Paper to be presented at the DRUID Academy conference in Rebild, Aalborg, Denmark on January

21-23, 2015

Pharmaceutical Mergers and Their Effect on Parallel R&D Paths

Ute Laermann-nguyen
Philipps-UniversitÃ¤t Marburg
Department of Economic Policy
ute.laermann@wiwi.uni-marburg.de

Abstract

The impact of M&As on innovation performance is an open and important research topic, analyzed in the industrial economics as well as the strategic management discipline (de Man & Duysters 2005). But there has been little work on the question how R&D project portfolios are restructured, which projects are maintained and which projects are abandoned after a merger. From a resource-based perspective, M&As might be motivated by the objective of integrating new knowledge or other resources into the firm (Wernerfelt 1984). This implies that acquirers might maintain R&D projects of the target which are different or complementary to the own ones. One question, which is particular important from a competition policy perspective, is whether they also maintain largely similar R&D activities, i.e. from areas in which they were competitors in regard to innovation before the merger. Despite of the advantages of pursuing parallel R&D efforts, e.g. the increased probability to find problem solutions, the acceleration of development, and the enhanced capacity to react to changes in consumer requirements (Thomke, von Hippel & Franke 1998), it is not very likely that largely similar projects are maintained in the course of a merger, since it would cause higher R&D costs (Smith & Reinertsen 1991), a rise in overall project coordination (Thomke 2003), and cannibalization effects between both products when development is continued until market launch (Gilbert & Sunshine 1995).

This study suggests that the relatedness of the target's and the acquirer's R&D projects has a crucial influence on their probability to be discontinued after a merger. One assumption tested in this work is that, in general, projects of the target are more likely to be discontinued than projects of the acquirer. In particular, it is supposed that the probability to be abandoned for target projects is higher when these projects are largely similar to those of the acquirer than when they are complementary or distinct.

The sample consists of all R&D projects of the pharmaceutical M&As reviewed by the European Commission or the US antitrust authorities between 2003 and 2006. The data stems from the database Pipeline (Informa Healthcare), which contains the development history of all R&D projects of the major pharmaceutical firms. Overall, 1843 R&D projects are examined. The projects are classified as similar, complementary or distinct when the other party was active in the same technological field, in the same superior technological area but in a different subordinate field, or in distinct technological areas. A logit model is used to measure the effect of the independent variables originator and relatedness on the dependent variable project abandonment. To analyze whether the probability of discontinuation is especially high for similar projects of the target, the interaction effect between originator and relatedness is examined. Furthermore, control variables concerning project- and firm-specific attributes are considered.

The results confirm the previously specified hypotheses. Projects of the target firm have a higher probability of abandonment post-merger than projects of the acquirer. Additionally, the relatedness of the target's and the acquirer's R&D projects has a crucial influence on their probability to be discontinued. R&D projects of the acquired firm which are similar to those of the acquirer face a higher probability of abandonment than R&D projects of the target from distinct technological areas.

Literature

De Man, A.-P./ Duysters, G. (2005): Collaboration and Innovation: A Review of the Effects of Mergers, Acquisitions and Alliances on Innovation, in: Technovation, Vol. 25, pp. 1377-1387.

Gilbert, R. J./ Sunshine, S. C. (1995): Incorporating Dynamic Efficiency Concerns in Merger Analysis: The Use of Innovation Markets, in: Antitrust Law Journal, Vol. 63, pp. 569-601.

Smith, P. G./ Reinertsen, D. G. (1991): Developing Products in Half the Time, New York: Van Nostrand Reinhold.

Thomke, S. H. (2003): Experimentation Matters: Unlocking the Potential of New Technologies for Innovation, Boston: Harvard Business School Press.

Thomke, S. H./ von Hippel, E./ Franke, R. (1998): Modes of Experimentation: An Innovation Process - and Competitive - Variable, in: Research Policy, Vol. 27, pp. 315-332.

Wernerfelt, B. (1984): A Resource-Based View of the Firm, in: Strategic Management Journal, Vol. 5, No. 2, pp. 171-180.

Jelcodes:O32,-

1. Introduction

The impact of mergers and acquisitions on innovation is an open and important research topic, but there has been little work on the question how R&D project portfolios are restructured, which projects are maintained and which projects are abandoned after a merger. From a theoretical perspective, important insights might be gained from the strategic management literature on corporate diversification and the literature on parallel strategies in research and development. The strategic management literature analyzes the incentives to pursue corporate diversification strategies, mainly in conjunction with the resource-based view of the firm (Chatterjee & Wernerfelt 1991; Markides & Williamson 1994). Mergers may be motivated by the objective of acquiring and integrating new knowledge or other resources into the firm (Hagedoorn & Duysters 2002). Evolutionary theories highlight the importance of tacit resources, i.e. knowledge and firm-specific routines, which are difficult to imitate and imperfectly tradable (Nelson & Winter 1982, p. 99). Firms may use mergers or acquisitions to gain access to different skills, broaden their technology profile and complement their capabilities (Vermeulen & Barkema 2001). This implies that acquirers might maintain R&D projects of the target which are different or complementary to the own ones. One question, which is particular important from a competition policy perspective, is whether they also maintain largely substitutive R&D activities, i.e. from areas in which they were competitors in regard to innovation before the merger. The strategic management literature on parallel strategies in research and development highlights that there are several advantages of pursuing two or more distinct approaches to a single task in parallel, e.g. the increased probability to find new and better problem solutions (Nelson 1961), the acceleration of the innovation process (Smith & Reinertsen 1991), and the enhanced capacity to react to changes in consumer requirements and competitive environments (Thomke 1997; Frenken et al. 2004). But this literature also reveals a variety of disadvantages of parallel R&D strategies, e.g. the negative effects on allocative efficiency due to the consumption of additional resources and higher R&D costs (Thomke et al. 1998), the raise in project coordination (Thomke 2003), and the potential of cannibalization effects when the parallel strategies are continued until commercialization and two or more rival products are launched (Abernathy & Rosenbloom 1969; Gilbert & Sunshine 1995). In the course of a merger or acquisition, it is not very likely that largely similar projects are maintained because a merger requires extensive financial resources, which are often raised through leverage financing, leading to higher capital costs and fewer remaining resources left for R&D (Hall 1990, p. 113; Hitt et al. 1996, p. 1089). Thus, the relatedness between the target's and the acquirer's R&D projects may have a crucial influence on their probability to be discontinued after a merger.

Empirical studies in industrial economics generally find negative effects of mergers and acquisitions on innovation (De Man & Duysters 2005). Most of the studies are based on quantitative data and consider R&D expenditures and the number of patent applications as indicators for R&D input and output (Ravenscraft & Scherer 1987; Hitt et al. 1991; Hall 1999; Bloningen & Taylor 2000). Empirical work in the strategic management field usually contains smaller samples and is based on qualitative analyses (Granstrand & Sjölander 1990; Chakrabarti et al. 1994; Bresman et al. 1999; Capron et al. 1999; Ernst & Vitt 2000). These studies show more positive results, but only when certain conditions are met. The M&As should be conducted due to mainly technological motives, the integration between both firms should be managed effectively, key personnel should be retained, and both firms should possess an already strong internal knowledge base so that identifying and integrating the partner is facilitated (Cassiman et al. 2005, p. 198). Some studies highlight the importance of the acquirer and the target's resource relatedness as determinant of the innovation performance of the merged firm (Ahuja & Katila 2001; Vermeulen & Barkema 2001; Cassiman et al. 2005; Cloodt et al. 2006; Makri et al. 2010). Ahuja and Katila (2001) detect that neither too much nor too little technological relatedness is beneficial for post-merger innovation and that technological relatedness and post-merger innovation output are linked by an inverse U-shaped relation.

This study suggests that the relatedness of the target's and the acquirer's R&D projects has a crucial influence on their probability to be discontinued after a merger. One assumption tested in this work is that, in general, projects of the target are more likely to be discontinued than projects of the acquirer. In particular, it is supposed that the probability to be abandoned for target projects is higher when these projects are largely similar to those of the acquirer than when they are complementary or distinct. A new database is used which enables the analysis on the project level. Additionally, a more precise concept and measure of technological relatedness is developed, which facilitates a profound analysis of the role of relatedness of both firms' resources in the context of M&As.

The paper proceeds as follows: The next section reviews the relevant literature. Then, the concept of technological relatedness applied in this study is explained and specific hypotheses are developed in regard to the abandonment of R&D projects post-merger. Subsequently, the sample and data used are described and the methodological proceeding is illustrated. Finally, the results are presented and discussed.

2. Literature review

2.1. Restructuring of the target and the acquirer

Mergers may be conducted due to several strategic considerations. Industrial organization literature suggests that firms engage in M&As to raise market power, to enter into new markets, to increase bargaining power vis-à-vis suppliers, or to realize economies of scale and scope (Caves 1989; Hitt et al. 1996; De Man & Duysters 2005). Traditionally, economies of scale and scope have been linked to production, but the concept has been expanded to other areas such as R&D. Economies of scale and scope in R&D enhance R&D efficiency (Röller et al. 2001), but overall, this is accompanied by a reduction of R&D expenditures (Hitt et al. 1990). The financial economics literature proposes that firms diversify through M&As because of capital market imperfections, internal inefficiencies, and management motives (Jensen and Ruback 1983). Due to a higher dept ratio, opportunity costs are raised in regard to R&D (Hitt et al. 1991). This enhances the probability that R&D expenditures are cut and duplicative R&D activities are discontinued (Cassiman et al. 2005, p. 197). The strategic management literature explains M&As from a resource-based perspective and analyzes their impact on performance (Penrose 1959; Wernerfelt 1984). Since it incorporates a dynamic view on the environment in which firms operate, it is best suited as a framework to analyze restructuring processes of firms through M&As (Capron et al. 1998, p. 632).

In the resource-based theory a firm is understood as a bundle of resources and one firm differs from another due to the specific resources it owns (Penrose 1959). Some resources may generate advantages over other firms, but are difficult to imitate and imperfectly tradable because they are enclosed in a wide organizational context (Lippman & Rumelt 1982; Dosi et al. 1996). One reason might be that they consist of tacit knowledge, like values, norms, and culture, which is difficult to evaluate (James et al. 1998, p. 566). Additionally, opportunistic behavior between the supplier and the consumer might appear because of information asymmetry in favor of the supplier. Since for others it is nearly impossible to imitate specific routines of a successful firm and failures in the market for resources exist, M&As may be the only way to get access to them (Karim & Mitchell 2000, p. 1063). Furthermore, the increased complexity of products makes it difficult for firms to develop all their technologies and competences internally (Granstrand & Sjölander 1990, p. 38).

Obtaining resources through M&As may open up opportunities for change because new competences can be combined with existing capabilities (Kogut & Zander 1992). Internal diversification is strongly influenced by already existing resources because of the path-dependency of learning processes (Nelson & Winter 1982; Dosi et al. 1996). Firms accumulate resources based on what they have learned in the past (Teece et al. 1997, p.

522). In fields where they already possess some skills, their absorptive capacity is higher (Cohen & Levinthal 1990, p. 131). Thus, firms may exploit existing competences instead of exploring new ideas. But the focus of exploration of already existing skills bears the risk of lock-in into suboptimal paths. Hence, it is important for a firm to keep the balance between exploration of new technologies and exploitation of existing capabilities (March 1991). In this sense, mergers and acquisitions may be used to complement the exploitation of internal capabilities by gaining access to specific external competences, thereby changing present structures and routines (Bresman et al. 1999).

In the empirical literature on the effects of M&As on innovation only very view studies examine the restructuring of resources between the target and the acquirer. Granstrand and Sjölander (1990) investigate the frequency, causes and effects of acquisitions of small, technology-intensive firms by large corporations. They find that small firms are bought by large firms when their resource base is complementary to that of the acquirer and their integration enables the absorption of competitive advantages (Granstrand & Sjölander 1990, p. 382). Capron et al. (1998) examine 253 horizontal acquisitions in Europe and the US and emphasize failures in the market for resources as incentive to engage in M&As. They detect that firms frequently redeploy R&D, manufacturing and marketing resources either from the acquired to the acquiring firm or vice versa, but that these resources are rarely transferred in both directions at the same time (Capron et al. 1998, p. 651). In contrast, financial and management resources only flow in one direction, from the acquirer to the target. The bigger the asymmetry in regard to the resource strength between target and acquirer, the more restructuring occurs from the firm with the stronger position on the relevant resource dimension to the firm with the weaker position (Capron et al. 1998, p. 648). Capron et al. (1999) use the same data set, but extent their analysis by also looking at asset divestiture following restructuring processes after horizontal acquisitions. They find that target firms are generally more affected by asset divestitures than acquiring firms (Capron et al. 1999, p. 28). Karim and Mitchell (2000) study 3000 US healthcare firms involved in M&As between 1978 and 1995 and detect that product lines of the target are more often subject to reconfiguration than product lines of the acquirer. Acquisitions offer opportunities for firms to build on existing resources and obtain substantially different ones. Substantial expansion into new technological categories might be worthwhile when the resources are far from existing competences of the firm and beyond the firm's capability to develop them internally (Karim & Mitchell 2000, p. 1076).

2.2. Knowledge, resource and technological relatedness

Relatedness has primarily been considered in the strategic management literature and rarely in economics or finance (Larsson & Finkelstein 1999, p. 3). A crucial theorem in this literature is that the overall value of a multi-business firm overtakes the sum of the values of the single businesses when synergies between the businesses can be realized (Goold & Luchs 1993, p. 16). These synergies can arise in two forms: Super-additive value or sub-additive production costs (Tanriverdi & Venkatraman 2005, p. 99). Super-additive value is generated when the value of two businesses together is greater than the sum of the values of each single business (Davis & Thomas 1993, p. 1334). Sub-additive production costs refer to the phenomenon when the joint costs of two businesses are lower than the sum of their single costs, which is generally described with the term 'economies of scope' (Tanriverdi & Venkatraman 2005, p. 99).[1]

Synergies can arise at many points along the value chain and may be due to product relatedness, R&D relatedness, manufacturing relatedness, managerial relatedness etc. (Tanriverdi & Venkatraman 2005). For high-technology firms, knowledge is the most important resource, on which competitive advantages are built (Cloodt et al. 2006, p. 643). Thus, many studies in the strategic management tradition focus their analysis on the area of R&D and the most frequently analyzed type of synergy is the knowledge relatedness of businesses (Tanriverdi & Venkatraman 2005, p. 99). Quite often, the terms 'technological relatedness', 'resource relatedness' and 'knowledge relatedness' are used interchangeably. Most of the studies analyze the link between relatedness and firm performance (Palich et al. 2000, p. 155). An established proposal in the literature on corporate diversification is that related diversification outperforms unrelated diversification (Miller 2006).

Tanriverdi and Venkatraman (2005) criticize that many authors emphasize the sharing of resources, i.e. business units use common factors of production and realize economies of scope. Thus, the main type of synergy captured by resource relatedness is the sub-additivity in production costs and not the super-additivity in value, which arises from resource combinations (Tanriverdi & Venkatraman 2005, p. 100). In this sense, 'relatedness' refers to the similarity of resources. The literature on corporate diversification differentiates only related and unrelated diversification, i.e. similarity or dissimilarity of operations. Complementary sources of synergy are not included in the traditional concept of relatedness (Larsson & Finkelstein 1999, p. 5; Makri et al. 2010, p. 605). Tanriverdi and Venkatraman (2005) refer to the concept of complementarities, which is based on Edgeworth

[1] In contrast to that, the term 'economies of scale' refers to cost savings by increasing output quantity of one particular business (Capron 1999, p. 989).

complements: “activities are Edgeworth complements if doing (more of) any one of them increases the returns to doing (more of) the others” (Milgrom & Roberts 1995, p. 181). Thus, complementary resources are resources which depend on another and support one another (Tanriverdi & Venkatraman 2005, p. 100).

The idea that resource complementarity is an important source of synergy has been discovered in the empirical literature on M&As or alliances (Harrison et al. 1991). Subsequently, theoretical work in the strategic management tradition emphasized the performance impact of synergies between complementary resources (Porter 1996). Complementary resources generate super-additive value synergies which have a stronger effect on firm performance than cost-based synergies (Harrison et al. 2001, pp. 680). Additionally, complementarities are highly firm-specific. Therefore, they are hard to observe and imitate by competitors (Porter 1996, p. 70). Similarities are easier to identify. And even if a competitor succeeds to determine complementarities, it is unlikely that he can implement all necessary modifications to achieve the same effect. A negative outcome on firm performance can result as soon as one modification cannot be implemented and the synergies cannot be realized (Milgrom & Roberts 1995). If complementary resources are combined, the potential of learning effects is higher than when largely similar resources are consolidated. Learning effects can lead to substantial change and to the development of a competitive advantage (Hitt et al. 2001). According to Prahalad and Hamel (1990, p. 82), firms may develop and strengthen core competences through “the collective learning in the organization, especially how to coordinate diverse production skills and integrate multiple streams of technologies”. In contrast, similarities only create short-term value through economies of scale. But it is hard to identify a potential target with the adequate complementary capabilities because the information asymmetry is higher in comparison to a more similar target (Harrison et al. 2001, p. 683). Additionally, successful integration of the acquired firm into the acquiring firm is critical (Haspeslagh & Jemison 1991).

In the empirical literature on the effects of M&As on innovation the positive influence of complementary resources is generally confirmed (Cassiman et al. 2005; Cloodt et al. 2006; Makri et al. 2010). Cassiman et al. (2005) find a remarkable increase of R&D efficiency in case of technologically complementary entities and a negative effect for technologically substitutive parties. Makri et al. (2010) distinguish between the role of scientific and technological knowledge as determinants of the impact of M&As on innovation. They detect that complementary scientific and complementary technological knowledge both contribute to post-merger innovation performance by encouraging higher quality and more novel innovations. In contrast, knowledge similarities have no influence on innovation quantity or quality, but a negative effect on invention novelty (Makri et al. 2010, p. 620). In accordance

with Ahuja and Katila (2001), Cloodt et al. (2006, p. 649) show that technological relatedness has a curvilinear impact on the post-merger innovation performance of the acquiring firm. Unrelated technologies often bring about a radical change of the R&D organization, which might cause negative effects on short-term innovation performance. In contrast, if knowledge is too similar, its influence on post-merger innovation performance is weak. Thus, the authors emphasize that "one has to strive for moderate relatedness between knowledge bases" (Cloodt et al. 2006, p. 645).

3. Concept of relatedness and hypotheses

3.1. Concept of relatedness

As we have seen in the previous section, relatedness of both firms' R&D projects might be an important predictor of whether they are retained or discontinued. But the literature could not manage to develop a consistent concept of relatedness until now. In some studies relatedness is defined very broadly, with no differentiation between 'similarity' and 'complementarity' (Farjoun 1998). Sometimes complementarity is insufficiently specified (Mowery et al. 1998) or totally neglected (Lane & Lubatkin 1998). In other analyses entirely distinct resources are not considered (Cassiman et al. 2005; Makri et al. 2010). Another problem is that relatedness is measured very broadly, e.g. by looking at industry SIC codes (Larsson & Finkelstein 1999). Thus, in many studies it appears to be based on facts that merging firms have either largely similar or widely complementary resources (Harrison et al. 2001). But in reality, merging firms may have similar, complementary and totally distinct resources at the same time. Through M&As, firms may realize economies of scale, economies of scope, and may extent their businesses to totally new areas simultaneously.

I test the relatedness argument at the level of R&D projects. With this fine level of consideration, it is possible to distinguish between similar, complementary and distinct technological fields between both firms. Additionally, the focus is set on technological relatedness, not on market relatedness. Market relatedness can also have an influence on the R&D process post-merger, but only indirectly (Cassiman et al. 2005, p. 200). The reason to focus on technological relatedness is that R&D plays a crucial role in high-tech industries and competition mainly takes place in regard to innovation.

My analysis is based on the pharmaceutical industry, where a lot of consolidation has taken place in the last decades (Kummer 2005). I use data from the database Pipeline (Informa Healthcare), which contains all R&D projects from major pharmaceutical companies

worldwide.[2] The relevant projects are classified according to diseases they treat. Thus, technological relatedness is measured in regard to the objectives pursued by the R&D efforts. The diseases are then pooled to disease groups, based on the classification used in the database which largely coincides with the International Statistical Classification of Diseases and Related Health Problems (ICD) of the WHO. The R&D portfolios of the two merging parties are compared with each other. Technological fields are identified as similar if both parties have projects in development for the same disease. In these areas, the parties were competitors in regard to innovation before the merger. For example, both firms have projects in development for the treatment of acute myelogenous leukemia. These projects are not entirely identical because they come from different originators and may be based on different substances or mechanisms of action. But when the firms merge, these projects can be regarded as redundant by the management of the new firm because the finished products are going to have the same area of application. In contrast, technological fields are identified as complementary if both firms have R&D projects in the same disease group, but for different diseases. For example, both firms have projects in development in the disease group cancer, but one of them has R&D projects for the treatment of acute lymphocytic leukemia and the other for acute myelogenous leukemia. When the firms merge, these projects can be regarded as complementary in the sense that the underlying knowledge can support the development of both projects and the new firm might be able to develop a core competence in the treatment of cancer, especially leukemia. In comparison to that, distinct projects are projects where only one of both firms is active in the entire disease group.[3] For example, only one of the merging firms has projects in development in the disease group parasitic and the other firm is active in other disease groups. When both firms merge, the realization of economies of scale or synergies between the projects in these different disease groups is unlikely. But the expansion into new research areas through the merger might be interesting or even necessary to change the existing structures of the company.

3.2. Hypotheses

Empirical work on the restructuring of resources between acquired and acquiring firm has shown that targets are more affected by redeployment than acquirers (Karim & Mitchell 2000, p. 1072) and that more assets of the target are divested than assets of the acquirer (Capron et al. 1999, p. 28). One possible reason might be that the acquirer integrates those resources which are valuable for him and divests the others or rather adopts promising R&D projects

[2] See section 4.1 for a more detailed description of the data and the proceeding.

[3] Note that I only analyze horizontal M&As in one industry. Thus, a certain kind of relatedness between the technological areas always exists.

which fit well into his own project portfolio and discontinues the others. Frequently, acquirers are bigger than target firms (Granstrand & Sjölander 1990, p. 369) and therefore in a more powerful position. Walsh (1988) has shown that management turnover rates in acquired firms are significantly higher than general turnover rates. And even if the acquired managers stay, they often feel a loss of status at their job, being dominated by the executives of the acquiring firm (Lubatkin et al. 1999; Hambrick & Canella 1993, p. 733). Thus, power in the merged firm is not equally distributed between personnel from the acquired and the acquiring firm. If the cultural differences between the two firms are huge, these inequalities are even more enforced (Haspeslagh & Jemison 1991; Datta 1991). Generally, managers tend to adhere to projects which they already know and to favor their own projects over external projects (Ernst & Vitt 2000, p. 109). Thus, I expect that:

Hypothesis 1: The probability of discontinuation of R&D projects post-merger is higher for projects initiated by the target than for projects initiated by the acquirer.

The literature review in the previous section has shown that firms use M&As to gain access to specific competences and resources which they cannot develop internally or only under enormous effort (Vermeulen & Barkema 2001). Thus, R&D projects which are in distinct technological fields to their own R&D projects might be especially interesting for acquirers. In contrast, if the R&D projects of the target are very similar to projects of the acquirer, managers of the acquiring firm might tend to evaluate the target's projects as redundant, favor the own ones, and arrange the abandonment of the target's projects. A continuation of the experiments of both firms in parallel is not very likely since it would cause higher R&D costs (Thomke et al. 1998), a rise in overall project coordination (Thomke 2003), and cannibalization effects between both products when development is continued until market launch (Gilbert & Sunshine 1995). Thus, I suggest that:

Hypothesis 2: For R&D projects of the target which are similar to those of the acquirer the probability of discontinuation post-merger is higher than for R&D projects of the target which are distinct to those of the acquirer.

Empirical studies on the effects of M&As on innovation have shown that if the merging firms possess largely complementary resources, their post-merger innovation performance is enhanced (Cassiman et al. 2005). The acquiring firm might appreciate projects of the target if they are in complementary technological fields to its own projects because they supplement and enrich the own project portfolio. From a theoretical perspective, synergies between the complementary projects of the target and the acquirer may arise. The competences and skills involved in the development of the target's projects may help the new enterprise to establish a core competence in the superior technological area and to develop a sustainable

competitive advantage vis-à-vis competitors. Thus, the termination of the target's complementary projects is not very likely. In contrast, pursuing similar projects of the target firm might bring about the disadvantages for the new enterprise mentioned above. Thus, I suppose that:

Hypothesis 3: For R&D projects of the target which are similar to those of the acquirer the probability of discontinuation post-merger is higher than for R&D projects of the target which are complementary to those of the acquirer.

Complementary projects of the acquired firm might be interesting for the acquirer because the involved resources and competences might enhance the development of the own projects in the subordinate technological area. But also distinct projects of the target might be worthwhile if the acquirer wants to extend the own competences into totally new areas. Thus, it is not quite clear from a theoretical perspective whether acquiring firms rather maintain projects of the target which are complementary or projects which are totally distinct to the own ones. Therefore, I test two alternative hypotheses concerning the comparison between complementary and distinct technological fields:

Hypothesis 4: For R&D projects of the target which are complementary to those of the acquirer the probability of discontinuation post-merger is lower than for R&D projects of the target which are distinct to those of the acquirer.

Hypothesis 4^{alt}: For R&D projects of the target which are complementary to those of the acquirer the probability of discontinuation post-merger is higher than for R&D projects of the target which are distinct to those of the acquirer.

To summarize, based on the literature review in the previous section, I have developed four different hypotheses. The first hypothesis focuses on the link between originator of the project and likelihood of abandonment. I expect that the probability of discontinuation is higher for projects initiated by the target than for projects initiated by the acquirer.

The other three hypotheses focus on the link between the resource relatedness of both firms pre-merger and the probability of abandonment of R&D projects of the target. I expect that the likelihood of discontinuation of the target's projects is higher when they are similar to those of the acquirer than when they are complementary or distinct. Finally, I test two alternative hypotheses concerning the comparison between complementary and distinct technological fields because it is not quite clear from the theoretical literature whether acquiring firms rather maintain projects of the target which are complementary or which are totally distinct to the own ones.

4. Research design

4.1. Data and sample selection

The database Pipeline (Informa Healthcare) provides the most comprehensive history of pharmaceutical R&D projects from 1980 until today and covers all significant new drug candidates of the major pharmaceutical and biotech firms worldwide from preclinical testing through approval of the drug until withdrawal from marketing. It contains information from official sources, like regulatory authorities (FDA, EMEA etc.) or public trials registries, conferences or research centers, journals or press releases and from the companies themselves. To the best of my knowledge, this database has not been used in other empirical investigations concerning the innovative activity of the pharmaceutical industry. The sample includes all R&D projects of large M&As which took place between 2003 and 2006 and which were reviewed by the European Commission or the US antitrust authorities in regard to their impact on innovation (see table 1 below).[4] Cases are excluded when only OTC drugs or generic medicaments were considered by the competition authorities. Thus, the sample contains only R&D projects of M&As in which technology played a substantial role.

Table 1: Considered M&As and sample of R&D projects

Merger/acquisition		Enforcement year	Authority	Number of projects
UCB	Schwarz Pharma	2006	EC	64
Allergan	Inamed Corporation	2006	FTC	62
Bayer	Schering	2006	EC	204
Novartis	Chiron	2005	EC	449
Solvay	Fournier	2005	EC	58
Yamanouchi	Fujisawa	2004	EC	117
Genzyme Corporation	ILEX Oncology, Inc.	2004	FTC	104
Cima Labs	Cephalon	2004	FTC	61
Sanofi-Synthelabo	Aventis	2004	FTC/EC	343
Pfizer Inc.	Pharmacia Corp.	2003	FTC/EC	381
∑				**1843**

EC= European Commission, FTC= Federal Trade Commission

All projects which both firms had in development three months before the first announcement of the merger or acquisition were collected. Projects which both companies had not developed by themselves, but rather acquired a license from other companies, were excluded. This was possible since the database Pipeline specifies the licensees on each

[4] Since the Department of Justice did not investigate any merger cases concerning the pharmaceutical industry, only cases examined by the Federal Trade Commission are included in the sample.

drug profile. Furthermore, the firms usually use code letters for their experimental substances, which are also specified on each profile. With these codes, I was able to identify the originator of each project. Additionally, the development history of each compound is indicated on its profile. Therefore, it was possible to determine whether the development of a certain project has been initiated before or after the relevant merger. When I was not able to identify the exact beginning of development, I submitted a research request to the Pipeline staff and they researched the issue for me or asked the relevant company directly.

Overall 1843 R&D projects were analyzed (see table 1, p. 11). The projects were classified according to their relatedness as described in section 3.1 (pp. 7). In a next step, it was examined whether the R&D projects which both firms had in development pre-merger were still under development, launched by the new entity, or discontinued two years after approval of the transaction.

4.2. Variables

The dependent variable in this study is the abandonment of an R&D project after a merger or acquisition. I examined every R&D project under development three months before the relevant merger and coded it 0 if it was still under development or already launched two years after approval or 1 if it was discontinued during the relevant time period. Projects which were discontinued due to medical reasons, e.g. adverse events or lack of efficiency, were classified as not discontinued since I am only interested in the strategic abandonment of research projects. Additionally, I assume that the breakup due to medical motives occurs independently of a merger or acquisition.

Since I am interested in the influence of the originator of each project and the relatedness of the projects of both firms on their probability to be discontinued, I analyzed 'technological field' and 'originator' as independent variables. Additionally, I examined the interaction effect between both variables to analyze whether the relatedness between both firms has different influences on the probability of abandonment of the target's and the acquirer's projects. Furthermore, I introduced control variables which may also affect the discontinuation rate. Since I only studied R&D projects of pharmaceutical firms, I did not control for industry factors, but for firm-specific and project-specific attributes. As project-specific characteristics I examined the overall number of indications for which the project under consideration was in development, the project age - indicated by the development phase before the merger -, the disease group of the project, the delivery mode planned for the final drug and the mechanism of action of the compound. Two firm-specific attributes were also included as control variables: The relative size of the target and the change in R&D intensity of the new

enterprise compared to the intensity of both firms pre-merger. The relative target size was calculated as the total number of projects in development by the target compared to the total number of projects in development by the acquirer. R&D intensity was measured as the ratio of a firm's R&D expenditures compared to the company's sales and the change in R&D intensity was calculated as the difference between the R&D intensity pre-merger and two years after approval. The relevant data was collected from the annual reports of the firms.[5]

4.3. Statistical analysis

Since the dependent variable is dichotomous and the independent variables are categorical or metric, I conducted my statistical analysis by using a logistic regression model (Andreß et al. 1997, p. 20). I am interested in the probability that an R&D project is discontinued after a merger or acquisition. With a logit model, we can estimate the probability of discontinuation of an R&D project as a function of project-specific and firm-specific attributes. The estimation is based on the following mathematical model:

$$\ln\left(\frac{p(y=1)}{1-p(y=1)}\right) = \alpha + \Sigma_i \beta_i x_i$$

where $p(y=1)$ is the dependent variable, the probability of abandonment of an R&D project post-merger, x_i is the independent variable, β_i is the estimated coefficient, and α is a constant (Agresti 2007, p. 115). The logarithm guarantees that the probability only takes values between 0 and 1. The coefficients estimate the impact of the independent variables on the dependent variable. A positive value implies that the independent variable increases the probability of abandonment. Logit models are based on maximum-likelihood estimations which provide consistent and asymptotically efficient parameter estimates for large samples (Andreß et al. 1997, p. 47). To test the significance of the model, I used $-2LL$ (-2 times the logarithmic likelihood), which is approximately distributed as a chi-square statistic (Andreß et al. 1997, p. 48). The lower the $-2LL$, the better is the model. Additionally, I applied the log-likelihood ratio test to indicate the goodness of fit of the model. It is conducted by subtracting the $-2LL$ values of the unrestricted model, which contains all relevant parameters, from the restricted model, which does not include one or more of these parameters (Andreß et al. 1997, pp. 44). Thus, it tests whether the unrestricted model has a significantly better explanatory power than the restricted model. Furthermore, I tested the significance of each estimated parameter value by using the Wald statistic, which is asymptotically chi-square

[5] Additionally, I controlled for two other variables: Patent application and merger motive. Since I did not receive significant results concerning these variables, I excluded them from the model.

distributed (Agresti 2007, p. 11). IBM SPSS Statistics 20 was used as program for the estimation.

5. Results

Table 2 below shows the frequency of the parameter values of the dependent and the independent categorical variables. Overall 409 of the 1843 R&D projects were terminated without medical reasons after the merger or acquisition (22.2%). In regard to the relatedness of the target's and the acquirer's projects, 37.9% of all projects were in similar, 46.1% in complementary, and 16.0% in distinct technological fields. Thus, the majority of the analyzed projects belonged to technological fields which were complementary between the merging parties. The rate of discontinuation was highest for similar (24.4%), moderate for complementary (21.6%), and lowest for distinct projects (18.6%). Furthermore, 68.4% of the total number of projects were initiated by the acquiring firm and only 31.6% by the target. This implies that mainly large firms merged with smaller companies. Only 16.6% of the acquirer's projects were terminated post-merger, whereas 34.3% projects of the target were abandoned.

Table 2: Distribution of the dependent variable and the categorical independent variables

		Discontinued without reason					
		no		yes			
		total	% (line)	total	% (line)	total	% (sample)
Technological field	similar	528	75,6%	170	24,4%	698	37,9%
	complementary	666	78,4%	184	21,6%	850	46,1%
	distinct	240	81,4%	55	18,6%	295	16,0%
Originator	acquirer	1051	83,4%	209	16,6%	1260	68,4%
	target	383	65,7%	200	34,3%	583	31,6%
Number of indications	1	367	66,8%	182	33,2%	549	29,8%
	2	203	69,0%	91	31,0%	294	16,0%
	3	172	81,5%	39	18,5%	211	11,4%
	4 or more	692	87,7%	97	12,3%	789	42,8%
Project age	preclinical	731	77,6%	211	22,4%	942	51,1%
	phase I	300	82,4%	64	17,6%	364	19,8%
	phase II	233	73,7%	83	26,3%	316	17,1%
	phase III	142	77,6%	41	22,4%	183	9,9%
	pre-registration/registered	28	73,7%	10	26,3%	38	2,1%

Disease group	alimentary/metabolic	126	77,8%	36	22,2%	162	8,8%
	blood & clotting	60	87,0%	9	13,0%	69	3,7%
	cancer	403	77,6%	116	22,4%	519	28,2%
	cardiovascular	130	76,0%	41	24,0%	171	9,3%
	dermatological	36	70,6%	15	29,4%	51	2,8%
	genitourinary	81	85,3%	14	14,7%	95	5,2%
	hormonal	9	90,0%	1	10,0%	10	0,5%
	immunological	17	81,0%	4	19,0%	21	1,1%
	infectious disease	126	75,4%	41	24,6%	167	9,1%
	miscellaneous	11	61,1%	7	38,9%	18	1,0%
	musculoskeletal	76	78,4%	21	21,6%	97	5,3%
	neurological	243	75,5%	79	24,5%	322	17,5%
	parasitic	11	100,0%	0	0,0%	11	0,6%
	respiratory	56	72,7%	21	27,3%	77	4,2%
	sensory	49	92,5%	4	7,5%	53	2,9%
Delivery mode	unique	549	83,9%	105	16,1%	654	35,5%
	not unique	701	83,7%	137	16,3%	838	45,5%
	unspecified	184	52,4%	167	47,6%	351	19,0%
Mechanism of action	uncommon	848	76,1%	267	23,9%	1115	60,5%
	common	497	85,1%	87	14,9%	584	31,7%
	unidentified	89	61,8%	55	38,2%	144	7,8%
Relative target size	smaller	1056	80,1%	263	19,9%	1319	71,6%
	similar	111	61,3%	70	38,7%	181	9,8%
	bigger	267	77,8%	76	22,2%	343	18,6%
Group total		1434	77,8%	409	22,2%	1843	100,0%

Table 3 presents the descriptive statistics for the metric variable R&D intensity. Unfortunately, I could not identify all relevant values. For 58 of the overall 1843 analyzed projects I could not receive information about the R&D expenditures of the originator.[6] Thus, in regard to the control variable R&D intensity, the number of analyzed parameters decreased to 1785. In the logistic regression with SPSS I included the missing values in the analysis. The descriptive statistics show that overall, the R&D intensity decreased after the merger or acquisition.

Table 3: Descriptive statistics for the metric variable R&D intensity

	N	Minimum	Maximum	Mean value	Standard deviation	Variance
R&D intensity	1785	-,59845	,05530	-,0581803	,13680628	,019
Valid values (listwise)	1785					

[6] This was the case for Fournier Pharma, which was acquired by Solvay in 2005. Since Solvay in turn was acquired by Abbott in 2009, I contacted Abbott, but they were not able to provide me the relevant information.

Additionally, I tested for multicollinearity between the independent variables, using Kendall's Tau for variables with at least ordinal scale and biserial correlations for variables with nominal scale. All correlations had low coefficients and showed no indication of serious multicollinearity.

The results of the logistic regression are presented in table 4 below. Four different models were tested. For each category of the independent variables except the reference category the value of the Exp(B) coefficient and its significance are specified. The logistic model illustrated in section 4.3 (p. 13) is based on the odds that a specific event will happen, e.g. a research project will be abandoned. The odds are the ratio between the probability that the event will occur and the likelihood that it will not occur. Thus, the Exp(B) coefficient is the exponential function at point B. It represents the change in the odds ratio associated with a one unit change in the independent variable, based on the assumption that the values of all other variables stay the same. If Exp(B) is bigger than one the odds increase, if it is smaller the odds decrease, and if it is one the odds stay the same (Andreß et al. 1997, pp. 270).

Model 1 in table 4 contains the dependent variable and the independent variables. The interaction term between technological field and originator is not included. A significant coefficient is shown for originator (with a level of significance of $p < 0.01$). Thus, the originator of an R&D project has a significant influence on the probability that the project is terminated after a merger. Since Exp(B)=0.345 and the target firm is selected as reference category, the odds that a project is discontinued post-merger are 65.5% (1 - 0.345) lower for a project initiated by the acquirer than for a project initiated by the target. This result provides strong support for hypothesis 1.

Table 4: Logistic regression estimates

	Model 1	**Model 2**	**Model 3**	**Model 4**
Technological field				
similar			1,132	10,511***
complementary	0,986	0,884		9,287***
distinct	0,955	0,095***	0,108***	
Originator (reference: target)	0,345***	0,279***	0,343***	3,956*
Number of indications (reference: one indication)				
2 indications	1,015	1,088	1,088	1,088
3 indications	0,541***	0,563**	0,563**	0,563**
4 or more indications	0,278***	0,281***	0,281***	0,281***
Project age (reference: preclinical)				
phase I	1,325	1,292	1,292	1,292
phase II	2,933***	3,047***	3,047***	3,047***
phase III	2,084***	2,221***	2,221***	2,221***
pre-registration/registered	1,401	1,507	1,507	1,507

Disease group (reference: cancer)				
alimentary/metabolic	0,384***	0,378***	0,378***	0,378***
blood & clotting	0,365**	0,369**	0,369**	0,369**
cardiovascular	0,462***	0,432***	0,432***	0,432***
dermatological	0,932	1,100	1,100	1,100
genitourinary	0,251***	0,255***	0,255***	0,255***
hormonal, parasitic	0,029***	0,026***	0,026***	0,026***
immunological	0,233**	0,554	0,554	0,554
infectious disease	0,408***	0,399***	0,399***	0,399***
miscellaneous	0,393	0,358	0,358	0,358
musculoskeletal	0,404***	0,482**	0,482**	0,482**
neurological	0,465***	0,446***	0,446***	0,446***
respiratory	0,779	0,676	0,676	0,676
sensory	0,197**	0,179***	0,179***	0,179***
Delivery mode (reference: unique)				
not unique	1,648***	1,628***	1,628***	1,628***
unspecified	6,128***	6,256***	6,256***	6,256***
Mechanism of action (reference: uncommon)				
common	0,495***	0,484***	0,484***	0,484***
unidentified	1,044	0,973	0,973	0,973
Relative target size (reference: equal)				
smaller	0,386***	0,349***	0,349***	0,349***
bigger	0,283***	0,270***	0,270***	0,270***
R&D intensity	0,080***	0,087***	0,087***	0,087***
Interaction between originator and technological field				
originator by similar technological field			0,815	0,071***
originator by complementary technological field		1,228		0,087***
originator by distinct technological field		14,161***	11,536***	
Constant (α)	1,606	1,799*	1,590	0,171**
Model log-likelihood (-2LL)	1553,123	1538,338	1538,338	1538,338
Log-likelihood ratio	397,981***	14,79***	14,79***	14,79***

n = 1843; significant estimates: * p<0.1; ** p<0.05; *** p<0.01;

dependent variable: discontinuation of the R&D project without reason (1/0);
reported coefficients: changes in odds ratio (exp(B)); reported coefficient < 1: odds ratio is decreasing for change in independent variable by one unit; coefficient = 1: odds ratio is not changing; coefficient > 1 : odds ratio is increasing;

changes for indicator variables are for discretionary changes from 0 to 1.

Concerning hypotheses 2, 3, 4 and 4^{alt}, important results are presented by model 2, 3, and 4. All three models contain the dependent variable, the independent variables and the interaction term between technological field and originator. The difference between the three models consists of the selection of different reference categories for the variable technological field. In model 2, the category similar is selected as reference category, in model 3 complementary, and in model 4 distinct technological fields. In contrast to model 1, model 2 presents a significant coefficient for distinct technological fields (with a level of

significance of $p < 0.01$). Since the interaction term between technological field and originator is included in the model, the Exp(B) only refers to the reference category of the other variable in the interaction term, i.e. in this case only to projects initiated by the target. Since Exp(B)=0.095 and the reference category is similar, the odds that a project of the target firm is discontinued is 90.5% lower for projects distinct to those of the acquirer than for projects similar to those of the acquirer. This result provides strong support for hypothesis 2.

Model 3 gives a significant coefficient for distinct technological fields, too (with a level of significance of $p < 0.01$). In this model, the category complementary is chosen as reference category. Since Exp(B)=0.108, the odds that a project of the target firm is abandoned is 89.2% lower for projects distinct to those of the acquirer than for projects complementary to those of the acquirer. Thus, this result supports hypothesis 4^{alt} and disproves hypothesis 4.

Model 4 shows significant coefficients for similar and for complementary technological fields (with a level of significance of $p < 0.01$). In this model, the category distinct is chosen as reference category. Thus, model 4 confirms the results in regard to the comparison of the probability of discontinuation between similar and distinct and between complementary and distinct technological fields, also supporting hypothesis 2 and 4^{alt}.

Furthermore, models 2 and 3 contain the comparison of the probability of abandonment between similar and complementary technological fields. Since the coefficients are not significant, hypothesis 3 is neither supported nor disproved.

In regard to the independent variable originator, models 2, 3, and 4 present interesting refinements since, in contrast to model 1, the interaction between technological field and originator is also considered. In model 2 the Exp(B) of originator only relates to the reference category similar technological fields. Therefore, Exp(B)=0.279 (with a level of significance of $p < 0.01$) means that the odds of abandonment of similar research projects are 72.1% lower for projects initiated by the acquirer than for projects initiated by the target. In model 3, the category complementary is selected as reference category. Since Exp(B)=0.343 (with a level of significance of $p < 0.01$), the odds of abandonment of complementary R&D projects are 65,7% lower for projects of the acquirer than for projects of the target. Finally, also model 4 shows a slightly significant coefficient for originator (with a level of significance of $p < 0.1$). Here, the category distinct is selected as reference category for the variable technological field. Since Exp(B)=3.956, the odds of discontinuation of distinct R&D projects are 3.956 times higher for projects of the acquirer than for projects of the target.

Additionally, in table 4 (pp. 16) the effects of the control variables are also shown. The number of indications for which a certain project is in development, the age of the project, the disease group in which the project is in development, the delivery mode planned for the final drug, the mechanism of action of the compound, the relative size of the target firm, and the

change in R&D intensity all influence the probability of abandonment of an R&D project post-merger.

6. Discussion and conclusions

To summarize, I hypothesized that the probability of discontinuation of R&D projects is higher for projects initiated by the target than for projects initiated by the acquirer. Additionally, I supposed that the likelihood of abandonment of R&D projects of the target is even higher when they are similar to those of the acquirer than when they are complementary or distinct. Since from a theoretical perspective it is not quite clear whether acquiring firms rather maintain complementary or distinct projects of the acquired firm, I formulated two alternative hypotheses concerning the comparison between complementary and distinct projects of the target. To test my assumptions, I analyzed 1843 R&D projects under development by pharmaceutical firms involved in M&As between 2003 and 2006.

The empirical analysis has revealed strong support for my hypotheses. In fact, the probability of abandonment of R&D projects is higher for projects initiated by the target than for projects initiated by the acquirer. Additionally, the relatedness of the target's and the acquirer's R&D projects has a crucial influence on the probability of abandonment of the target's projects. R&D projects of the acquired firm which are similar to those of the acquirer face a higher probability of abandonment than R&D projects of the target which are distinct to those of the acquirer. Furthermore, complementary projects of the target are terminated more often than distinct projects. These results support hypotheses 1, 2, and 4^{alt}. Hypothesis 3 is neither supported nor disproved, since no significant results could be observed. Thus, it is still unclear, whether acquiring firms rather maintain complementary or similar projects of the target.

The analysis has also shown some interesting refinements in regard to the role of the originator of the considered project: Similar projects of the target are terminated more often than similar projects of the acquirer. The same relation applies for complementary projects. In contrast, distinct projects of the target are discontinued less frequently than distinct projects of the acquirer.

The empirical results indicate that firms acquire others to gain access to specific competences, resources, and skills. In general, the own projects of the acquirer are favored over the projects of the target. The acquirer only adopts promising R&D projects of the target which are valuable for him and discontinues the others. In particular, the results support the assumption that M&As are used to expand into areas which are far from own competences and to diversify the own project portfolio. R&D projects of the target which are in distinct

technological fields are discontinued rarely. Projects of the target from similar technological areas are terminated more often, since they might be evaluated as redundant by the managers of the acquiring firm. From a competition policy perspective, this is an important result. It implies that M&As are used to buy competitors in innovation, terminate promising rival projects, and prevent that an innovative competing drug will be launched. From a consumer welfare perspective, it would be better when both drugs reach the market. This issue is especially delicate when it is about two potentially life-saving treatments.
Complementary projects of the target are also terminated more often than distinct projects. This implies that the strengthening of already existing competences through the acquisition of complementary skills does not play such an important role in connection with M&As than the expansion into new areas. Perhaps strategic alliances are a more adequate instrument to gain access to complementary resources. The results indicate that the expansion into different areas and the acquisition of rivals in regard to R&D play a more important role in the course of M&As than the purchase of complementary competences.

While my work has shown which R&D projects are discontinued after a merger or acquisition, an interesting issue for further research is the question how launch rates are affected. I found that the relatedness of the target's and the acquirer's projects has a crucial influence on the probability of abandonment of these projects. It is still an open question whether this relatedness also determines future launch rates. Thus, it should be analyzed whether a high discontinuation rate in a specific technological area entails a low future launch rate in this technological field or whether market launch rates are not affected by discontinuation rates. Additionally, another interesting path for research is the analysis of discontinuation rates of pharmaceutical R&D projects in general. A comparison between the general rate and the rate in the course of a merger would shed light on the question whether more R&D projects are terminated after M&As and would contribute substantially to the discussion on their impact on innovation.

While Pipeline is one of the most detailed and advanced databases in regard to pharmaceutical R&D projects, limitations of the data and my study should be taken into consideration. The database contains only information the firms want to announce. Thus, it is possible that we do not have information about compounds detected prior to the merger, kept in secret by the firms and terminated afterwards. Thus, I cannot assert that the data is complete, but I can affirm that it is the most elaborate source of information available.

Literature

Abernathy, W. J./ Rosenbloom, R. S. (1969): Parallel strategies in development projects, in: *Management Science*, Vol. 15, Application Series, pp. B486-B505.

Agresti, A. (2007): *An Introduction to Categorical Data Analysis*, 2nd Edition, New York: Wiley.

Ahuja, G./ Katila, R. (2001): Technological acquisitions and the innovation performance of the acquiring firms: A longitudinal study, in: *Strategic Management Journal*, Vol. 22, pp. 197-220.

Andreß, H.-J./ Hagenaares, J. A./ Kühnel, S. (1997): *Analyse von Tabellen und Kategorialen Daten*, Berlin: Springer.

Blonigen, B. A./ Taylor, C. T. (2000): R&D intensity and acquisitions in high-technology industries, in: *Journal of Industrial Economics*, Vol. 48, pp. 47-70.

Bresman, H./ Birkinshaw, J./ Nobel, R. (1999): Knowledge transfers in international acquisitions, in: *Journal of International Business Studies*, Vol. 30, pp. 439-462.

Capron, L./ Dussauge, P./ Mitchell, W. (1998): Resource redeployment following horizontal acquisitions in Europe and North America, 1988-1992, in: *Strategic Management Journal*, Vol. 19, pp. 631-661.

Capron, L./ Mitchell, W./ Swaminathan, A. (1999): Post-acquisition resource redeployment and asset divestiture: An evolutionary view, Working Paper, University of Michigan.

Cassiman, B./ Colombo, M./ Garrone, P./ Veugelers, R. (2005): The impact of M&A on the R&D process: An empirical analysis of the role of technological and market relatedness, in: *Research Policy*, Vol. 34, pp. 195-220.

Caves, R. F. (1989): Mergers, takeovers, and economic efficiency, in: *International Journal of Industrial Organization*, Vol. 7, pp. 151-174.

Chakrabarti, A./ Hauschildt, J./ Süverkrüp, C. (1994): Does it pay to acquire technological firms? in: *R&D Management*, Vol. 24, pp. 47-56.

Chatterjee, S./ Wernerfelt, B. (1991): The link between resources and types of diversification: Theory and evidence, in: *Strategic Management Journal*, Vol. 12, pp. 33-48.

Cloodt, M./ Hagedoorn, J./ Van Kranenburg, H. (2006): Mergers and acquisitions: Their effect on the innovative performance of companies in high-tech industries, in: *Research Policy*, Vol. 35, pp. 642-645.

Cohen, W. M./ Levinthal, D. A. (1990): Absorptive capacity: A new perspective on learning and innovation, in: *Administrative Science Quarterly*, Vol. 35, pp. 128-152.

Datta, D. K. (1991): Organizational fit and acquisition performance: Effects of post-acquisition integration, in: *Strategic Management Journal*, Vol. 12, pp. 281-297.

Davis, R./ Thomas, L. G. (1993): Direct estimation of synergy: A new approach to the diversity performance debate, in: *Management Science*, Vol. 39, pp. 1334-1346.

De Man, A.-P./ Duysters, G. (2005): Collaboration and innovation: A review of the effects of mergers, acquisitions and alliances on innovation, in: *Technovation*, Vol. 25, pp. 1377-1387.

Dosi, G./ Marengo, L./ Fagiolo, G. (1996): Learning in evolutionary environments, Working paper, University of Rome.

Ernst, H./ Vitt, J. (2000): The influence of corporate acquisitions on the behavior of key inventors, in: *R&D Management*, Vol. 30, pp. 105-119.

Farjoun, M. (1998): The independent and joint effects of the skill and physical bases of relatedness in diversification, in: *Strategic Management Journal*, Vol. 19, pp. 611-630.

Frenken, K./ Hekkert, M./ Godfroij, P. (2004): R&D portfolios in environmentally friendly automotive propulsion: Variety, competition and policy implications, in: *Technological Forecasting & Social Change,* Vol. 71, pp. 485-507.

Gilbert, R. J./ Sunshine, S. (1995): Incorporating dynamic efficiency concerns in merger analysis: The use of innovation markets, in: *Antitrust Law Journal*, Vol. 63, pp. 569-601.

Goold, M./ Luchs, K. (1993): Why diversify? Four decades of management thinking, in: *Academy of Management Executive*, Vol. 7, pp. 7-25.

Granstrand, O./ Sjölander, S. (1990): Managing innovation in multi-technology corporations, in: *Research Policy*, Vol. 19, pp. 35-60.

Hagedoorn, J./ Duysters, G. (2002): External sources of innovation capabilities: The preference for strategic alliances or mergers and acquisitions, in: *Journal of Management Studies*, Vol. 39, pp. 167-186.

Hall, B. H. (1990): The impact of corporate restructuring on industrial research and development, in: *Brookings Papers on Economic Activity*, *Special Issue Microeconomics*, pp. 85-124.

Hall, B. H. (1999): Mergers and R&D revisited, Working Paper, UC Berkeley.

Hambrick, D. C./ Cannella, A. A.(1993): Relative standing: A framework for understanding departures of acquired executives, in: *Academy of Management Journal*, Vol. 36, pp. 733-762.

Harrison, J./ Hitt, M. A./ Hoskisson, R. E./ Ireland, R. D. (1991): Synergies and post-acquisition performance: Differences verus similarities in resource allocations, in: *Journal of Management*, Vol. 17, pp. 173-190.

Harrison, J./ Hitt, M. A./ Hoskisson, R. E./ Ireland, R. D. (2001): Resource complementarity in business combinations: Extending the logic to organizational alliances, in: *Journal of Management*, Vol. 27, pp. 679-693.

Haspeslagh, P. C./ Jemison, D. B. (1991): *Managing Acquisitions: Creating Value Through Corporate Renewal*, New York: Free Press.

Hitt, M. A./ Harrison, J. S./ Ireland, R. D. (2001): *Mergers & Acquisitions: A Guide to Creating Value for Stakeholders*, New York: Oxford University Press.

Hitt, M. A./ Hoskisson, R. E./ Ireland, D. R. (1990): Mergers and acquisitions and managerial commitment to innovation in m-form firms, in: *Strategic Management Journal*, Vol. 11, pp. 29-47.

Hitt, M. A./ Hoskisson, R. E./ Ireland, D. R./ Harrison, S. J. (1991): Effects of acquisitions on R&D inputs and outputs, in: *Academy of Management Journal*, Vol. 34, pp. 693-711.

Hitt, M./ Hoskisson, R. E./ Johnson, R. A./ Moesel, D. D. (1996): The market for corporate control and firm innovation, in: *Academy of Management Journal*, Vol. 39, pp. 1084-1119.

James, A. D./ Georghiou, L./ Metcalfe, J. S. (1998): Integrating technology into merger and acquisition decision making, in: *Technovation*, Vol. 18, pp. 563-573.

Jensen, M. C./ Ruback, R. S. (1983): The market for corporate control: The scientific evidence, in: *Journal of Financial Economics*, Vol. 11, pp. 5-50.

Karim, S./ Mitchell, W. (2000): Path-dependent and path-breaking change: Reconfiguring business resources following acquisitions in the U.S. medical sector, 1978-1995, in: *Strategic Management Journal*, Vol. 21, pp. 1061-1081.

Kogut, B./ Zander, U. (1992): Knowledge of the firm, combinative capabilities, and the replication of technology, in: *Organization Science*, Vol. 3, pp. 383-397.

Kummer, C. (2005): *Internationale Fusions- und Akquisitionsaktivität, historische Entwicklung, Verbreitung und strategische Intentionen*, Wiesbaden: DUV.

Lane, P. J./ Lubatkin, M. H. (1998): Relative absorptive capacity and interorganizational learning, in: *Strategic Management Journal*, Vol. 19, pp. 461-477.

Larsson, R./ Finkelstein, S. (1999): Integrating strategic, organizational, and human resource perspectives on mergers and acquisitions: A case survey of synergy realization, in: *Organization Science*, Vol. 10, pp. 1-25.

Lippman, S. A./ Rumelt, R. P. (1982): Uncertain imitability: An analysis of interfirm differences in efficiency under competition, in: *The Bell Journal of Competition*, Vol. 13, pp. 418-438.

Lubatkin, M./ Schweiger, D./ Weber, Y. (1999): Top management turnover in related M&A's: An additional test of the theory of relative standing, in: *Journal of Management*, Vol. 25, pp. 55-73.

Makri, M./ Hitt, M. A./ Lane, P. J. (2010): Complementary technologies, knowledge relatedness, and invention outcomes in high technology mergers and acquisitions, in: *Strategic Management Journal*, Vol. 31, pp. 602-628.

March, J. G. (1991): Exploration and exploitation in organizational learning, in: *Organization Science*, Vol. 2, pp. 71-87.

Markides, C./ Williamson, P. J. (1994): Related diversification, core competencies, and corporate performance, in: *Strategic Management Journal*, Vol. 15, pp. 149-165.

Milgrom, P. R./ Roberts, J. (1995): Complementarities and fit, strategy, structure and organizational change in manufacturing, in: *Journal of Accounting and Economics*, Vol. 19, pp. 179-208.

Miller, D. J. (2006): Technological diversity, related diversification, and firm performance, in: *Strategic Management Journal*, Vol. 27, pp. 601-619.

Mowery, D. C./ Oxley, J. E./ Silverman, B. S. (1998): Technological overlap and interfirm cooperation: Implications for the resource-based view of the firm, in: *Research Policy*, Vol. 27, pp. 507-523.

Nelson, R. R. (1961): Uncertainty, learning, and the economics of parallel research and development efforts, in: *Review of Economics and Statistics*, Vol. 43, pp. 351-364.

Nelson, R. R./ Winter, S. (1982): *An Evolutionary Theory of Economic Change*, Cambridge: Belknap Press of Harvard UP.

Palich, L. E/ Cardinal, L. B./ Miller, C. C. (2000): Curvilinearity in the diversification-performance linkage: An examination of over three decades of research, in: *Strategic Management Journal*, Vol. 21, pp. 155-174.

Penrose, E. T. (1959): *The Theory of the Growth of the Firm*, New York: Wiley.

Porter, M. E. (1996): What is strategy? in: *Harvard Business Review*, Vol. 74, pp. 61-78.

Prahalad, C. K./ Hamel, G. (1990): The core competence of the corporation, in: *Harvard Business Review*, Vol. 68, pp. 79-91.

Ravenscraft, D. J./ Scherer, F. M. (1987): *Mergers, Sell-offs, and Economic Efficiency*, Washington, DC: The Brookings Institution.

Röller, L.-H./ Stennek, J./ Verboven, F. (2001): Efficiency gains from mergers, Discussion Papers WZB, Wissenschaftszentrum Berlin für Sozialforschung, Forschungsschwerpunkt Marktprozess und Unternehmensentwicklung, No. FS IV 00-09.

Smith, P. G./ Reinertsen, D. G. (1991): *Developing Products in Half the Time*, New York: Van Nostrand Reinhold.

Tanriverdi, H./ Venkatraman, N. (2005): Knowledge relatedness and the performance of multibusiness firms, in: *Strategic Management Journal*, Vol. 26, pp. 97-119.

Teece, D. J./ Pisano, G./ Shuen, A. (1997): Dynamic capabilities and strategic management, in: *Strategic Management Journal*, Vol. 18, pp. 509-533.

Thomke, S. H. (1997): The role of flexibility in the development of new products: An empirical study, in: *Research Policy*, Vol. 26, pp. 105-119.

Thomke, S. H. (2003): *Experimentation Matters: Unlocking the Potential of New Technologies for Innovation*, Boston: Harvard Business School Press.

Thomke, S. H./ van Hippel, E./ Franke, R. (1998): Modes of experimentation: An innovation process – and competitive – variable, in: *Research Policy*, Vol. 27, pp. 315-332.

Vermeulen, F./ Barkema, H. G. (2001): Learning through acquisitions, in: *Academy of Management Journal*, Vol. 44, pp. 457-476.

Walsh, J. P. (1988): Top management turnover following mergers and acquisitions, in: *Strategic Management Journal*, Vol. 9, pp. 173-183.

Wernerfelt, B. (1984): A resource-based view of the firm, in: *Strategic Management Journal*, Vol. 5, pp. 171-180.