	0.186	0.390	0.125	0.332	-1.77	*
IND9	0.169	0.376	0.236	0.425	0.073	0.261	-4.73	***
IND10	0.044	0.206	0.054	0.226	0.031	0.174	-1.15	
IND11	0.061	0.240	0.046	0.211	0.083	0.277	1.64	
N	472		280		192			

All variables are dummy variables. Columns with heading SD display standard deviations. The last two columns display t-statistics whether a T-test on mean difference between the respective group of R&D and non-R&D performers rejects the Null hypothesis of no difference. The asterisks indicate the corresponding level of significance (* 10 %, ** 5 %, *** 1 %).

Table A 3: Estimation results of heteroscedasticity consistent ordered Probit models (continued from Table 3)

	Dependent variable: Profit over sales							
	2011 I		2012 II		2011 III		2012 IV	
IND1	-0.626		-1.604		-0.770		-1.773	*
	(0.976)		(1.013)		(0.941)		(0.979)	
IND2	-0.516		-1.902	*	-0.637		-2.032	*
	(1.208)		(1.116)		(1.185)		(1.103)	
IND3	0.994		0.471		0.906		0.412	
	(1.472)		(1.386)		(1.471)		(1.403)	
IND4	3.970	***	2.176	*	4.150	***	2.207	*
	(1.410)		(1.315)		(1.413)		(1.328)	
IND5	0.347		-0.297		0.204		-0.450	
	(1.191)		(0.972)		(1.165)		(0.952)	
IND6	1.967		1.200		1.754		0.954	
	(1.370)		(1.281)		(1.342)		(1.248)	
IND7	-0.029		-0.862		-0.101		-0.942	
	(0.926)		(0.890)		(0.896)		(0.864)	
IND8	2.342	**	2.404	***	2.423	***	2.486	***
	(0.934)		(0.863)		(0.911)		(0.844)	
IND9	2.996	***	1.859		2.706	**	1.444	
	(1.154)		(1.191)		(1.127)		(1.137)	
IND10	0.498		0.494		0.331		0.245	
	(1.347)		(1.277)		(1.366)		(1.312)	
Wald - Test: joint significance of industry dummies	31.45	***	39.97	***	33.60	***	43.64	***
$R^2_{McFadden}$	0.81		0.81		0.80		0.80	
N	472		472		472		472	
Log likelihood	-919		-916		-915		-910	
LR-test on hetero-scedasticity	LRχ2 (11) = 49.95	***	LRχ2 (11) = 54.79	***	LRχ2 (11) = 50.91	***	LRχ2 (11) = 54.41	***

All variables are dummy variables. Standard errors are shown in parentheses. Asterisks indicate significance levels of 10% (*), 5% (**) and 1% (***) respectively. Heteroscedasticity term includes East and 10 industry dummies.

Table A 4: Estimation results of heteroscedasticity consistent ordered Probit models for a sample excluding small firms and a sample of R&D performing firms (continued from Table 4)

	Dependent variable: Profit over sales 2012			
	Small firms excluded		R&D performing firms	
	I	II	III	IV
IND1	-2.478 *	-2.992 **	1.671	0.972
	(1.321)	(1.202)	(2.118)	(2.094)
IND2	-2.511 *	-2.647 *	-0.739	-0.913
	(1.526)	(1.495)	(1.496)	(1.517)
IND3	-0.069	-0.111	5.528	5.961
	(1.590)	(1.563)	(5.736)	(5.836)
IND4	0.589	0.093	3.291 **	2.881 *
	(1.625)	(1.466)	(1.641)	(1.624)
IND5	-0.132	-0.669	-0.087	-0.143
	(1.291)	(1.264)	(1.345)	(1.309)
IND6	0.425	-0.025	2.981	2.830
	(1.592)	(1.489)	(1.937)	(1.908)
IND7	-0.588	-0.765	0.416	0.212
	(1.148)	(1.086)	(1.373)	(1.314)
IND8	1.567	1.520	2.508 *	2.583 **
	(1.130)	(1.079)	(1.322)	(1.270)
IND9	1.639	0.491	3.272 **	2.760 *
	(1.497)	(1.408)	(1.653)	(1.575)
IND10	0.281	0.080	0.649	0.109
	(1.523)	(1.482)	(1.790)	(1.851)
Wald - Test: joint significance of industry dummies	26.02 **	32.28 **	21.44 **	20.73 **
$R^2_{McFadden}$	0.52	0.75	0.59	0.65
N	357	357	280	280
Log likelihood	-687	-670	-530	-526
LR-test on hetero-scedasticity:	LRχ2 (11)= 38.56 ***	LRχ2 (11)= 37.49 ***	LRχ2 (16)= 68.91 ***	LRχ2 (16)= 66.64 ***

All variables are dummy variables. Asterisks indicate significance levels of 10% (*), 5% (**) and 1% (***) respectively. Heteroscedasticity term for the sample in columns I and II includes East and 10 industry dummies while it includes 5 size dummies, East and 10 industry dummies for the sample in columns III and IV.

Table A 5: Correlation matrix and variance inflation factors

		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
A	PROFIT 2012	1														
B	PROFIT 2011	0.737	1													
C	RDINT	0.048	0.073	1												
D	MSHARE	0.169	0.156	0.102	1											
E	BUYCON	-0.046	-0.069	0.054	0.093	1										
F	SUBSTIT[a]	-0.196	-0.184	-0.201	-0.115	-0.076	1									
G	ELAST_L[a]	0.102	0.105	-0.022	0.133	-0.078	-0.151	1								
H	ELAST_M[a]	-0.107	-0.114	-0.027	-0.146	0.007	0.173	-0.671	1							
I	ELAST_H[a]	-0.119	-0.098	0.024	-0.002	0.077	0.093	-0.262	-0.324	1						
J	COMP[a]	0.175	0.121	0.020	0.119	0.068	-0.090	0.072	-0.045	-0.025	1					
K	DIVERS	-0.035	0.038	0.057	-0.103	-0.160	-0.087	0.001	-0.021	-0.021	0.083	1				
L	EXPORT	0.146	0.171	0.173	0.097	-0.056	-0.208	0.056	-0.056	-0.067	0.150	0.055	1			
M	SIZE	0.014	0.016	0.015	-0.022	-0.129	-0.038	-0.029	0.041	-0.039	0.064	0.089	0.286	1		
N	FOREIGN[a]	-0.107	-0.028	-0.034	-0.004	-0.042	0.016	-0.003	-0.045	0.077	0.002	-0.014	0.149	0.006	1	
O	EAST[a]	0.020	0.008	0.146	-0.035	0.197	-0.006	-0.126	0.077	0.0361	-0.041	-0.129	-0.179	-0.168	-0.067	1
VIF		2.41	2.31	1.25	1.12	1.20	1.21	3.63	3.91	2.30	1.11	1.16	1.33	1.16	1.08	1.17
Mean VIF		1.76														
N		472														

[a] Dummy variable. Correlations and variance inflation factors of industry dummies are not presented but available from the author upon request.