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Review of the Literature on the Impact of Mergers on Innovation

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Review of the literature on the impact of mergers on innovation

Both M&A and innovation are instruments for growth and competitive advantage. Therefore they are fundamental to each firm's competitive strategy. Usually, both instruments have been studied separately, but much less in conjunction. This is unfortunate as both processes - the process of innovation and the process of mergers and acquisitions - are intimately connected. The impact of mergers on innovation can only be rigorously assessed, if the converse direction of influence - mergers caused by innovation - is accounted for. Therefore this review tries to take a balanced view on both processes and to point out links between them. Nevertheless, the focus is on the impact of mergers on innovation.

Although innovation is a highly complex matter, the question as to the impact of mergers on innovation boils down to the simple basic question: How do mergers change the incentives to innovate for the merging parties and for the remaining firms in the industry? It is therefore important to analyze determinants of these incentives.

One of these determinants is the appropriability of the benefits of an innovation. The appropriability in turn depends on a host of circumstances. Among them the available institutional framework of intellectual property rights, the probable degree of knowledge spillovers, and the intensity of product market competition figure prominently.

Another determinant is the ability to successfully engage in an innovation project. The ability again is in turn dependent on many aspects: the ability to finance the innovation project, the access to the use of intellectual property rights necessary for implementing the innovation, the absorptive capacity necessary to enter the innovation project successfully, which may be dependent on the distance to the current technological frontier, the availability of relevant human capital either internally or on the job market, the relationship to public research facilities etc.

Potentially, mergers can change almost every determinant of innovation incentives which may be relevant either for the merged entity or the remaining firms or both. This multidimensionality of the paths of impact via the many determinants poses a formidable problem to any analysis of the merger-innovation connection. The complexity of the task is even larger because the determinants enumerated so far do only represent broad categories of which each exhibits a number of dimensions by itself and because the impact of mergers on innovation incentives can go in opposite directions for different determinants. For example, a merger may increase the ability of a merged entity in terms of increased knowledge, but may deter rivals from continuing an otherwise promising innovation project leading to a similar new product. It is obviously not clear whether the incentive to realize the merging firms' project is increased by a merger or not.

Therefore, it is not surprising that the literature has not reached a unified and sound background for judging the effects of mergers on innovation. Indeed, there are only very few contributions dealing directly with the merger-innovation connection. But there are substantially more contributions on the correlates of innovation like the size of a firm, the intensity of competition in the product market etc. As these have some bearing on the subject of our inquiry they are also surveyed in the following.

The review will be structured as follows. First, in section 1, we will review the few studies which analyze the impact of mergers on innovation directly. Then, in section 2 we will collect the relevant contributions on the relation of product market intensity and innovation. A merger will typically (but not necessarily) reduce the intensity of competition. Therefore this relation is obviously important to assess the probable impact of a merger on innovation. Moreover, merger control is currently driven by a judgment as to whether a merger would lessen competition or not. Therefore the relation between competition and innovation is also important from this perspective.

Next, in section 3, we will review the literature on mergers and acquisitions. This literature is concerned with the impact of a merger in the first place but also – especially in its empirical part – with the causes of mergers. As innovative processes may be one of such a cause this information should be helpful to understand the merger-innovation link.

Section 4 gathers some supplementary aspects. Some mergers are motivated by its potential to obtain access to patents or licenses and some mergers are cleared on the condition to provide licenses to rival firms. Therefore we also review the literature on the incentives to offer licenses. The numerous contributions to the effect of spillovers of R&D have also a bearing on the merger-innovation link. Although most of this literature is on the effect of research joint ventures, it discusses the internalization of external effects. The literature on corporate finance stresses the impact of leverage on innovative activity. As mergers are often accompanied with increased financial leverage – especially in leveraged buy outs – this literature is included as well. Most of these strands of literature ignore the fact that a merger may affect the ability of the related firms to innovate. This is the main issue of the technology management literature which concentrates on the conditions for realizing technological synergies. Hence it will also be included. Finally, we offer some thoughts on the notions of technological opportunity and appropriability as a means to explain industry specific shocks. Generally for each of these strands of literature, we will first review theoretical studies (if existent) and then empirical contributions (if existent).

The review ends with some summarizing remarks in section 5.

1. Studies focusing on the link of mergers and innovation

At the beginning of 2006 an extensive search of the exiting literature has not revealed a single theoretical contribution that deals directly with the subject of this section. This finding is in accordance with Cassiman et al. (2005) who claim this fact as well. In the meantime two theoretical studies appeared which will be reviewed next. But there are also some empirical contributions. First we present some of these studies which do not consider a specialized industry but rather use data covering many industries. At the end of this section we review some studies which are concerned with one industry. Studies are only included if they focus on merger specific changes in innovation behaviour.

Kleer (2006) and Jost and van der Velden (2006) analyze the impact of mergers on innovative activity. The former study focuses on incremental process innovation while the latter deals with a patent race context stressing drastic innovation. As the results are more or less in line with each other and Kleer's analysis is more elaborate I focus on his study. In a context which abstracts from the organizational problems of a merger he finds that a merger increases the incentives for innovative activity of the merging parties. But depending on the strength of these merged entity rivals increase (low strength) or decrease (substantial strength) their innovative activity. Once, organizational problems of a merger are accounted for, even the

clear picture of increased incentives for the merging parties disappears. Interestingly he finds that for most cases social surplus increases due to merger. This last result may be dependent on the specification of demand and cost structures. It should also be noted that his modelling strategy is essentially static.

Ravenscraft and Scherer (1987) suggests a negative impact of mergers on R&D. They analyze 2955 US lines of business and acquisitions for the period of 1950-1977 and compare R&D of acquirers to R&D of the industry average for the period 1974-1977. Their indicator for R&D was R&D intensity (R&D spending/sales).

Similarly Hall (1990) studies a sample of 2500 US manufacturing firms (1967-1987) and finds evidence of a very weak negative impact of R&D intensity. M&A which led to increased financial leverage decrease R&D intensity substantially and significantly. In Hall (1999) she revisits the issue on a new sample of about 6000 firms for the period 1976-1995. Identifying acquisitions which perform R&D before and after the acquisition leaves her with 479 M&A cases. In contrast to the 1990 paper she estimates a propensity score for firms to be an acquirer and uses this score to stratify the sample. The propensity to be an acquirer is estimated as function of size (employment), R&D, cash flow, capital intensity and Tobin's Q. Comparing firms with a similar propensity score which did acquire to those who didn't reveals that for high propensity scores mergers have a positive impact on R&D intensity and growth. In contrast for those with a low propensity score the impact is reversed. Thus the earlier finding of almost no impact obscures the heterogeneity among firms.

Hitt et al. (1991) use a sample of 191 US M&A for the period 1970-1986 and analyze R&D intensity and innovation output as measured by the number of patents divided by sales. Compared to the industry average, firms show lower innovation activity on both counts after going through a M&A process. Hitt et al. (1996) use another sample of 250 US firms for the period 1985-1991 to study among other influences the impact of M&A on innovation. The innovation measure is R&D intensity and the intensity of new products introduced (number of product introductions divided by sales). Both measures are combined via a factor analysis. They suggest a number of hypotheses. We report only on those which are relevant to innovation. One hypothesis holds that acquisition intensity (number of acquisitions) reduces internal innovation. A second holds that acquisitions lead to a shift from strategic controls to financial controls. This shift has an indirect negative impact on internal innovation. All of these hypotheses are supported by the econometric results.

Capron (1999) studies the long-term performance of horizontal acquisitions. As in Hitt et al. (1996) the scope of the paper is much broader than on the innovation impact. His sample consists of 253 US and European acquirers in manufacturing industries and is based on a survey of managers of the acquiring firms. These were asked to reply on a 5 point scale on the change of capability for product innovation and on the change of the development design cycle (time to market). They report mixed effects of M&A on innovation capabilities. Firms redeployed assets from acquirer to target and vice versa to a large extent. This effect had a positive effect on innovation capabilities. On the other hand acquisitions also led to a substantial divesture of the target's assets which had a negative effect on innovation capabilities. 50% of the M&A are reported to have improved these abilities.

Bertrand and Zuniga (2006) analyze the impact of mergers on innovation in OECD countries for the period 1990-1999. In contrast to the above contributions they use data on the industry level. They look at the R&D intensity (spending divided by production level) of an industry. One explanatory variable is the number of M&A in a given industry. Other control variables

are included. On the aggregated level they find no significant impact of mergers on innovation. However they distinguish low-, medium-, and high-technology industries. Moreover they distinguish between domestic and cross-border M&A and analyze the impact on R&D for inward and outward mergers. They find that M&A had a positive impact in low-technology intensive industries and that this is concentrated on domestic mergers. In medium- and high-technology industries domestic mergers reduced R&D investments, while cross-border mergers have the opposite effect. Finally it is the target firms which profit from cross-border mergers and not the acquiring firms in terms of R&D investments.

Cassiman et al. (2005) analyze the effect of M&A on the R&D process concentrating on the role of technological- and market-relatedness. Their study is based on 31 in-depth cases of individual merger deals. All data originate from a survey of the managers of the firms. R&D measures include change of inputs (personnel, laboratories etc.), outputs (greater speed of developing technological knowledge, more patents, etc.), and performance (more productive R&D personnel, increase of returns on R&D, etc.) due to the merger. Their findings can be summarized as follows. M&A partners with complementary technologies result in more R&D activities, while for partners with substitutive technologies the reverse is true. The efficiency of R&D is also increased with complementary technologies. When partners were active in the same technological field the reduction of R&D is more prominent. Finally the gain in efficiency of R&D is smaller if the partners were rivals in the product market than if they were not.

Ahuja and Katila (2001) consider a sample of 72 large firms of the chemicals industry in Europe, America and Japan for the period 1980-1991. Innovation is measured as the number of USPTO based patents obtained 1 to 4 years after the acquisition by the acquiring firm. They distinguish technological acquisitions from non-technological acquisitions and find that the latter do not have a significant impact on their innovation measure. For the technological acquisitions they find that the absolute size of the knowledge base of the target has a positive impact on innovation, the relative size of the knowledge base of the target has a negative impact on innovation and the relatedness of the knowledge bases of both firms have an inverse-U shape. The size of the knowledge base is measured by the patents held or cited by the respective firm 5 years before the acquisition. The relative knowledge base is the target's base divided by the acquirer's base. Relatedness is constructed from similar patents. Cloodt et al. (2006) confirm these results for OECD-dataset on high-tech industries with only minor modifications.

Danzon et al. (2004) analyze the post-merger performance of the pharmaceutical industry on the firm level for the period 1988-2000. They are not explicit about the international composition of their sample (383 firms) but claim that it is US biased. They split the sample into large and small firms. As in Hall (1999) they first estimate propensity scores for being involved in a merger. They find that large firm mergers are connected to expiring drug patents, while small firms propensity to be involved in a merger (target) is connected to financial distress. The impact of mergers on R&D is only one of their performance indicators. R&D is measured as R&D investments. Controlling for the propensity score large firms that merged did not show significantly different R&D activities up to 3 years after the merger compared to firms that did not merge. In general small firms exhibited lower R&D investment growth if they merged. Only small firms with a very high propensity score witnessed an higher R&D activity.

Frey and Hussinger (2006) concentrate on the probability of being a merger target depending on the innovative performance of the firm. Hence, here it is not the impact of a merger on

innovation, but on the contrary the impact of innovative performance on being involved in a merger as a target. They find that the stock of patents has a negative impact on this probability and cross-border dummy has also a negative impact, but the interaction term of the technical proximity (closeness of patent portfolios) with the cross-border dummy triggers a positive impact, while the same interaction term for domestic mergers does not. As some firms engage in innovation in order to be acquired the causality of this relationship, however, is not clear and I did not find a discussion of this potential problem in this work (as in many others' work). In a related framework Ali-Yrkkö (2006) focuses on the quality of patents (measured by forward and backward citations) as an inducement to acquire a firm holding such patents. The author does not find significant effects from the quality of patents in his analysis of Finish acquisitions, but reports (also referring to earlier work of the author) that patents are positively correlated with acquisition by a foreign firm, while there is no such effect for domestic acquisitions. While this is consistent with Frey and Hussinger as both stress the technological justification of foreign acquisitions (as opposed to domestic ones), the impact of the number of patents diverge in both studies.

An example of the opposite focus (does innovation activity of a firm trigger the active acquisition of other firms?) is the paper by Blonigen and Taylor (2000). They find that acquiring firms in their data on firms in the US electronic and electrical equipment industry from 1985 to 1993 are typically firms with low R&D intensity. These authors control for some variables indicating the financial performance and account for simultaneity problems. This suggests together with the results of the preceding paragraphs that acquiring firms look for targets with an attractive innovation portfolio.

It is apparent from these studies that at an aggregate level the impact of M&A on innovation is negligible or negative. On the other hand, the reviewed research reveals also that a more disaggregated strategy and one which accounts for endogeneity shows patterns that are in contradiction to the aggregate view. There *is* evidence that innovation improves due to a merger. Obviously, this state of the art is not suitable to inform a merger review process. The presumption that mergers are detrimental to innovation seems not to be generally true and the case for positive impacts is very dispersed among some aspects of the merging entities, some relating to the technology level, some to its size, some to the level of financial distress, some to the strategic or organizational fit etc. Moreover, measures of innovation are different across the studies, econometric methodology is different, and some use case studies based on surveys with a correspondingly small sample size.

It should also be noted that the dimensions of appropriability and ability are not fully covered by the above studies. In some cases mergers end a patent dispute. This improves the appropriability and the innovation potential of a firm. Knowledge spillovers may be concentrated in merging parties before the merger. Again, a merger improves appropriability and innovation potential. A merger may involve 2 partners which before the merger were intense competitors to each other. Thus a merger would change the intensity of product market competition. Again, appropriability would be improved with a positive impact on innovation. Similar examples could be found on the ability side. All of these instances might be difficult to pin down empirically due to data availability. It is nevertheless striking that these considerations which are central parts of the innovation or merger literature – although not simultaneously – do not shine up in the above studies.

Aside from the theoretical contributions (which however is ambiguous in its results at the present state of the art) the reviewed research also neglects the impact of mergers on the remaining competitors completely. If R&D belongs to the class of strategic substitutes,

competitors will change their R&D levels downward (upwards) if the merged entity increases (decreases) R&D post-merger. The point is that comparing the R&D activities of the merged entity to those of the remaining competitors does not measure accurately what would have happened without the merger. But this is the important question for merger control. In such proceedings it will be important to know how competitors (actual or potential) are affected by the merger. This leaves quite a problem for a potential use of studies with a research design like those reviewed in the merger review. It should be noted that in these studies it is never claimed that they could be used in such a context. They set out to enquire into different types of questions which are more oriented towards management. But in a merger control context we are left with a clear deficit in understanding the complete impact on innovation.

2. Innovation and Product Market Competition

As has been noted in the introduction the literature dealing with the link between product market competition and innovation should be able to provide useful information on the merger-innovation connection. Unfortunately, neither theoretical nor empirical analysis provides a clear view on this topic. Neither the position according to which competition hinders innovation (often attributed to Schumpeter) nor the position according to which competition spurs innovation (often attributed to Arrow) receives unambiguous support. This is not to say that we have no relevant theory on this issue but that different modelling strategies lead to widely differing conclusions. As these strategies reflect different settings in different real circumstances one conclusion which can be drawn from this state of affairs is: The impact of the intensity of product market competition on innovation is quite different in different contexts. This section reviews some contributions to substantiate this view. It is helpful to structure it into three parts. The first two deal with theoretical contributions and the third with empirical studies. The theoretical parts are concerned with nonexclusive IP rights and with exclusive IP rights respectively (Gilbert (2006)).

2.1 Nonexclusive IP rights

The term “nonexclusive IP rights” should be interpreted with caution. The situation captured with this notion is one in which several firms may engage in innovative activities and the result is not of the “winner takes all” type. Rather all firms can protect their innovative success by trade secrets or by patents which do not infringe on each other. Hence, the success of one firm does not exclude another firm from using its own innovation. Gilbert (2006) argues that this may be the typical set up for process innovations.

Indeed the respective voluminous literature models process innovation (in the form of reducing marginal costs). Most of it considers a symmetric and static setting, i.e. the cost functions and demand systems are identical across firms a priori but may be changed by innovation and there is no time dimension. This is certainly inadequate to capture real life situations but is helpful to expose the relevant forces. Drawing from overviews on this literature by Belleflamme and Vergari (2006), Gilbert (2006) and Vives (2006) there is no clear positive or negative relationship between the intensity of product market competition and innovation even in this restricted modelling context. The results depend very much on the fact whether entry is easy or not and on the way in which the intensity of competition is measured. This intensity could be measured by the number of competitors, the ease of entry, or the degree of substitutability of products (Vives (2006)). Under most circumstances a higher degree of substitutability (higher intensity of competition) leads to higher innovative efforts by each firm. Again under most circumstances higher number of competitors reduces the innovative efforts by each firm independently of whether this number is changed in a

comparative statics sense or due to a decrease in entry costs. The effects at work are the following. The incentive to engage in innovative activities in cost reducing innovations is on the one hand proportional to the output to which it can be applied. A higher number of competitors reduce this output and hence this incentive is diminished. On the other hand lower cost due to innovation decreases prices which boosts demand. In general terms these opposing forces may lead to ambiguous results. The term "under most circumstances" means in this context that the usual specifications of demand imply a dominance of the "output effect" (Vives (2006)).

Note that the fact that innovative efforts per firm decrease with the number of competitors does not imply that aggregate efforts will decrease as well. Indeed the path breaking analysis of Dixit and Stiglitz (1977) suggests otherwise. This provides an important caveat for using R&D inputs as a measure for innovative performance. In this context a large number of firms leads to larger aggregate R&D expenditures, but the costs (the innovative result) are higher. From a social point of view it would be preferable if only one firm would perform the innovation and then let the other firms use it. In short: larger innovative efforts are not welfare improving per se.

Product innovations enter the picture only very artificially in terms of more competitors each providing one variant of a product. As Gilbert (2006) points out portfolio effects of products should play an important role which is hard to capture in a symmetric modelling approach. The punch line of this literature is thus: under the usual circumstances "nonexclusive" process-innovations are hampered by competition in the product market, if measured by the number of rivals. But the reverse is true if the intensity of competition is measured by the degree of substitutability.

These studies suggest that the relationship between innovative and competitive activity is monotonically increasing or decreasing depending on our measure of competitiveness. Schmidt (1997) presents a model which can generate in inverse U-shaped relationship. He departs from the setup used in the above studies in that firms are lead by managers (not by the owners), that the result of innovative efforts is not certain, and that firms may go bankrupt which imposes a substantial loss on the managers. An increase of the intensity of competition is modelled by the change of a parameter which decreases profits cet. par. In this framework an increase in competitive vigour (take more rivals as an example) has two effects. Firstly, the demand reducing effect of more rivals reduces the incentive for managers to innovate (as in the above studies). Secondly, the increased number of rivals increases the probability of going bankrupt. As managers strive to escape from this potential result the incentive to innovate (reduce costs) is increased. Schmidt shows that these opposing forces generate an inverse U-shaped relationship between innovation and competition, if the product market is a homogenous Bertrand market.

It is obvious that the static nature of these studies cannot fully capture the process of innovation in a dynamic way where some firms may be technologically ahead of their rivals. The analysis by Aghion et al. (2005) is of a dynamic nature and also shows that there might be an inverse-U shaped relation between product market competition and innovation. They set up a step by step innovation model in the sense that innovations come in successive steps where each firm can only make the next step after completing the last step. In each period firms can influence the probability of completing the step by R&D expenditures. Although the step structure can be quite general in principle (cp. Aghion et al, (2001)) firms and the R&D process are modelled in this paper such that firms in one "sector" can be only one step apart. As this study is in the tradition of growth theory, "sector" is understood in the macroeconomic

sense. But it seems justified to conjecture that the model could also be applied to an industry with some sub sectors. Each sector contains 2 firms that compete in the product market. Given the assumptions on the R&D process there are always two regimes possible: Both firms have completed the same step. In this case the firms compete "neck-to-neck". Or one firm lags one step behind the other (the "laggard regime").

The intensity of competition is measured by a parameter which could reflect the degree of substitutability. This intensity has different impacts in both regimes. If it is high a laggard has not much to gain (Schumpeter) and hence there will not be much innovation effort in a laggard regime. But starting from a neck-to-neck regime, firms have much to win (i.e., escape the competition). Therefore with high intensity of competition neck-to-neck sectors will have the stronger incentives to invest in R&D. For similar reasons the reverse holds true, if the intensity of competition is low. Given the stochastic nature of innovation, sectors will move stochastically from regime to the other. Suppose now that the intensity is low. As we have seen, laggards have a strong incentive to innovate while neck-to-neck firms have not. This implies that firms will be most of the time in the neck-to-neck regime. Hence an increase in competition increases the incentive to innovate for such firms. On the other hand, if competition is high to begin with the sector will be in the laggard regime for similar reasons as above. Hence an increase in competition will decrease the innovative effort. This provides the basic intuition to the result. It should be noted that even in this restricted model one (Schumpeter) or the other effect (escape the competition) may dominate for all parameter values. Hence there is no guarantee for an inverse-U shape but there may be a monotonically increasing or decreasing relation. However, this occurs for entirely different reasons compared to the analysis of Schmidt (1997). The main virtue of Aghion et al.'s modelling approach lies in the joint consideration of both effects. It highlights under what circumstances one effect may be more likely.

Another recent contribution is due to Hörner (2004). He presents a model which looks similar to the basic setup of Aghion et al. (2005) in that firms proceed step by step in their perpetual technological endeavours. There, one firm may be an arbitrary number of steps ahead or behind. Unfortunately, the author does not model product market competition. Therefore his results cannot be easily related to the Aghion et al. paper. It is worth noting, however, that they display a wide variety of different equilibrium structures of investments in R&D. R&D efforts may be particularly high, if both firms are neck-to-neck. For other parameter constellations a firm's efforts may be particularly high, if it is sufficiently far ahead. But this does not compare easily with the preceding paper. Indeed, the latter case is ruled out there. Therefore Hörner's contribution tells us that an analysis à la Aghion et al. (2005) leaves out some aspects which may alter the message of their paper.

In summary, this section has shown that there are no robust and unambiguous theoretical results on the relationship between the intensity of competition and innovation, despite the fact that many aspects of reality have been excluded a priori. Therefore, in different empirical situations different results should be expected. This finding favours in depth analysis of one sector rather than overall cross section studies. It has also shown that this relationship may not be monotonic. Indeed there are some good reasons - derived from economic theory - to believe that this is probably the case. Finally, we have seen that more innovative activity is not necessarily welfare improving.

2.2 Exclusive IP rights

In contrast to the preceding section, here IP rights – like patents - prevent other firms from using an innovative technology of the inventor and there is no easy way to invent around. Most of the literature in this strand assumes that IP rights protection last forever. This assumption is of course unrealistic for most real life situations. But it helps again to identify essential forces working on the incentive to innovate.

In his seminal paper Arrow (1962) exposes one of these forces: the *replacement effect* as it was termed by Tirole (1989) or "profit effect" by others. He compares two situations. In the first one an unchallenged monopolist considers a cost reducing innovation. In the second situation one firm under perfect competition considers the same innovation. As the incentive is measured by the difference in profit that a firm can earn if it invests in R&D compared to what it could earn without such an investment, it follows that the competitive situation provides higher incentives. This becomes particularly clear if a drastic innovation is considered. A drastic innovation decreases costs to such an extent that the monopoly price with these lower cost is below the higher status quo costs. Hence the ex post profits are the same for both situations but the ex ante profits are higher for the monopolist compared to the firm under perfect competition. Therefore the incentive of the latter is larger. In this simple framework the result also holds for innovations which are not drastic. The monopolist replaces an already high level of profits by an even higher one, while the competitive firm replaces a low profit by a substantially higher one.

This result is of course vulnerable to changes in the underlying assumptions. So far the competitive situation is modelled in a homogenous commodity context under perfect competition. In an oligopolistic market with product differentiation the result would not hold in general and the monopolist may have the larger incentive. The conclusions also do not carry over to product innovations in any general sense. A monopolist may sell his old and the new product and use both to segment his customers. A firm under perfect competition may make only a positive profit with his new product. Hence it is easily conceivable that the monopolist has the larger incentive. Greenstein and Ramey (1998) provide an example in a vertically differentiated product context and Gilbert (2006) provides one in a horizontally differentiated product model. While the conclusions from Arrow's analysis are thus not universal we can nevertheless argue that a very intense competitive situation yields a higher incentive, if the old product becomes obsolete (does not attract customers any more).

So far the monopolist was completely shielded from competition. Gilbert and Newbery (1982) propose a simple model in which the monopolist is threatened by a potential entrant. The monopolist has an old technology (or product). He considers investing in R&D to introduce a new technology. If he innovates the potential entrant does not enter. The entrant only enters the market if he has the new technology available. Hence, there are two mutually exclusive situations of which one is assumed to occur: a) the monopolist innovates and remains monopolist and b) the entrant innovates and a duopoly emerges. In this context the incentives to innovate are reversed compared to Arrow's analysis. Here the status quo profit of the monopolist (using the old technology) does not matter, because the entrant will enter with the new technology if he does not innovate. Therefore the relevant profit difference compares his ex post monopoly profit (after successful innovation) with his duopoly profit which obtains if he does not innovate. The incentive of the entrant is measured by his duopoly profit. As the ex post monopoly profit is always at least as large as the sum of both duopoly profits, the monopolist's incentive is at least as large as the entrant's incentive. Indeed, only if the old technology becomes obsolete, both incentives are equal.

This model highlights another force: the *efficiency effect* as it was termed by Tirole (1989) and "competitive threat" by others. A dominant firm has more to loose, if a competitor rather than himself innovates. Thus, the force behind this effect is the competitive threat. Again, the conclusion of this simple model is vulnerable to changes in the assumptions. For instance, if there are several incumbents and the innovation lowers the costs slightly the innovating incumbent's profits will only increase by a small amount. Likewise the profit may not decrease substantially when the entrant is successful. In such a case the entrant may have the larger incentive, e.g. Vickers (1985). The picture also changes if the assumption of equal costs among incumbents is relaxed (Boone (2001)). Nevertheless, the replacement and the efficiency effect turn out to be very helpful in understanding the relative incentives of firms.

Both models could be understood as reflecting a situation where a new technology is developed by a pure research firm and the question is which firm would bid most for this innovation. They do not reflect well the situation where R&D is performed within the firms that supply the products based on the innovation. If this case is considered it should be acknowledged that innovation is an uncertain endeavour. In many cases several firms pursue similar ideas. Given our current focus on exclusive IP rights this will frequently mean that only one firm obtains the IP right (patent). This is the realm of the patent race literature.

Its early contributions (for a summary see Reinganum (1989)) focuses on one innovation project usually paying no attention to the behaviour on product markets. There are at least two firms which compete to be the first in completing the innovation in which case the winning firm obtains an exogenously fixed "prize". The prize is usually interpreted as the profit to be derived from a corresponding patent. Competition in innovative success works via investments in R&D which in turn influences the probability to be the first successful firm. The early contributions consider symmetric firms (equally capable and equal prize). They very much concentrate on the impact of the number of competing firms on innovation and provide conditions under which an increasing number of firms raises each firm's innovative effort (Lee and Wilde (1980), Reinganum (1982)). It is often stressed that patent races imply too much innovative effort: As the firms only consider the impact of their efforts on their own success, they tend to invest "too much". Furthermore, too many firms enter the patent race, although only one firm obtains the prize invalidating the efforts of the remaining firms. Hence, "duplication" of innovative effort is excessive. However, this view posits that innovative effort for one innovation project cannot be used for another project which is certainly not true in general. Moreover, the success of patented innovation may be more fragile, if more firms are competing. And finally, the prize does not correspond to social value. Even a monopolist cannot appropriate to full consumer surplus under usual circumstances. Today it seems agreed upon that innovation is not excessive from the social point of view (Scotchmer (2004), Katz and Shelanski (2006)), although there are also sceptical views e.g. Carlton and Gertner (2003). Hence, the value of this literature derives from the demonstration of the possibility that innovative efforts per firm may increase, if more firms compete for success, and that research efforts may turn out to be strategic complements.

More relevant to merger analysis, however, are modelling strategies where firms start in an asymmetric situation as in Gilbert and Newbery (1982). The early contributions have considered a situation with 2 firms where one firm is a current incumbent and the other firm is an entrant. The entrant may be interpreted as a firm with low profits before successful innovation. Reinganum (1983) shows that the potential success of the entrant induces the incumbent to invest in higher innovative efforts compared to the situation without an entrant (efficiency effect). If the innovation is such that the successful innovator captures a large

share of the market, the entrant will nevertheless invest more in innovation than the incumbent (dominance of the replacement effect). The intuitive reasoning for this result is quite straight forward. In each period of time there are three possible states of nature: the incumbent is successful, the entrant is successful, and no firm is successful so far. Compare the first two events. In case of such an innovation both firms have similar profit differentials where these refer to the comparison of a successful innovation versus no successful innovation (small efficiency effect). Hence the incentive for both firms to win the race are of same order of magnitude from this point of view. However, in the third event the incumbent cannibalizes his current profit if he is successful and this reduces his incentive compared to the entrant (replacement effect). This framework can be generalized to more firms and put into a context with a potential stream of innovation projects. This induces a process of "creative destruction" where incumbents temporarily enjoy a comfortable "monopoly" position but where the identity of the incumbent changes continuously (Reinganum (1985)). If the entrant innovator only captures a modest market share the incentives of an incumbent may be stronger (dominance of the efficiency effect). It is at this point that the literature on patent races links easiest to the literature on the impact of product market competition on innovation.

This implies that in this context both the replacement and the efficiency effect are at play. Their relative strength determines which type of firm has the larger incentive. And this in turn is closely connected to the innovative progress embodied in the new technology. If its induced product is considered to be of considerably higher value to consumers or if costs are reduced substantially, the innovator should capture a large part of the market. In this case the disadvantaged firm (the entrant) is predicted to have the higher incentive to innovate.

The contributions of the patent race literature surveyed so far, use the exponential distribution for modelling the probability of success in a time interval as a function of R&D effort in this time interval. This leads to a memory-less structure of the model. The history of R&D efforts does not influence the probability of current success. Only current effort counts. Therefore R&D investments do not change over time in equilibrium. This modelling approach provides tractability, but neglects that past experience in R&D usually has an impact on current success. Indeed being ahead in a technology race cannot be modelled in this framework.

This point has been taken up quite early e.g. by Fudenberg et al. (1983), Grossman and Shapiro (1987), Harris and Vickers (1987). They introduce several stages into a patent race. Each stage must be successfully completed, before the next stage can be entered. For each stage the probability of success is again exponential and depends on current R&D efforts. In this framework a firm is ahead if it has completed a stage before the rival does. These types of models usually suggest that a firm which is ahead will probably keep its leading position. The leader will invest more than the followers because completion of a stage increases the incentives to invest in R&D. Although followers may catch up or even leapfrog the current leader in principle, the probability of winning is higher for the leader. As being the leader is therefore a rewarding goal, competition for leadership is very intense in many of these models, whenever rivals perceive themselves as equally advanced in the technology race. The result that the dynamics of R&D competition reinforces dominant positions in the R&D dimension obviously adds another aspect which is not necessarily connected to either the replacement or the efficiency effect. If an incumbent firm has more experience in conducting R&D for a certain project this effect would complement the efficiency effect and diminish the replacement effect. This builds on the assumption that this effect of a leading position in a patent race holds for sufficiently general circumstances.

Unfortunately, this assumption turns out to be wrong. Doraszelski (2003) uses the same modelling strategy as Reinganum (1982) but allows the current success probability to depend on the accumulated R&D investments. This variation forces this author to rely on numerical simulations for many of his results. He adds the *knowledge effect*: If one firm has accumulated more knowledge its chances to win the race are increased and therefore further R&D efforts are less rewarding. The leading firm can afford to rest on its laurels. Hence, this effect is completely contrary to the effect that was suggested by the stages of innovation approach reviewed in the last section. This may induce the follower to invest more in R&D and to catch up. While this effect is not strategic, strategic effects play an important role. But these are far from being unambiguous. Firms may react aggressively or submissively to an increase in the knowledge base of the rival. They may compete most intensely or not if their knowledge stocks are similar. If the stock of knowledge exhibits decreasing or constant returns the knowledge effect induces the follower to invest more in R&D. If there are increasing returns his numerical results suggest that the follower invests more if his knowledge base is sufficiently large.

Hence, the implications from the patent race literature are clearly not pointing to an unambiguous direction. Much depends on the relative strength of the replacement, efficiency and knowledge effect, while the strength of the latter also depends on the economies of scale of knowledge accumulation. If a prediction from this can be deduced, it would suggest that for a relatively risk-free innovation project (small impact of the replacement effect), for which experience in relevant R&D is desirable, a dominating firm in product and innovation markets has the best incentives and chances to complete the project successfully.

All of these contributions aim at one innovation project. This neglects the fact that a level of technological competence may not only be valuable for one project but for more projects. In such a situation the race never ends (in contrast to the patent race). One successfully completed project is supplanted by another project, sequentially or even simultaneously. And the success in preceding projects helps in securing income. Being ahead (more successful projects) usually provides an advantage. Such an analysis could borrow from modelling approaches reviewed at the end of section 2.1 (Aghion et al. (2005), Hörner (2004)). To the best of my knowledge such an encompassing analysis does not exist so far.

2.3 Empirical studies

Given the fact that theoretical studies tell us that details matter, empirical analysis has the potential to sort out details that may matter theoretically but are of negligible importance in practice. The early empirical literature has produced a wealth of studies on the relationship of firm size or industry concentration and R&D connected to the so called Schumpeter hypotheses. As mergers usually increase the size of a firm and also increase concentration it would be valuable to have solid information on this link. However, as Cohen and Levin (1989) remark in their survey: “The most notable feature of this considerable body of empirical research on the relationship between firm size and innovation is its inconclusiveness.” and “The empirical results concerning how firm size and market structure relate to innovation are perhaps most accurately described as fragile.” Many potential causes for this unsatisfactory outcome have been put forward. One of them is certainly the mismatch of quite coarse and aggregated data (e.g. R&D expenditures on the firm level) with the theoretical details.

Given the effort that theorists have put into explaining an inverse U-shaped – see above – it is noteworthy that Levin et al. (1985) found evidence of such a shape. They used R&D intensity

and a rate of introductions of innovations (at the FTC line of business level) as a measure of innovative activity and the concentration ratio CR_4 as a measure of concentration. This relationship peaked statistically significantly at a concentration ratio of about 0.5 which is quite in line with Scherer's (1967) earlier finding in this respect. However, the significance of the concentration variables dramatically decreased when Levin et al. introduced measures of technological opportunity and appropriability for each firm.

What do the more recent empirical studies tell us? With respect to the relationship of innovation and size the papers by Cohen and Klepper (1996a, 1996b) are instructive. In their 1996a paper they find e.g. that R&D expenditures are increasing in size where size is measured on the business unit and not at the corporate level. Moreover, adding size (sales) at the corporate level does add almost no explanatory power. This is in line with the theoretical arguments summarized in section 2.1 (predominance of the "demand effect"). These theoretical arguments focus on a specific market. An empirical validation therefore should not start on a corporate level when measuring size of the relevant entity but closer to a relevant market section of the respective company. Therefore the size of a business unit is better suited for such a test than the corporate size. This also speaks against arguments (in the "Schumpeter"-tradition) saying that large firms provide a better platform (more internal funds, economies of scope etc.) to provide incentives for innovation.

These authors also find that the impact of the size on product innovations is insignificant. In their 1996b paper they substantiate the view that the R&D proportion of process innovations among all innovative efforts is increasing in size. In their theoretical reasoning supporting this view they distinguish process and product innovation by the ability to market the innovation in a disembodied form (license). Their view is that product innovations are easier to successfully license than are process innovations. Given that therefore small firms are more likely to perform product innovations which are patentable and that patent counts are frequently employed as performance measures of innovation this could partly explain why small firms within one industry are usually reported to be more efficient in using their R&D expenditures (e.g. Acs and Audretsch (1988)). Indeed this is considered a stylized fact by Cohen and Klepper.

Despite the fact that the theoretical underpinning of the demand effect rests on symmetric models these can be used to suggest an increased incentive of larger business units. The alternative approach rests on the Gilbert and Newberry approach and distinguishes between "incumbents" and "entrants" and is thus asymmetric. In a patent race version of Reinganum the efficiency effect has to be weighed against the replacement effect. Depending on the relative strength of these effects the incumbent has a higher incentive to innovate or not. In Czarnitzki and Kraft (2004) the authors use the Mannheim innovation panel (MIP) to shed light on the impact of such asymmetric situations. The panel contains survey answers on the question whether firms primarily defend their market position (incumbents) or whether they plan to expand to new markets (entrants). From this it is clear that incumbents and entrants do not necessarily exhibit different sizes. Indeed in a tobit analysis with R&D intensity as a function of size, status of being entrant, and some other determinants size exhibits a positive and significant impact. More importantly the status of being a challenger has a positive and significant impact while an interaction term of being a defensive firm with a large share of the market has a negative effect. This supports a view that the replacement effect is stronger than the efficiency effect. In a follow up study Czarnitzki and Kraft (2005) show that incumbents' R&D expenditures on licenses are higher than those of entrants independently of whether these are measured as intensity (over sales) or as share of total R&D expenditures. Hence, the efficiency effect is dominant for these types of R&D expenditures which is nicely in line with

the theoretical findings in section 2.2. Again, these measures of license expenditures increase with size.

These findings speak for a positive relationship of size and R&D measures. But they also show that other dimensions are important as well. Czarnitzki and Kraft point at the strategic options open to a firm. A defensive corporate strategy has different consequences compared to an expansionary strategy. Interestingly, size matters in their study despite the firm level data employed.

As we now turn to the effect of market structure on innovation, it is noteworthy that the Herfindahl measures of concentration fail to be significant in the papers by Czarnitzki and Kraft. They include a firm specific Lerner index in their 2005 study and find that this index has a significant and positive impact on license expenditures.

Blundell et al. (1999) find that concentration matters. They find that fewer innovations (innovation counts, SPRU data on British firms between 1972 and 1982) are introduced in more concentrated (measured by CR_5) industries and that within industries larger firms introduce more innovations. Interestingly, cash flow of firms turns out not to be a significant determinant of innovative activities. Hence, the deep pocket argument for large firms being conducive for financing innovation does not find support here. They account for the simultaneity of innovation and product market activities by lagged variables.

The study by Aghion et al. (2005) (cp. section 2.1) did not only contain a theoretical model which can account for an inversely U-shaped relationship between innovation and competition but also finds empirical support for this possibility. In this study innovation is measured on an industry level by the average number of patents weighted by citation numbers. Intensity of competition was measured by an average Lerner index. These authors account for the simultaneity by using information of some relevant policy changes.

Kukuk and Stadler (2005) present a study based on the MIP (see above). They introduce another distinction on an empirical level: the competition in the innovation market and the competition in the product market. Based on questions as to how many rivals firms face in the product markets (3 categories) and as to how firms view their technological rivalry in the future (reduced, unchanged, increased) they find that the rivalry in the technological market increases planned innovations while the rivalry in the product market does not significantly change them. Moreover, size enhances such efforts significantly. They show also that past innovations are a very potent predictor of future innovations, a finding which is confirmed e.g. by Peters (2006). All of these results remain essentially unchanged if product and process innovations are distinguished – with the exception that size does not matter for product innovations which confirms Cohen and Klepper.

Finally, Tang (2006) provides a fairly detailed correlation analysis on the basis of a recent Canadian innovation survey. The study distinguishes between innovation inputs and outputs and 4 categories of competition. The latter are: 1) ease of substitution by rivals' products, 2) constant arrival of new competing products, 3) obsolescence of products, and 4) rapid change of technologies. All of the data are generated by perceptions of the relevant managers. The author attributes category 1) to product market competition and the remaining categories to technology competition. The latter part seems to be highly debatable. Three correlation analyses are performed: innovation output versus competition, innovation output versus innovation input, and innovation input versus competition.

Innovation output is measured by product innovation, process innovation or both. Firms responded on a yes or no basis. The respective multinomial logit regression reveals the following picture: Easy substitutability diminishes the innovative output of those firms which have product innovations only or product and process innovations, while firms with process innovations only have no significant dependence on this potential determinant. The remaining categories of competitive threat increase innovative output in product innovation and simultaneous product and process innovation. For firms with process innovations only quick obsolescence turns out to be significantly negative. A size dummy is significantly positive for all types of innovation with the exception of firms conducting product innovation only.

Innovation input is measured by "acquisition of technology", "R&D only" and "R&D and acquisition of technology". R&D is primarily connected to product innovation while acquisition of technology is mainly linked to process innovation. A size dummy is not significant for almost all specifications. Innovation input in relation to competitive intensity reveals similar patterns as the innovation-competition link. Again, if perceived substitutability has a significant effect then it turns out to be negative (for the product plus process innovation category).

Hence judging from these few contributions which afforded the effort to account for simultaneity bias, which introduced more dimensions, and which used more voluminous and detailed data, things seem to be on more secure ground, but the consensus what makes up a secure ground is not yet decided. Size seems to be a good candidate for a positive impact on process innovation, while it is not for product innovation. However, data sources and dimensions vary widely. Some are quantitative in the sense that they give the share of sales, some are quantitative in the sense that they provide a count of innovations (e.g. patent counts), some are just reporting the fact of innovation or no innovation. All of these situations induce different methodological requests which are not always appropriately taken care of.

More importantly, many empirical analyses give rise to the impression that they do not give attention to the findings of competing studies. If they do, this is often at such an aggregate level that the claim of the original study can hardly be recognized. This criticism holds also for the relationship of empirical studies to theoretical ones. Usually one study is picked without considering the qualifying assumptions of these studies. Hence, claims are usually exaggerated. Indeed, one cannot avoid the impression that theoretical arguments are used *after* an empirical "result" has been obtained which requires an explanation.

While this can justifiably interpreted as bad practice on the empirical front the reverse applies as well: Theorists have provided some isolated chunks. This was adequate at the beginning of theoretical reasoning in this respect. But now, empirical analysis has provided some evidence which is not easily consistent with the partial analysis of theoretical reasoning. Despite the pitfalls with which these empirical analyses may be inflicted, it would be very helpful, if theorists would take the empirical endeavours as serious indications of what happens in the world of innovation.

2.4 Summary

The relation between the intensity of product market competition and innovation turns out to be far more complex as some commentators seem to imply. This complexity starts with the notion of intensity of competition. Depending on what meaning is given to this term theory suggests diverging implications. This is particularly clear in the framework of "non-exclusionary" IP rights. Intense competition may be due to more rivals, easy substitution

possibilities by customers, ease and frequency of entry. It is therefore not very surprising that empirical studies have not found a robust relation when using cross industry studies and only one indicator of product market intensity. Rather it is in line with the theoretical literature that concentration measures like the Herfindahl index and market power indices like the Lerner index may give opposing results (e.g. Czarnitzki and Kraft). The finding by Kukuk and Stadler according to which the product market competition does not matter while the competition in the innovation market has a significant impact are also in accordance with theory in that its arguments point at the importance of the competitive situation in a product market after successful completion of an innovation project. For this their indicator for the intensity technology competition may be a suitable proxy.

Size turns out to be positively correlated with innovation activities in most studies with the exception of product innovations. This fits nicely with the theoretical arguments if process innovations are attributed to the "non-exclusionary" category. However, size is not necessarily a guarantee for large R&D input and large innovative outputs. Several contributions point to the dependence on the strategic situation (illustrating the relevance of the effects laid out in section 2.2) or on the level of unit (firm versus business unit). Some studies do not support the view that the financial capacity of a big firm induces more innovative efforts. There is also evidence the efficiency in the transformation from innovative inputs into outputs is higher with smaller firms. And all of them confirm the view that details matter.

3. Mergers and acquisitions

Some mergers and acquisitions are motivated by the prospect to obtain access to technological knowledge. Hence, mergers do not only have an impact on innovation but also innovation may have an impact on merger activity. This has obvious consequences for econometric work. If for no other reason it seems therefore important to gather information on the causes and consequences of merger activity. In the following section the theoretical literature on this issue is summarized. Section 3.2 contains an overview of the empirical literature.

3.1 Mergers in the theoretical literature

Most studies are driven by an interest to inform competition policy or to understand why so many mergers do not fulfil their promises. Managers usually claim synergies of various sorts as their reason to merge with another company. In as far such synergies save economic resources mergers would not be subject to criticism from a welfare point of view. Antitrust concerns aim at the consequences of a merger for market power. At least the competition between the merging parties can be expected to diminish or even to disappear. Therefore it can be safely assumed that prices would increase for this reason cet. par. and thus welfare would decrease (Schulz (2003)). Of course, for a full picture the potential advantage of synergies in costs (the efficiency defence) have to be weighed against the danger of increased prices.

Farrell and Shapiro (1990) provide an analysis which shows that a merger can only be welfare enhancing if it triggers substantial cost reductions. This result can in their analysis also be expressed as a function concentrations ratios. Under the hypothesis that mergers are only achieved if profits rise, this boils down to a threshold value of concentration. If the concentration of a merger is below this threshold a merger is welfare increasing.

As both synergies and increased market power speak for increased profits, ceteris paribus, this provides a puzzle against the empirical evidence that many mergers do not perform and indeed destroy profits (see section 3.2). One potential reason for this empirical finding may be that synergies do not materialize but to the contrary considerable transaction costs related to joining the two companies do arise. The early theoretical literature has also found a reason that is not dependent on merger related cost reductions: The remaining firms in the market may react in a way that renders the merger unprofitable. This was formally shown by Salant et al. (1983) or Perry and Porter (1985) in a context where costs do not change in a relevant way due to the merger and competition is modelled as a homogenous Cournot oligopoly. The intuition for this result is quite straightforward: After such a merger the merger parties restrain their output. This increases the price and thus provides an incentive for the remaining firms to increase their output. They show that this in turn decreases the profits of the merging parties to such an extent that they loose profits compared to the status quo, unless the merger comprises a very large part of the industry. Obviously, this effect cannot work, if the merger creates a monopoly.

This result is also noteworthy in the context of empirical work as it highlights the importance of reactions by merger outsiders. Ignoring them may lead to completely misleading conclusions. However, it also leaves us also with a puzzle. Most mergers are not close to creating monopolies. Hence we are told that most merger proposals are unprofitable. Why are they proposed, if they destroy profitability? This question has occupied quite a number of studies.

Deneckere and Davidson (1985) present a model in a price setting oligopoly with differentiated products. Here, mergers indeed gain even if they are “small”. However, the outsiders usually gain more. The reason is again that the merger provides a positive externality on the remaining firms: Due to the merger the participating parties increase prices which provides incentives to the merger outsiders to increase their prices in such a way that their market share increases as well. This provides another puzzle: While now a merger may be profitable on its own, a firm may gain more if it turns down a merger proposal. Why should mergers form in such a context? It may be noteworthy at this stage to point out that some authors categorize mergers as “anticompetitive” if they impose a positive externality on rivals (e.g. Fridolfsson (2007)). This has an empirical analogue: in the empirical literature mergers are sometimes classified as anticompetitive if the merger-outsiders’ share prices rise in reaction to a merger.

While the distinction of quantity versus price competition resolves one incentive puzzle (market power can increase profits despite reactions from rivals) it is still not clear why mergers form. One suggestion in quantity setting context by Daughety (1990) was that a merger provides a superior position vis-à-vis the remaining firms. This is modelled by granting the merging firm a Stackelberg leadership position. Now a merger becomes profitable for most cases. But now a merger typically increases the output which would imply zero antitrust activities against mergers. There have been some refinements on this approach: e.g. Creane and Davidson (2005) and Huck et al. (2004)).

Banal-Estanol (2007) provides a paper where merger incentives are influenced by private information about cost or demand parameters in a quantity competition framework. He finds that there always higher incentives to merge in such an uncertain environment and that the welfare consequences are usually less objectionable than in a corresponding deterministic case from an social surplus point of view. Davidson and Mukherjee (2007) present a model where entry and exit is free. In such a context the distinction between quantity versus price

competition is not very relevant and usually firms considering a merger will find it profitable and more so than remaining alone.

From these studies one could conclude that the results of the early studies on this issue are substantially modified, if more aspects are introduced in the analysis. But it is advisable to be cautious about this conclusion, because all of them are in a ceteris paribus manner. There does not exist rigorous studies joining several aspects at a time.

All of these studies are examples of comparative analysis. They show that even in their fairly restricted modelling framework the consequences of an exogenously determined merger proposal may be quite different with respect to profit incentives - even when constrained to pure market power effects. If profits would usually increase after a merger this might not be considered as particularly relevant, but in many cases mergers are not profit enhancing. Thus, it would not be wise to dispose of the knowledge contained in them.

Nevertheless, it must be admitted that these analyses neglect many aspects. Among these is the question as to which firms are likely to merge. As the setup of the above models is symmetric (same costs and demand conditions for all firms), it is not surprising that the respective contributions do not provide an answer to this question. There is however a small literature on endogenous mergers.

Kamien and Zang (1990) present a model where all firms simultaneously can bid for every other firm and at the same time decide on a price at which they are willing sell out. In contrast to Salant et al. a merged company may induce the merged firms to compete against each other. The reason behind this lies in the fact that the competition among merged firms –which cannibalises profits on one hand – diminishes the external effect on the remaining rivals on the other hand. This can be profitable and can in the end also justify that complete monopolization does not occur in such a set up, if the number of competitors is large enough at the beginning. It should however be noted that this approach allows for a vast variety of equilibria, among which the one with the qualified characteristics is only one.

Horn and Persson (2001) use a framework of cooperative game theory to generate conclusions on the end result of a merger process. Given their use of the core concept it is not entirely surprising that such a process would end in monopoly if permitted by competition authorities and by mergers with maximum industry profits if all mergers but the one to monopoly are prohibited. Obviously this gives a fairly different picture compared with Kamien and Zang.

One wonders which of the unrealistic features of both models is responsible. It is certainly not an aspect of real life that all firms bid for every other firm and each is prepared to sell out at an appropriate price at each moment in time. Nor does the concept of the core necessarily provide a valid prediction of a dynamic merger process. It is therefore helpful that other authors have tried to model the merger process itself.

Fridolfsson and Stennek (2005a and b) and Fridolfsson (2007) suggest a setup where mergers are responding to shocks. In each period there is a certain probability that a specific firm is up to make a merger proposal to another firm. These exogenous shocks are attributed to effects of deregulation, globalization or technological progress. Some part of these studies is devoted to merger control which will be suppressed here. These studies have – among other aspects – an important message for empirical work: Profits may go down due to merger and simultaneously share prices may go up. This argument is contained in Fridolfsson and Stennek (2005b). The intuition is simple: A merger may decrease profits, but profits may

decrease even more if a firm does not participate in a merger. Of course, this is only possible if the merger imposes a negative externalities on outside rivals. Such a case may occur if the merged entity lowers costs to a large extent or –more relevant for the current purpose – if the merged entity introduces a major innovation. Hence a nominal decrease of profits cannot be interpreted per se as failing success. The relevant comparison is not profit after completed merger and status quo profits but those related to the status that would have been obtained otherwise. This has some similarities to the relevant arguments in the patent race literature summarized above. In addition, in a world where demand for a recent innovative product increases such "first round" loss may pay off in the future as well aimed investment.

The most relevant message for empirical work from all of these studies is: The impact of a merger can only be justifiably judged, if the impact of the merger on the remaining rivals (the external effect) is accounted for. This impact may be positive ("anti-competitive merger") or positive ("pro-competitive merger") and may thus work in opposite directions.

The most ambitious approach is due to Gowrisankaran (2001) which builds on Ericson and Pakes (1995). In this model firms can decide on merger, exit, capital investment, and entry in each period. The merger decision is not up to every active firm but only to the largest firm at the beginning of each period. The author looks for a Markov perfect equilibrium of this dynamic game. The model cannot be solved analytically. Therefore the author uses numerical simulation methods to obtain results. Among these are: in most cases the possibility of mergers induces higher producer surplus and lower consumer surplus. Moreover, the firms invest less in a regime allowing mergers. As in the words of the author the investment is sometimes interpreted as R&D this has some bearing on the basic question underlying this survey. It should be noted however, that the basics of the model use a regular (stochastic) investment story.

Summarizing these results it seems clear that the (positive or negative) external effect in Salant et al. and others is important and cannot be disregarded a priori. Aside from this a multitude of impacts of merger activity is possible - and partly due to this externality. The incentive to merge may in the end be positively associated with the expected level of market power and it may also be positively associated to a decrease joint costs of the merged parties. The latter part is not analyzed in the theoretical literature and the former part has not such an unambiguous impact. Hence, empirical evaluation seems appropriate.

3.2 Empirical studies of mergers and acquisitions

As one can read from the last section, theorists have to admit that they have found some interesting results on the impact of mergers but they do not offer a specific cause for mergers, aside from some exogenous shocks. The empirical literature has devoted most of its efforts on impacts as well. But there are also some contributions on the causes of mergers.

One strand of the literature on the consequences of mergers - which is more in the tradition of industrial organization - studies the performance of merged firms. A typical contribution would look at the evolution of profits of a merged entity and compare it with some industry specific benchmark. The most recent large scale work is due to Gugler et al. (2003). Based on an international database of mergers they have data on 2704 mergers one year after completion of the merger and on 1250 mergers five year after completion. The figures for year 2 -4 are in between these values. They compare actual profits and sales in the first 5 years after completion with projected profits and sales based on the respective performance of the median firm in the industry. Based on this comparison the mean profits of mergers are

significantly (at the 10% level or better) higher for each year while their sales are strongly significantly (at the 1% level) lower for each year. Both results are in line with most other work on this issue (cp. Gugler et al. (2003) or Schulz (2003)).

For each year the authors also provide the percentage of those merged companies with a higher profit. For the 5-th year (with small variations for the remaining years) they report 57.6% of all merged firms which implies that about 43% of the merged firms fared worse compared to what had happened without the merger. This figure is comparable with numbers usually provided by consulting firms which claim about 50% failures. Hence, the overall positive picture on mergers – in terms of profits – has considerable dark spots.

The authors also try to shed light on the question whether the merger had positive efficiency effects. They argue that a decrease in sales after a merger speaks for an efficiency decline (if profits decline as well) or for a dominating increase in market power (if profits increase). This concerns 55.8% of all mergers. In both cases this would imply that welfare declines. Pesendorfer (2003) finds for the paper industry that about three quarters of the acquiring firms loose market shares, but at the same time most firms experience cost savings after the merger. He estimates profit increases for merged firms on average. But his estimates also predict an increase in welfare for those market segments where such an impact is significant. This casts doubt on the interpretation of Gugler et al. (2003).

Andrade et al. (2001) provide - among other aspects - an overview on the literature predominantly affiliated with the finance literature. This literature uses event studies analyzing the change of share prices of acquiring and target firms around the announcement date. Like this strand of literature in general, the authors find that the share price of the acquiring firm typically decreases (not significantly at the 5% level, one day after announcement versus one day before announcement) while the share price of target firms usually rise considerably and significantly. The combined effect is positive but quite close to zero. These results are quite stable for a subdivision of the time span from 1973 to 1998 in decades.

The overall picture seems thus again moderately positive. However, there remains the puzzle why the share holders of target firms are usually the only winners while the share holders of the acquiring firm break even at best. Jovanovic and Braguinsky (2002) develop a theoretical model to explain that this may be due to the fact that an announcement of an acquisition reveals the high value of the target and low value of the acquirer. This is partly consistent with the findings of McGuckin and Nguyen (1995) to the effect that targets are more productive (up to a certain size). However, this is not completely convincing. If more productive (targets) firms can ask a higher price this suggests that there are more bidders. If this is the case why did this information not show up in share prices according to the efficient market hypothesis on which the finance literature is based? On the other hand, in as far plants were acquired, why would a firm gain by selling an above average productive plant? Hence, the puzzle is not resolved.

Moreover, the fact that the returns for an average acquiring firm is not significantly different from zero does not mean that there are no considerable wealth effects. Moeller et al. (2005) consider the US merger waves in the eighties and nineties of the past century. They found that share holders of acquiring firms lost 240 billion dollars in the nineties (versus 7 billion dollars in the eighties) and that this is not matched by the gain of the share holders of target firms. The combined wealth of both groups falls by 134 billion dollars in the nineties. These authors try also to explain their findings on the grounds of the results of a voluminous literature which

attempts to relate the returns of acquiring firms to their characteristics or the characteristics of a deal (e.g. stock versus cash). This literature is referenced there (their section IV) and is not repeated here because the authors did not find the respective results helpful to explain their finding which casts doubt on the generality of those results.

According to this type of studies the stock price performance of acquiring firms is even worse if a longer time interval is allowed for comparison. E.g. Loughran and Vijh (1997) find that acquiring firms using stock financing have returns of -25.2% over the five-year period after the merger. On the other hand, the same authors find that for cash mergers earn 18.5%. However, Andrade et al. (2001) and others are highly sceptical on a great variety of methodological concerns. One important concern is the validity - underlying most of the event studies - that the expected return in the 3 day window is close to zero quite independently of a sensible composition of the employed market portfolio.

Betzer and Metzger (2006) present a study which provides an event study and a study on the profit performance based on the same data set. Regarding both studies separately they are in line with those reported above. This is despite the fact they employ a matching approach, meaning that they look for a firm which has more or less the same characteristics like size and profitability to the firms before merger and compare the performance (profit and abnormal return respectively) using these matching firms. Given the theoretical arguments of Fridolfsson and Stennek this cannot necessarily be expected, as the external effects exhibited in their arguments should hit a matching firm more than a median firm of an industry. Nevertheless they find support for the view that profit performance and stock market performance do not necessarily coincide. In this they support the arguments of Fridolfsson and Stennek, while it has to be kept in mind that the discrepancy of these two measures of success was known before this study and was indeed a starting point for these authors. For their category “intra industry transaction and industry peer group” they find 38% of transactions which show decreased profits but increased returns. In the same category they find that both profits and returns show an increase for only approximately 29% of the transactions. Given that there is a very low correlation between success in profits and success in returns the authors argue that both methods should not be treated as substitutes but as complements.

Summarizing these studies, the average deal in mergers and acquisitions is successful, if measured by profit or return increases respectively, but not jointly. At least in the US the last merger wave in the late nineties had a positive average return but lead to a massive destruction of wealth. Overall there remains the question on why target firms profit so much more than the acquirers.

Studies on the causes of mergers and acquisitions echo the theoretical modelling to a large extent in that they attribute an important effect to exogenous factors. E.g. Mitchell and Mulherin (1996) perform such a study and analyze the merger wave in the eighties of the past century. They first find that M&A activities are different in different industries. Usually they cluster in some specific industries and even within these industries they cluster in a short period of time like two years. This can be considered as a first indication that the thrust of M&A activities is indeed industry specific. The authors engage into two sorts of empirical investigations of this phenomenon. First they consider whether there has been an industry specific shock which they measure as the deviation of sales growth (employment growth resp.) from the mean of all industries in their sample (which are 51) in absolute terms. A regression analysis reveals that such shocks are positively and significantly related to these activities, while growth of sales (employment) are not significant predictors. Given the fact

that these shocks are measured as absolute deviations from the overall average this means that booming as well as distressed industries attract larger M&A activities. As both types may have different implications for the (relative) performance it seems relevant to distinguish these types when considering the merger performance.

Second, they analyze several shocks such as deregulation, oil price shock, foreign competition and financial innovation. They relate these changes which are partly due to governmental action in industries which are considerably affected by them. They find that deregulation and financial innovation are significant while the remaining two are not. Deregulation has a positive impact. Financial innovations consist in the emergence of junk bonds as a means for financing M&A. They argue that R&D intensive industries are less attractive. Therefore they use the R&D intensity of an industry as proxy with the interpretation that those industries with a high intensity are less prone to attract M&A activity. This is supported by their econometric results and this finding in turn supports the more general hypothesis that mergers and acquisitions are driven by sector specific shocks, while the macroeconomic influences do not play a decisive role (growth rates are not significant). The clustering phenomenon is also confirmed by Andrade et al. (2001) for the nineties with an even stronger relationship to deregulation. For an overview on differing views on merger waves and an attempt to discriminate among them see Gugler et al. (2006).

Gugler and Siebert (2004) present a study of the semiconductor industry which is interesting in several respects. First, they study the impact of mergers (and research joint ventures RJV) on market share. For this industry mergers (and RJV) significantly increase the market share of the involved companies. Comparing these results with those of Gugler et al. (2003) speaks again for industry specific analysis of merger impacts. Second, although they are not the first to do so, they point at the simultaneity problem that such empirical studies face. If – as in their study - the effect of mergers on market share is considered, it may be the case that there is a common factor – e.g. productivity - triggering both an increase in market share and mergers. Therefore they estimate an endogenous switching model and find that firms expecting that a merger will increase their market shares are significantly more likely to actually merge. While thus the expectation of an increased market share increases the probability of being involved in a merger the authors look at other determinants of this probability. They use the accumulated patents, the size of the firm (total assets), its scope (indicator for the number of markets in which the firm is active), year and country effects. All of these variables turn out to be significant. As for the year dummies this conforms with Mitchell and Mulherin. Size and scope effects are positive and the stock of patents is negative. Interestingly, the results are very similar if the probability to form a RJV is considered - with the exception that the stock of patents turns out to be positively related. This is more or less consistent with the results found for propensity scores by Danzon et al. (2004) or Hall (1999).

3.3 Summary

From the preceding sections it seems clear that the overall view of the causes and consequences of mergers is still far from unanimous or unambiguous. The consequences – usually analyzed in terms of profitability and return – are positive on average but not necessarily when wealth effects are considered. At least some 30% of M&A transactions seem to be a failure in terms of profits or returns. Moeller et al. (2005) point to the effect that the disastrous wealth effects of the last merger wave (nineties until 2001) is due to some few spectacular failures. This may serve as a supporting argument for merger control although the mission of merger control is quite a different one. But it is hoped that this injunction can be

helpful for correcting the opinion of those who view merger control as means to inhibit wealth creation.

Indeed, the interpretation of the impacts of merger and acquisitions is obviously connected to the interpretation of the causes of these activities. E.g. Mitchell and Mulherin (1996) claim that antitrust authorities suspect merger candidates to enhance their market power while – in their view – they may only consist in a "normal" restructuring phase of an industry following a shock. The question whether it should be interpreted in this way.

The analysis of competition authorities follows economic theory in so far as they see market power is an important concern. It should however be noted that market power cannot really be considered as the cause of a specific merger. If market power is an incentive for a merger at a certain date, why was it not before? Hence, there is always an "exogenous" factor triggering merging activities. The incentives to increase market power compared to the current one must have increased. Hence shocks, may be industry specific shocks, are necessary to bring the theoretical argument of market power to bear. But a merger always provides the opportunity to realign prices, qualities, and product lines to the best of a company, not necessarily to the best of consumers. It increases the scope of a firm to react independently from the rivals (for the internal dimensions of the competitive instruments). This is exactly, what market power means. Hence, market power is unavoidably connected to a merger or acquisition. The question is rather, whether this increased scope of opportunities is used in favour of consumers or in favour of firms exclusively. The latter is a matter of concern.

This implies that mergers remain in the arena for justified scrutiny by competition authorities. But this does not deny that firms may react to industry shocks by merger and acquisitions because this is the most efficient way to deal with them. While industry wide shocks may be important triggers for M&A it should not be denied that firm specific "shocks" can also attribute to the propensity to merge and acquire. For the present purpose, a pharmaceutical firm which runs out of patented drugs and is threatened by generic drugs, because its specific stochastic outcome of the R&D process was a complete failure, may be induced to acquire a firm which owns some recently patented and licensed drug. Hence, in broad terms the incentive to merge is triggered in part by economic conditions impacting on the industry, in part on new technologies, and in part on firm specific fortunes in R&D or marketing activities and the like. Given this it seems wise to concentrate on specific features. It seems more adequate to consider specific industries and fairly detailed data to assess the acquiring and target firms alternatives. Finally, the arguments of Fridolfsson and co-authors imply that M&A transactions cannot be fully understood, if the consequences for merger outsiders are neglected.

4. Additional aspects

In this section some aspects are included which are complementary to the basic forces summarized in sections 2 and 3. We add a few remarks on licensing, spillovers, corporate finances, R&D management, and on the notion of technological opportunity and appropriability in the following subsections.

4.1 Licensing

In section 2 a very restricted set of property rights was considered: non-exclusionary rights and exclusionary rights. With the first variant licences have no role to play. This is different for the second variant. So far, this was not considered. The prize from winning a patent race was more or less exogenously fixed. When the patent race literature deals with the determinants of post innovation profit, then they refer to product market competition. However, the prize may also include license fees. The strand of literature dealing with licensing has found differing incentives and impacts relating to these. The common picture is that license fees help to provide incentives for innovation and thus induce more of it. But licensing can also be used in order to lower the incentives of a rival for innovating around a patent which the licensor owns (Gallini and Winter (1985)). We will concentrate on the more positive view on licensing.

Some part of the literature focuses on the licensing of one incumbent firm to one or more rivals. Most of this literatures (e.g. Katz and Shapiro (1986) or Kamien and Tauman (2002)) studies a cost reducing innovation and operates under the assumption that no future innovation will occur. Even in this situation one might think that firms to do not have an incentive to license a cost reducing innovation, as the lower cost of the rival will induce more intense product market competition. But the net impact of licensing depends very much on the intensity of product market competition. If competition is low (i.e., both are quasi local monopolists) a license will generate income for the licensor without changing the intensity of competition in an essential way. In this case licensing is profitable. If on the other hand product market competition is very intense, a license may not be profitable. This suggests that a merger – by reducing the intensity of product market competition – may not be detrimental to licensing and thus innovation incentives in the current context. It should be noted, however, that the assumption that future innovations are not feasible (or likely) is not convincing. In that licenses may improve on the capability of a rival to invent another cost reducing process the incentive to license are obviously dampened. However, there are also ways to overcome the latter problem. It is quite common (e.g. Arora et al. (2001), chapter 5) that license contracts include the transfer of complementary tacit knowledge embodied in the licensing firm. The license to use a certain technology may be useless without this transfer. This can serve as a hostage for the case that the licensee tries to invent around the licensed technology.

For product innovations which are continuously improved (i.e., which trigger a stream of innovations) the incentive to license has been established by O'Donoghue, T., Scotchmer, S., and J. Thisse (1998). They study a "quality ladder" model, where one firm innovates necessarily using the preceding innovations which are obtained and patented by other firms. Without licenses no innovation will occur. The value of a license depends (among other things) on the intensity of product market competition. Very intense competition and a fast arrival of quite small innovations depress the value of a license and thus the incentive to innovate. Again mergers may help in this context if they do not lessen the availability of new ideas.

The necessity of obtaining access to a patented innovation in order for another firm to develop another innovation may complicate the incentive issue in several aspects. Some "basic" innovations have the potential for several innovations in "applications" by different firms. Some "applied" innovations need not only access to one preceding patented innovation but to several. In order to secure the incentives to provide the basic innovation in the former case it is important to be able to collect license fees from the applied innovators (Green and Scotchmer (1995)). If the firm holding a patent on the basic innovation is not active on the application market, the license fees and the propensity to license will be higher if the product market competition is less intense. The same will be the case for a firm that is active on both

basic and applied innovation markets. Presumably the incentive to license will be reduced compared to a firm performing pure basic research. This will be particularly important if this firm fears that a rival may develop a higher quality product in the same market. Generally, the bargaining about license fees can be hampered by asymmetric information (Gallini and Wright (1990)). A firm seeking a license may have superior knowledge about the cost of developing an applied innovation as well as about the potential income generated by this innovation. This may inhibit licensing and provoke patent disputes. A merger between two firms one of which is active in the basic and the other being active in the applied segment may be beneficial to overcome this problem. On the other hand, it may induce a stronger incentive to deny licenses to the remaining rivals in the applied segment.

If several licenses are needed to successfully engage in an applied innovation the issue of the "anticommons" may arise. This refers to the situation that several firms price their respective products (here licenses) higher if they do so non-cooperatively than if they cooperatively choose the prices (fees). This will be the case if the products are complements and this case is certainly relevant for the present context. One solution to this problem is the creation of a patent pool (Lerner and Tirole (2002)) in which several firms market their licenses jointly. This would obviously also save on transactions cost. Note that in this respect a merger may also be beneficial.

Summary: The decision of a firm to license its innovation to a rival is shown to be positively affected by a low intensity of competition. It should be noted, however, that in such a context the incentive to innovate may be low in the first place. Therefore general conclusions to the effect that a low intensity of competition increases the incentives to innovate are not valid. The decision of a basic research firm to license its innovation to "applied" firms is shown to be favourably affected by a low intensity of competition. Again this is not convincing as the "escape the competition" effect is not accounted for in this literature.

Overall the results pertaining to the effect of licensing on innovation are based on quite partial modelling strategies. It is therefore premature to derive empirically relevant hypotheses from this strand of literature.

4.2 Spillovers in R&D

The use of existing knowledge is a crucial aspect of the innovation process. Part of the knowledge which is accessible to a firm originates from the innovative endeavours of another firm. Legal protection of property rights is not perfect and strategic measures to prevent leakages of relevant information may not be perfect either. These information flows are called (knowledge) spillovers. There is an extensive literature dealing with the effects of these spillovers. The most cited contribution is d'Aspremont and Jacquemin (1988). But there are many others, e.g. Amir (2000) or Kaiser (2001). All of these contributions focus on cost reducing innovations. The receiving firm obviously profits from such spillovers while the outgoing spillovers reduce the profit of the originating firm. These externalities dampen the incentive to engage in R&D. (As a by-product, it should be noted that R&D efforts are strategic substitutes for low spillovers while they are strategic complements for high spillovers in this literature. This is worth noticing as the patent race literature might have given the impression that innovation efforts are usually strategic complements.) The main theme of this literature is the incentive to form a research joint venture and its impact on the level of R&D. The principle findings are: 1) the incentive to form a joint venture exist for sufficiently large spillovers and they are larger if the products are complements rather than substitutes; 2) a joint venture increases the level of R&D effort as the external effects due to

spillovers can be internalized. As the case of complements can be interpreted to cover the case of vertically related firms, the first result would speak for more research agreements among vertically related firms than horizontally related firms. This accords well with the empirical findings. In this context, a merger would have similar effects on R&D efforts as a joint venture and would be positive for innovation.

There exists also a large empirical literature on spillovers. However, only very few contributions study the effects of joint ventures not to speak of mergers. The research that deals with detecting spillovers and their importance provides support to both their existence and their importance (for a recent contribution see Bloom et al. (2005)). Work on spillovers and cooperative research agreements is due to Cassiman and Veugelers (1999). These authors distinguish incoming and outgoing spillovers and measure them based on Belgian data of the Community Innovation Survey. They find that this distinction matters (which is not considered in most of the theoretical literature). Firms with higher incoming spillovers and lower outgoing spillovers have an increased tendency to engage into cooperative research agreements. While their results are very important in their own right, they leave critical questions unanswered which could be helpful in the present context. It would have been valuable if the effect of cooperative research agreements on R&D could have been analyzed. This did not happen probably due to data availability. The main focus is also on agreements in a vertical chain or with research institutes and not on agreements with rivals. This focus is understandable as the vast majority of agreement cases (303) turn out to be such agreements. But it leaves the question of the impact of a horizontal merger without empirical guidance.

Jirjahn and Kraft (2006) find in a study analyzing German establishment data that spillovers have a positive impact on incremental product innovations while they have no effect on drastic ones. Contrary to claims to be found in the literature under the notion of absorptive capacity (Cohen and Levinthal (1989)) an impact of the own level of R&D is not supported by the results of these authors. Another finding is that research cooperation influences the measures of product innovations positively.

Summary: The empirical literature on knowledge spillovers to date has not found a definite answer to the question whether the net effect of spillovers is negative or positive on R&D incentives (e.g. Geroski (1995), Cohen (1995)). Both theory and empirical work sometimes speak for a positive and sometimes for a negative effect. Details again matter in an essential way. Therefore there are no final conclusions to be drawn neither on the question whether spillovers foster innovative output nor on the question whether mergers are formed for internalizing their external effects.

4.3. Corporate Finance

The view of corporate finance stresses agency costs which arise because managers of a publicly listed firm have superior information on the operation of the company compared to the shareholders. They are able to obtain an information rent by following their own preferences more than is in the interest of the owners and may hide their inability (Jensen (1986)). Mergers in the form of takeovers are seen as a disciplinary device. They provide an opportunity to replace current managers by more able ones. In addition mergers often increase the level of debt and reduce free cash flow. Therefore spending has to be cut, including spending on R&D. More specific to R&D is the fact that it is risky, that outsider suffer from asymmetric information about the potential of a R&D project, and that it creates asset specificity. This implies that it is expensive to finance R&D by new debt. Indeed R&D is usually financed by internal equity. The asset specificity increases potential problems in debt

renegotiations. From this follows that R&D spending will be reduced by a merger. If the disciplinary function of the merger works, cutting unproductive R&D projects is more probable than cutting promising ones. Hence the net effect on R&D outcome is not necessarily negative.

Though there is not much empirical research on this topic there are some. Hall (1990) finds that R&D decreased after a merger which lead to higher leverage. This finding is supported by Hitt et al. (1991) and indirectly by Hitt et al. (1996).

It should also be noted that the threat of a takeover may have an additional negative impact on the pre merger firms as well. This is important to recognize if pre merger and post merger performance is compared. The literature points to the fact that managers may abandon profitable long term projects and pursue short run projects with relatively safe and early returns (Laverty 1996)).

Summary: Mergers as a disciplinary device decrease innovation inputs and but increase the efficiency of the innovation process in the merged entity. A merger leads to a focus on safe short term innovation projects in the pre merger firms.

4.4 R&D management and other ability related aspects

Mergers have the potential to optimize the use of the combined R&D capabilities of formerly independent companies. Some capabilities may be duplicative. A merger provides an opportunity to eliminate duplication. This aspect may imply lower R&D spending. On the other hand the possibility to arrange more profitable combinations out of the larger pool of R&D capabilities and financial means may increase the efficiency of the R&D process of a firm. Risks may be spread over a larger portfolio of projects. Research teams may be strengthened for particularly promising projects etc. These economies of scale in R&D will lead to more innovative output given the pre merger R&D inputs or the same R&D output can be obtained by less R&D input. There may also exist economies of scope in R&D. More applied segments (formerly associated to different firms) may use the same basic research facilities. This will lead to a more efficient R&D process. In summary, there should be a positive effect of a merger on the efficiency of the R&D process. However, the empirical results dealing with this issue are usually described as fragile (Cohen and Levin (1989)).

The management literature has pointed at several weaknesses of the arguments just outlined. These criticisms may be summarized as the complete absence of transactions costs. Neither economies of scale nor economies of scope are available without costs. On an abstract level these are the costs of reorganisation. The potential synergies of combining knowledge which was external to the respective other party before the merger can only realize if this knowledge enters this other party. But there may be huge problem to which the literature refers to as the “not invented here” syndrome. Hence a merger must be accompanied with suitable organizational structures that induce an easy inflow of knowledge of the respective other party. Capron (1999) identifies resource redeployment as a major source of value creation in M&A. But this has to be properly managed as well. Redeployment not to speak of divesture may have a very detrimental effect on key inventors who may just leave (Ernst and Vitt (2000)). Although larger firms (post merger) have much to gain by new combinations of their knowledge pool this may imply drastic changes of routines. But this may mean that one partner has to accept the routines of the other. If these are in considerable conflict to the pre merger routines of one party, the expected synergies may not arise. This possibility is

particularly likely if the acquiring and the acquired knowledge base are quite dissimilar (Ahuja and Katila (2001)).

While the arguments of the preceding paragraph referred to obstacles that might be implied by the subjective view of important people involved with R&D there is also some literature on the objective aspects that may evade such views. The central figure here is "strategic fitness" (Rumelt (1974)). In this view, strategic fitness is determined by the relatedness of the two parties. Similar product markets, similar production technologies or similar science-based research qualify for such relatedness (Rumelt (1974)). As the studies by Ahuja and Katila (2001) and by Cassiman et al. (2005) show, these dimensions are important in order to assess the impact of a merger on innovation. The latter study shows in addition that it is not just relatedness but whether a relationship is complementary or substitutive.

Summary: A merger has the potential to reduce duplicated R&D efforts and to optimize the innovation process of the merged firms. It therefore may increase the efficiency of the innovation process. The related transaction costs are lower, if the technological fields and product markets are related. More specifically, complementary technological fields are conducive to increased innovation effort and efficiency. If the technological fields are substitutive, mergers among rivals reap lower gains in innovation efficiency and reduce innovation inputs to a larger degree.

4.5 Technological opportunity and appropriability

There is a consensus in the empirical literature that the extent of innovative activities differs widely across industries and also within industries across time (Cohen (1995)). These are attributed to differences in technological opportunity and appropriability in different industries. Sometimes a discovery opens up the opportunity to improve products or processes in technological fields that are "close" enough to this discovery. Hence industries can be expected to profit from such a discovery in differing degrees and hence have differing technological opportunities. Likewise patents can be seen as ways to appropriate the returns of R&D. But it has been known for a long time that there are industries where it is relatively easy to invent around a patent of a rival. This is reflected in the patenting behaviour in the respective industries. While for pharmaceutical and chemical sectors patenting is very important it is not for most other industries (e.g. Mansfield (1986)). Hence innovating firms have to use other means to appropriate their return on R&D (e.g. trade secrets). Which one they use depends cet. par. on the value they attach to a patent and therefore appropriability will be different in different industries.

While this idea is straightforward it is much less obvious how to substantiate these claims empirically. Both opportunity and appropriability are extremely hard to measure. Sometimes opportunity is measured by the elasticity of unit cost with respect to R&D spending (e.g. Kukuk and Stadler (2005)). The simple idea behind this approach is that technological opportunity makes innovation easier thus decreasing R&D costs. In other work opportunity is retrospectively measured by citation of patents in a respective period (Trajtenberg (1990)). The latter possibility obviously is only possible if patents play an important role in the respective industry. There have been many more attempts to pin down technological opportunity empirically (Cohen (1995)) but often the proxies did not perform better than industry dummies. The reason for this unfortunate state can be seen in the many forms technological opportunity can take. Opportunity can be rooted in a scientific breakthrough which may be a good candidate for the biotech industry. It may be due to a change in import restrictions (Gilbert (2006)) which brings new ideas from foreign firms. Or it may be due to

suppliers or customers who may provide information on needs and ways to improve a product. In the latter case technological opportunity of one industry is fuelled by impacts from other industries. Hence, technological opportunity is not confined to the arena of one industry proper. It is therefore not surprising that many facets of this notion of technological opportunity are exemplified by case studies but that a consolidated view has not yet evolved (Cohen (1995)).

With respect to appropriability the situation is similar. As noted above, appropriation does not only depend on whether patents protect against imitation in a specific industry or not. Firms have additional means to protect their R&D investment. They may use trade secrets or they may use first mover advantages and learning curve effects. They may also invest in assets which are complementary, necessary, and specific to the innovation such that the innovation cannot be used without these assets. Such assets like a specific sales and service team must often be created for the new product even if the firm could act non-strategically. But this obviously also helps in strategic contexts by securing returns by selling complementary services (Teece (1986)). Appropriability is of course also connected to the spillovers which possibly endangers it and also to problems with license agreements. All of this is obviously not easy to subsume in a unified way.

Therefore we are back where we started: Industries are different in innovative activity. The notions of technological opportunity and appropriability suggest a unifying framework which may deliver on the conceptual level but does not help much on the empirical level. As so often above, we have to conclude that details matter and therefore in depth analysis of industry studies seem warranted.

5. Summary and conclusion

Innovation and M&A are two important forms of investment which follow partly their own logic respectively. But as different forms of investment are sometimes substitutes and sometimes complements it is not surprising that both are related to each other and should be studied together, especially if the impact of merger on innovation is the focus of analysis. As some firms merge, to boost their innovative performance, and some innovate to become an acquisition target, while other firms merge for entirely different reasons, it is not enough to look at the causal link from merger to innovation. In empirical analyses all types of mergers will typically occur and not controlling for the direction of causation leads to estimates which are hard to interpret.

Therefore we have considered the innovation process and the M&A process in isolation in order to find fundamental forces shaping these processes and in order to find arguments which help to answer the question what may induce mergers and innovation respectively. If for example the study of the innovation process reveals that spillovers are very important in the industry in question this provides an incentive to merge (or to form a RJV). If, on the other hand, a merger is interesting because the new product of another firm would perfectly fit the product line of the firm under consideration, innovation of the other firm triggered the merger. Hence, looking at the innovation and merger incentives separately helps to disentangle the motivations for a merger. The two examples turn out to be in the logic of the innovation process. Of course, the merger may also follow a pure merger logic of efficiency (synergy) or market power reasons with consequences on the innovative activities which however constitute a by-product only.

The latter logic seems to underlie the early empirical literature on the impact of mergers on innovation. Given the multitude of motivations linking merger and innovation it is not surprising that these studies did not find robust results. It is remarkable that those more recent studies which try to control for such motivations by using propensity scores or endogenous switching models obtain more reliable estimates.

The theory on mergers has pointed out the importance of the reactions by rivals quite early but probably more forcefully by the recent studies of Fridolfsson and co-authors. One benefit of this theoretical development can be seen in the insight how profitability measures using accounting data and rate of return data using stock prices are related to each other. The obvious message is that both measures do not have to point in the same direction. Another benefit is the insight that constructing a benchmark is not easy. Suppose that a merger induces the participating firms to cut back on their R&D expenditures and suppose that this induces the rivals to reduce R&D expenditures even more. Does the comparison of a rival with the merged firms provide meaningful information? In this case the merger would look good. But the impact on aggregate R&D would be negative. Obviously, this message could also be delivered by using any other individual matching concept for comparison. The effect may be mitigated, if instead a "median" type firm is used, if there is some heterogeneity of firms reactions and the matching firm (e.g. same propensity score) is more in line of the suggested reaction above compared to the median firm. It is interesting to note that the study of Betzer and Metzger (2006) reach similar conclusions as Gugler et al. (2003) despite of the fact that the first authors use a matching approach and the second a median firm benchmark. This may mean that the reaction of merger outsiders is similar. But this is no good news, as then both approaches are open to the above problem. It may on the other hand mean that strategic reactions do not play a large role and therefore the identity of the benchmark does not matter that much. This is an entirely open question. It would be of merit if both benchmark approaches would be applied to one dataset.

The literature on the causes of mergers often focuses on the industry specific shocks which – in this view – trigger an adjustment which in turn can take the form of M&A if this is the most economical way to adjust. In general this approach begs the question, as the answer is delegated to the "most economical way". However, if the shock is induced by a change in "technological regime" this might indeed speak for M&A. This view can be justified e.g. by views that stress the routine or the exploitation of a cash cow. In such a situation it may be profitable to jump on the changing technological regime train by M&A. The same jump within the company may invalidate valuable routines or cannibalize own technology or products. These shocks are also the triggering event in Boone (2006). In such cases firms confront constraints which they cannot economically deal with on their own. This may e.g. explain why pharmaceutical companies buy biotech firms. In such cases mergers are clearly caused by innovation (by others) and probably their own stock of patents does not help much in this respect. This is not to say that only technological shocks matter, but to stress that such shocks cause mergers rather than the other way around. In such a situation it is probable that the acquiring firm will improve the R&D potential of the innovating biotech firm. However this depends on the strength of the biotech firm. This firm may not be inclined to be acquired if strong. This fits well with the results of Danzon et al.

The theoretical literature does not focus on the industry specific shocks (with the notable exception of Boone (2006), which however is on the consequences of such shocks). This literature focuses –if at all – on the common random influences on the outcome of a firm's decision process. Investment projects – whether innovative ones or not – may fulfil their promise or they may not. This is not the world of regimes switches or radical innovations.

Unfortunately, the literature on this approach is not very precise in its predictions (Doraszelski (2003)) despite the fact that these contributions have to focus on quite restrictive circumstances. This renders an empirically relevant and reliable conclusion almost void - which should not imply that these types of analyses are useless – to the contrary. There are many conceivable other ways to model innovation and mergers. And it is not clear what the better way would be. This stresses the value of Doraszelski's contribution as the first viable attempt.

If the Ericson-Pakes model is considered as a model for innovation its merger appendix in Doraszelski (the largest firms may merge others not) is only one possible version. In a way it is consistent with the innovation theory claiming that the level of output is an incentive for innovation. On average it is a stylized fact that acquiring firms are big, but there are also exceptions which may however trigger large transactions volumes.

In short: the stochastic nature of the causes of mergers is not fully understood. For the major shocks like radical innovations or technology regime switches there is no remedy in sight. Otherwise they may not be radical. The usual up and downs of the discovery and development process are probably the more relevant description of the R&D process anyway. This forms the background for models like those of Ericson and Pakes or Doraszelski. Unfortunately, it is hard to see robust predictions form these models which is partly due to the numerical methods these authors have to use.

There are also deficits of the innovation literature. It its true that some fundamental forces have been identified. Among them are the efficiency effect (escape the competition), the replacement effect (profit effect), and the knowledge effect. These help structure the ideas about which firm would succeed in a race to an innovation. But it does not incorporate the full wealth of causes. Indeed the analysis of Hörner speaks for some aspects not accounted for by these considerations. This renders it hard to pin down characteristics of firms and of circumstances which may be inducements for innovation in general: everything depends on the whole trajectory of events. Change one aspect and the innovative outcome is different. This in itself is no deficit as this situation just mirrors the acknowledgement of the fact that details matter. But so far, they matter on the theoretical level. It is not clear whether all these contingencies really matter in practice. It would be very helpful to find out which aspects are particularly important for the incentives of merger candidates. The incentive to catch up or to leap frog against the incentive to gain an advantage that cannot be leap froged is not decided on the empirical front, neither without the consideration of mergers nor with such considerations.

In general, empirical studies often seem far removed from possible theoretical underpinnings. The replacement effect and the efficiency effect are known for at least 20 years. The intuition behind them is easy to grasp. Nevertheless the cited studies of Czarnitzki and Kraft are two of the very few studies which try to use this theoretical construct and are successful at it. It would be very helpful to have more of such studies.

The distinction of process and product innovation matters in theory and should therefore be distinguished in empirical work as well (if possible). The correlation analysis of Tang speaks for this from an empirical point of view. Other empirical studies have also found that the logic for both types of innovation is different. Among other things, size effects are to be expected from theoretical reasoning as more relevant for process innovations than for product innovations and this has found empirical support in some studies. As size is an important

aspect of mergers this speaks for the importance of this distinction. But to date most empirical studies do not account for that distinction.

Theory has also revealed that the intensity of competition does not have an unambiguous impact on innovation. Among other things this depends on the measure of intensity of competition. More importantly some indicators measure very different aspects of the intensity of competition (number of rivals versus substitutability). A merger will usually change the number of competitors but not the degree of substitutability. It would therefore be advisable to ponder the reasons to introduce a specific measure rather than another in an empirical investigation of the product competition/innovation link. From reading the respective literature this advice seems justified.

Theory necessarily abstracts from many aspects of a practical issue. It is usually hoped that the left out details are not relevant for the major question under scrutiny. With respect to innovation the only modelling strategy builds on the profit motive of a firm. Of course, this neglects at least two dimensions. First, many engineers and scientists are driven by the motive to find something new. They are just fascinated by cracking hard problems. Sometimes there is no need to have another person supporting such endeavours, because the motivation is completely intrinsic. In other cases the respect of a community of fellow scientists, engineers or inventors is surpassing the profit motive by far. Hence, empirical work may pick up some of these motivations which are not related to the profit motive. I would not know of studies which would employ the discrepancy of the profit motive prediction and the actual performance to shed light on the importance of this potential influence. But they would be helpful in the merger/innovation context as a merger could be predicted to have only minor impacts on innovation, if the researchers are intrinsically motivated and therefore just do "their thing".

Second, the theory on which this review was focussed did not consider where the capability for innovation came from. Present day growth theory stresses the importance of human capital. From this perspective it is clear that notions such as technological opportunity are also dependent on human capital related to such a technological opportunity. It is obvious that governmental action in the realms of higher education then can make a marked difference. Usually such influences can only be detected in the long run. But if, as in some empirical studies, different studies with potentially different governmental programs towards specific skills are compared among different countries such differences can be expected to be very important. In our present context it may e.g. trigger a merger of a domestic firm with a foreign firm because this provides access to relevantly trained R&D personnel.

This review has for its most part dwelled on issues of the M&A process and of the innovation process, separately and jointly. It has been argued that theoretical and econometric work have not exploited synergy effects between them to a satisfactory extent. Competition economists are quite hesitant to clear mergers, but it seems compelling from the arguments so far that they would not oppose if both parts of economics would at least form a RJV on this topic.

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