

Mergers & Acquisitions and Innovation Performance in the Telecommunications Equipment Industry

Tseveen Gantumur[®]
European University Viadrina

Andreas Stephan
European University Viadrina and DIW Berlin

ABSTRACT

In response to global market forces such as deregulation and globalization, technological change and digital convergence, the telecommunications in the 1990s witnessed an enormous worldwide round of Mergers & Acquisitions (M&A). Given both *M&A* and *Innovation* a major means of today's competitive strategy development, this paper examines the innovation determinants of M&A activity and the consequences of M&A transactions on the technological potential and the innovation performance. We examine the telecommunications equipment industry over the period 1988-2002, using a newly constructed dataset with firm-level data on M&A and innovation activity as well as financial characteristics. By implementing a counterfactual technique based on a matching propensity score procedure, the analysis controls for merger endogeneity and ex-ante observable firms characteristics. The study provides evidence that M&A realize significant positive changes to the firms' post merger innovation performance. The effects of M&A on the innovation performance are in turn driven by both the success in Research and Development (R&D) activity and the deterioration in internal technological capabilities at acquiring firms prior to a merger.

Keywords: Mergers & Acquisitions, Innovation Performance, Telecommunications Equipment Industry

JEL Classifications: L63, O30, L10

[®] Corresponding author: European University Viadrina, Faculty of Economics and Management Studies, Grosse Scharrnstrasse 59, D-15230 Frankfurt (Oder), eMail: gantumur@euv-ffo.de

1 Introduction

The telecommunications industry is moving fast both on the technology front and in terms of structure. A recent surge of Mergers and Acquisitions (M&A) in the telecommunications industry is a reflection of drastically changing environment of the market.¹ Deregulation and liberalization, technological innovation and digital convergence, and the evolving requirements of the capital markets have driven dramatic changes in the telecommunications industry as a whole, and the industry in turn has sparked fundamental changes in the economic landscape worldwide. As the telecommunications firms face increasing exposure to international competition, the industry has undergone a radical transformation creating exciting new opportunities and new challenges for infrastructure and service providers (Li and Whalley, 2002). Market winners are in most cases also technology leaders or highly capable of turning a base technology into a superior product that meets customer needs (Brodt and Knoll, 2004).

The rapid technological change, growing technological complexity and shortening product life cycles add new dimensions to an already complex scenario and increasingly force firms to source technologies externally. Firms will often prefer M&A to other cooperative approaches of R&D network building, e.g. R&D joint ventures, because an M&A provides an immediate controlling presence in the new, fast expanding market, rather than having to gradually build a new business or negotiate with a partner about developing a cooperation (Caves, 1982; Capron and Mitchell, 1997). While several analyses have stressed that the telecommunications industry has undergone major restructuring in the 1990s through intense M&A activity (e.g. Jamison, 1998; Kim, 2005; Rosenberg, 1998, Warf, 2003), we are not aware of any study which investigates the linkage between recent rises both in M&A and innovation activity. The goal of this paper is to uncover the keen reliance of the telecommunications firms on M&A as a technology sourcing strategy.

We aim at providing an answer to the following question: Why do firms in the telecommunications industry increasingly use M&A as a technology source? Does M&A affect the innovation performance of firms involved as their proponents expect? Before attempting to determine this task, however, a more basic question needs to be addressed, namely: Does an innovation activity of firms depict a significant predictor of entering the M&A market? Admittedly, technological reasons do not motivate all M&A. M&A can be motivated, for instance, by the desire to obtain financial synergies or market power, to obtain access to distribution channels, and/or to gain entry into new markets.² Such M&A may not be able to be

¹ Between 1996 and 2001, more than 20 M&A deals worth over \$20 billion took place in the telecom sector, 14 of which in the US. Telecom mergers amount for 7 of the largest operations announced in 2000, and 8 out of the 10 largest of all times (Le Blanc and Shelanski, 2002)

² For extensive review, see Shimizu et al. (2004)

directly expected to improve the firms' innovation performance. However, in high technology industries where innovation is a key to competitive advantage, firms will incorporate the impact of M&A on technological performance even when the transaction is not innovation-driven, choosing the most appropriate innovation and financial strategies. Moreover, to the extent that access to technology and know-how become increasingly important to succeed in the market, factors such as firm's size, history and equity become less and less critical requirements. This allows new challengers to realize tremendous growth rates. Furthermore, it spurs the quest for external knowledge sourcing both at the established and new firms in the market. As innovation is becoming indispensable for strategic competitiveness in the high technology industry, we ask: how do firms that choose M&A and firms that stay outside M&A market differ with respect to their innovation performance? The follow up question is then, what are the effects of M&A on the innovative performance of firms, if we control for the differences in innovation performance prior to M&A activities?

Though occurrence of M&A has grown dramatically in the last years, academic research on the relationship between innovation and M&A has not kept pace with the changes. In spite of the vast and rapidly growing body of literature on M&A³, empirical evidence that have explored this relationship is rather limited and often inconclusive⁴. The literature on the technological effects of M&A shows contradictory implications. On the one hand, M&A may build up competencies and foster innovation for a number of reasons. M&A can reduce high transaction costs related to transmission of knowledge between firms (Bresman et al, 1999). Furthermore, in fast moving markets with abbreviated product life cycles, firms may perceive they do not have the time to develop the requisite skills and knowledge internally and therefore turn outward, to M&A. In this sense, M&A may offer a quick access to knowledge assets (Warner et al, 2006). Moreover, M&A may extend the technological base of firms involved allowing them to achieve greater economies of scale and scope through more efficient deployment of knowledge resources. Also, M&A may enlarge the overall R&D budget of firms engaged enabling them to tackle larger R&D projects and thereby spreading the risk of innovation. In addition, the integration of complementary knowledge may also increase innovation through M&A leading to more advanced technologies being developed (Gerpott, 1995). Finally, by exchange of best practices on innovation management within the combined entity, firms may employ efficient technology integration.

On the other hand, innovation-driven M&A encompass the difficulties associated with innovation as well as the obstacles faced in mergers. First of all, differences in corporate culture, processes and knowledge base may impede a smooth transition of knowledge (Lane and

³ For review see Roeller et al. (2001) and Shimizu et al. (2004)

⁴ For review see Veugelers (2005)

Lubatkin, 1998; Very, 1997). Furthermore, M&A integration process is time consuming and costly this may divert management attention away from innovation (Hitt et al, 1996). Also, trade off payment of debt and debt costs for investment in R&D can occur due to M&A (Hitt et al, 1990). Furthermore, a disadvantage of M&A is that it involves entire firms whereas the advantages for knowledge exchange may be limited to only a small part of the firms involved. In M&A, knowledge beyond that required is acquired as well. This may cause indigestibility: a firm may acquire more knowledge than it can use in a meaningful way (Hennart and Reddy, 1997). At last, as the literature has shown, technologically motivated and intensive acquisitions are highly vulnerable to failure (Chakrabarti et al, 1994). One of the main reasons for this value destruction lies in the miscarried and inappropriate integration of the technology-based firm after the acquisition (Duysters and Hagedoorn, 2000). Even when the merger is successful in terms of the integration of R&D departments, in other business areas the merger may not be a success, influencing a disintegration of the entire firm.

One of the main reasons for the contradictions and inconclusiveness of previous studies might be due to cross-industry investigations. Consequently, we focus on the recent increase in M&A and innovation activities of firms in the telecommunications equipment industry as the existence of industry clustering in M&A activity is evident (Andrade et al, 2001). Lying at the core of the telecommunications industry, the telecommunications equipment industry takes a central role in the technological transformation of the entire industry. Also, the growing market concentration observed for technology producers and the relevance of patent-based technological standards in recent years are motives for selecting this well-defined industry.

This study provides empirical evidence on our research questions by considering the M&A that took place between telecommunications equipment firms during the period 1988-2002. It uses a newly created data set from the following four complementary data sources: NBER Patent, Thomson One Banker-Deals, Compustat and Global Vantage databases. To the data set on the telecommunications equipment firms we adopt a treatment effect estimation approach with endogenous selection using a matching propensity score technique. In order to explore the interrelationship between M&A and R&D of firms, we capture broad dimensions on both activities. We analyze R&D input and output as well as the knowledge stock and research productivity of firms. Furthermore, we reveal the role that a firm plays in transaction as an acquirer, a target, and a pooling merger.

We find evidence consistent with the following propositions. First, the telecommunications equipment firms undertake M&A in order to strengthen their success in innovation and thereby their market position. Second, the equipment manufacturers in telecommunications, which experienced low research productivity from on-going exploitation of R&D efforts in the past, are forced to explore potential future innovation trajectories in new

business units by acquisitions. Third, those telecommunications equipment firms, which declined in their inventive portfolio, are involved in pooling mergers to offer comprehensive and integrated equipment solutions. Finally, equipment firms in telecommunications can successfully outsource R&D through M&A as a means of revitalizing a firm by enhancing and supplementing its knowledge base effectively.

The article proceeds as follows. Section 2 draws a broad picture on the developments in telecommunications equipment industry with regard to its M&A and R&D activities. Section 3 presents the theoretical underpinnings of our research questions. Data description is provided in Section 4, while Section 5 discusses measures of performance and empirical methodology. We report empirical results in Section 6 and conclude with a discussion of findings in Section 7.

2 Telecommunications Equipment Industry

As a key of the entire industry the telecommunications equipment manufactures all equipment required for the use or provision of telecommunications and data services. The structure of the industry is presented in Figure 4 and described in Appendix.

Until recently, with its regulated and very stable market structure, the telecommunications industry had correspondingly little, if any, opportunities for mergers⁵. Most national telecommunications markets were characterized by vertically integrated national monopolies where telecommunications equipment production and demand largely was in the hands of government agencies. This picture radically changed in late 1980s with the beginning of the liberalization and deregulation process culminated in the standardization and subsequent rapid diffusion of the GSM⁶. During this period, the vertically integrated monopolies had dissolved, while R&D and innovation increasingly shifted towards the producers of telecommunications equipment. For the telecommunications equipment producers, regulatory liberalization has both implied the opening of new markets abroad and a shift in competition from the national to the global level.

In addition, the process of convergence between telecommunications, IT and broadcasting through its technological, organizational, and market/service aspects has a far-reaching influence on the market structure of the telecommunications industry (Tadayoni and Skouby, 1999; Kim, 2005). The ICT convergence essentially has come about through two parallel technological changes. The first initial radical innovation is the application of integrate circuit technology to allow digital switching of telephone calls that change the core design concepts of

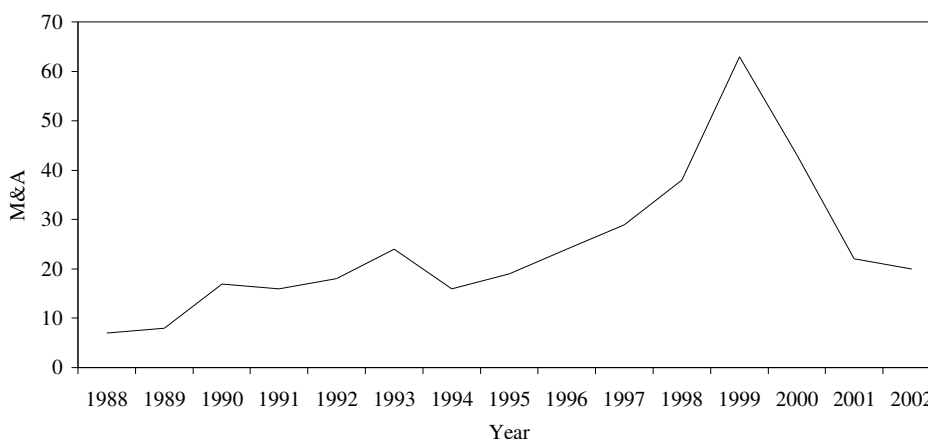
⁵ We employ hereafter the term “merger” to define both merger and acquisition if not otherwise indicated.

⁶ Global System for Mobile Communication

telephone systems. The second development is the Internet. It is based on the TCP/IP⁷ protocol that standardizes the rules of packaging, transmitting and receiving data over the Internet providing more flexibility and fitting further between information and telecommunications technologies (Minin and Palmberg, 2006).

As a result of international competition stemming from the liberalization of its market and pace of technological evolution, telecommunications firms that traditionally operated only in their home markets have expanded throughout the world, often by undertaking mergers of foreign telecommunications firms. The 1990s witnessed an enormous wave of mergers dramatically reconfigure the market structure of global telecommunications equipment (see Figure 1). Mergers provided a means of rapidly overcoming the shortcomings of existing networks and services as well as helped to address the inadequacies associated with the provision of such global services under the existing framework of correspondent relationships between telecommunications operator (Capron and Mitchell, 1997).

Figure 1. M&A in the Telecommunications Equipment Industry, 1988-2002



Source: Authors' calculations from Thomson One Banker-Deals

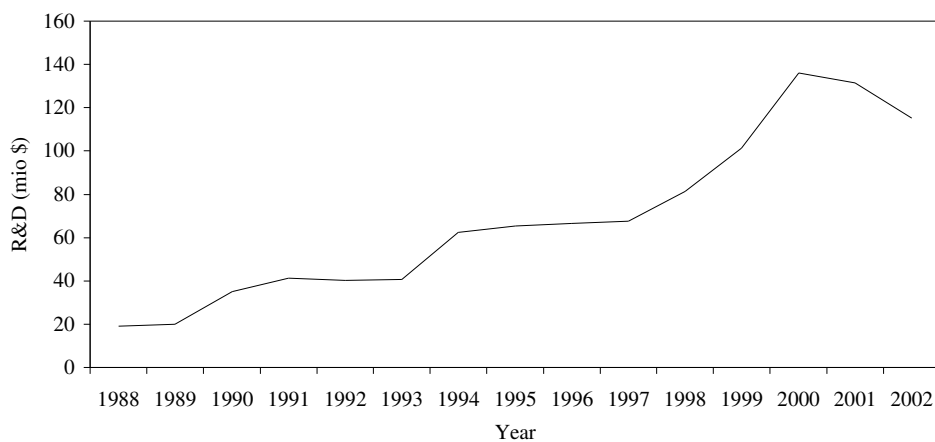
In the recent years, the existing network operators have rebuilt their telecommunications infrastructure to accommodate increased voice and data traffic. Major investments were undertaken to improve network capacity, enable the transport of high-speed data and to enhance the intelligence of the fixed network to enable customers to benefit from advanced services. Investment in R&D plays a major role in the growth and fall of the telecommunications equipment industry. While the trade and regulatory liberalization foremost has globalized the demand for telecommunications equipment, technological change in the industry has had pervasive effects further upstream on R&D. One aspect of this is ongoing convergence between

⁷ Transmission Control Protocol/Internet Protocol

various technology subfields of ICT that requires technological diversification amongst the incumbents and opens up multiple entry options (Minin and Palmberg, 2006) also for new players.

Figure 2 gives a broad overview of R&D expenditure for equipment manufacture firms of our sample over the last decade. During the monopoly era, hardly any visible importance to R&D was given as the technology was dominated by analog systems. Digitalization was the main technological achievement in communications, hence, new technologies were introduced into the market in all areas of communications, e.g. voice, data networks, satellite, cellular, switching and routing network devices, etc. Service firms for the first time had choices in terms of selecting the equipment manufactures. R&D experienced its peak during those years. However, after the telecom crash, both the sales volume and retail prices dropped. That affected directly the amount of R&D spending in 2001. Research did not make it through product lifecycles, and launching of new technologies was delayed, e.g., third generation (3G) wireless networks.

Figure 2. Average R&D expenditures in the Telecommunications Equipment Industry, 1988-2002

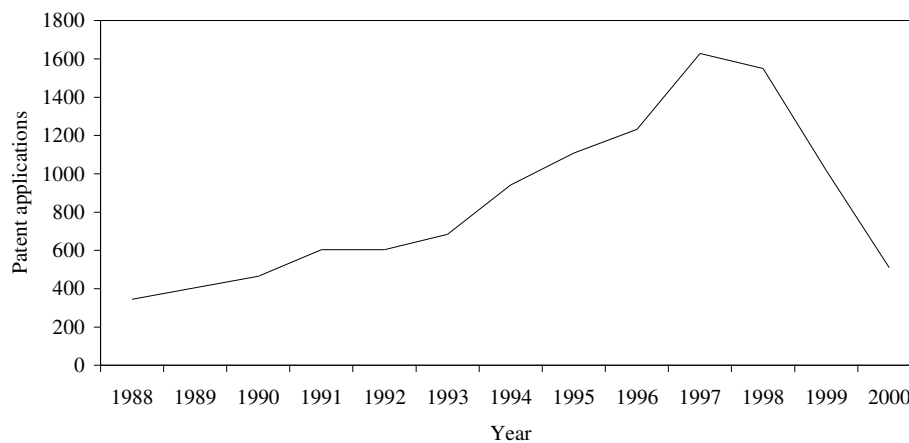


Source: Authors' calculations from Compustat and Global Vantage databases

In the digitalized markets, success is increasingly based on non-physical or intangible factors rather than merely on the telecommunications networks and other physical assets that provided the previous national telecom monopolies with a primary source of revenues (Quah, 2000). Recent intensive competition has dramatically changed the business environment of telecommunications firms and forced them to seek new strategies. Not only technological innovations themselves but also related patent right royalties or license fees may provide telecommunications firms with an outstanding source of income. It may be increasingly costly not to innovate since the license fees for patents relating to communication products become a

major cost for communication product manufacturers and their customers (Kretschmer, 1997). The growth in the patenting of the worldwide telecommunications equipment industry has been tremendous (see Figure 3). From 1988 to 1998 the number of communication equipment patents applied by the UPSTO increased more than four times. The abrupt fall in the patent applications after 1998 in the Figure 3 is caused primarily by the truncation of patent data sample.⁸

Figure 3. Patenting in the Telecommunications Equipment Industry, 1988-2000



Source: Authors' calculations from NBER Patent Database

To summarize the M&A and R&D trends, the telecommunications equipment industry in the 1990s has experienced the race of technological changes and a major restructuring that characterized through intense merger activity.

3 Theoretical Background

Technological change influences the ability of firms to integrate, build and reconfigure internal and external competencies to address altering competitive and technological challenges. Dosi (1988) described the technological changes to be continuous or incremental in that they reflect a path dependent and cumulative development as a technological paradigm or pattern of inquiry. Incremental change tends to reinforce the market power of incumbent firms because it utilizes existing competencies in development and can be deployed through an established set of sales and marketing resources (Tece, 1996). Accumulated prior knowledge and heuristics constitute the related problem-solving knowledge that permits incumbents to acquire related problem-

⁸ We date the patents in our sample by the date of application, although we consider only patents that eventually granted. We have all patents that granted by 2002, so our patent numbers are not quite complete in the later years. For this reason, we end our analysis on patents in 2000, because in subsequent years a truncation due to the grant lag appears more visible.

solving capabilities. Learning capabilities involve the development of the capacity to assimilate existing knowledge, while problem-solving skills represent a capacity to create new knowledge, and they are mutually inclusive.

To the extent that the innovation embodies new skills or knowledge, incumbents can be hindered in responding as they may have little or no relevant development history to draw upon (Dosi, 1988). Firms must absorb the environmental information on innovation and eventually to be able to exploit it through new products or processes in the market. Cohen and Levinthal (1989) elucidated the two faces of R&D activity. That is, R&D activity does not only stimulate innovation but also enhance firms' ability to assimilate outside knowledge. The second face of R&D is called the absorptive capacity and is considered to be crucial particularly for assessing the effective contribution by spillovers from others. Defined as a set of knowledge and competencies, the firm's knowledge base remains a preliminary condition in the assimilation of spillovers from R&D efforts of environment. For Rosenberg (1990), fundamental research inside the firm has strong complementarities with external R&D. All in all, both Cohen & Levinthal and Rosenberg insist on potential synergies between the firm's own knowledge base and external flows of scientific and technical knowledge. Thus, the responsiveness of R&D activity to exploit external knowledge flows is an indication of the importance of absorptive capacity. In industries like telecommunications, this response must be quick due to highly competitive conditions caused by short product cycles, new technologies, frequent entry by unexpected outsiders, repositioning by incumbents, and radical redefinitions of market boundaries as ICT industries converge. Highly reactive firms with high absorptive capacities will not wait for failure to spur development. By contributing R&D to the firms' absorptive capacity, however, it should be beared in mind that technological performance does not necessarily depend on past or referential performance, but on absorptive capacity generated in past. In other words, firms with high absorptive capacity will exploit new ideas regardless of past performance.

Firms, especially those with high technological content, strive to overcome constraints aligned with cost, appropriation, absorptive capacity, and time regarding performing R&D. Thus, firms are faced with the associated objectives of developing a response to an innovation and doing so in a timely fashion. Therefore, for firms that decide to conduct R&D activities, there is a crucial strategic choice to be made. Traditionally, the economic literature on the choice of strategies for performing R&D basically considers two alternatives: either R&D is performed internally or it is acquired externally; these two alternatives could also be combined. The theoretical literature, drawing on transaction costs economics (Coase, 1937; Williamson, 1981) and property rights theory (Hart and Moore, 1986), considers the choice between external sourcing and internal development as substitutes, i.e. the classical make-or-buy decision.

Technological know how is often tacit and can therefore not be easily transmitted from one firm to another (Larsson et al, 1998). In order to avoid high transaction costs, firms may be induced to engage in a merger in order to solve problems related to the transmission of tacit knowledge (Bresman et al, 1999). At the same time, because of high risk due to the low probability of innovation success and the length of required time for innovation to provide adequate returns, internal developments may be perceived by firms (Hundley et al, 1996). Thus, firms prefer to invest fewer resources in internal R&D when faced with resource constraints or attractive external innovation sources exist. It is argued that acquisitions of firms with an innovative portfolio of interest often represent more certainty and lower risk of exploiting knowledge assets than do new ventures (Chakrabarti et al, 1994). Engaging in acquisitions, firms, however, may trade off payment of debt and debt costs for investment in R&D. That is, as the innovation developments embeds assets that are largely non-redeployable, firms are likely to prefer the use of debt to fund acquisitions rather than to support innovation activities (Hitt et al, 1990).

However, due to the fact that the financial and innovation strategies of future-oriented firms are jointly decided, a financials lack is an imperative for firms pursuing a competitive strategy premised on innovation. Hence, the mutually exclusive choice between these innovation strategies is too restrictive. Moreover, R&D strategy adopted by a firm depends very broadly on its environment and on differences in the abilities of the firms to conduct R&D activities. While the difficulty in being a good 'buyer' when one is not also a 'maker' and vice versa occurs, most theories of economic organization that rely on a comparison of costs or benefits per transaction to explain the organization of economic activity have typically ignored the possibility of multiple innovation sources.

The studies inspired by the resource- and knowledge-based approaches argue that a firm can rely on combination of different strategies to engage in innovation. Following the absorptive capacity argument, the ability to recognize the value of new information and also to integrate and deploy it, is enhanced when the new knowledge is related to what is already known (Cohen and Levinthal, 1990). The combination of similar fields of technology are expected to enable firms to share technological expertise, shorten the innovation lead time, and to engage in larger projects than would be possible within the once separated firms (Kogut and Zander, 1992). Yet, the relatedness between the knowledge bases is likely to have a non-monotonic influence on subsequent integrated innovation performance (Lubatkin, 1983; Lane and Lubatkin, 1998). In other words, with increasing relatedness the innovation performance will increase firstly reaching some optimum and then will decrease. Ahuja and Katila (2001) showed that, from one side, when the knowledge bases of acquiring and acquired firms are very similar, then the beneficial effects of such combination would be limited, as there will not be much to learn from each other. From the other side, when the knowledge bases are very distinct, absence of

common skills and similar cognitive structures and lack of adequate absorptive capacity will impede communication and knowledge transfer. Nevertheless, distinctive knowledge bases of internal and external sources can be particularly valuable under conditions of technological uncertainty (Sorenson and Sorensen, 2001) and might be usable in a creating knowledge complementarities.

It is theoretically evident that the firms who invest in R&D have, in any case, a natural advantage in the exploitation of high technology, and if the results of their own R&D have not been satisfactory, those firms are inclined to procure technology externally. In this context, to justify the desideratum of external technology source, it is essential to attend to the increasing evidence that a firm's size and position within the industry affects the nature and the type of innovation it is engaged in (Hart and Ramanantsoa, 1992; Christensen, 1997). First, pursuing to develop the knowledge and to create a new internally, firms might be hindered particularly by radical or significant innovations rather than by minor or incremental innovations since the later are technological changes that are close to current expertise. This is distinctive to established firms in the market or market leaders, mostly large firms, which tend to innovate to reinforce their positions or to enhance their core competencies. The improvements on their R&D can be indeed significant, but they are not likely to change the status quo.

Second, prior success in developing competencies may block firms from adjusting from environment. For developments that differ greatly from existing knowledge, the former competencies may become rigidities or barriers to performance. To utilize fully its strengths, large firms need the path to innovation to be predictable. Having less to gain from a radical, new design than a market challenger, they are less likely to pursue disruptive technologies or to embrace new innovations that would threaten their dominance.

Finally, large firms might prefer exploitative investments rather than explorative as the later is uncertain in payoff and organizationally challenging. But the ongoing exploitation of the existing knowledge and capabilities, even those that make an organization successful for a certain time, after a point impedes the creation of new knowledge and eventually lead to technological exhaustion (March, 1991; Vermeulen and Barkema, 2001). These self-reinforcing capacities can create also competency-destroying technological change.

On the other hand, new firms or market challengers, mostly small firms, are more entrepreneurial and can respond more quickly to unexpected opportunities. By creating new fields of technology or new skills where the market leader does not have expertise or an established position, they are looking for opportunities to upset the leader's position and to radically change the competitive situation, eliminating or diminishing the leader' market dominance. While they are more likely to fail, they are more willing or able to venture into

completely new and non-tasted directions because they have less of a vested interest in the current technology and are not tied to sunk investments in obsolete technologies.

At the same time, small challengers have fewer resources to spend on R&D and because of a lack of strong enterprise channels are less likely to have the resources to bring an invention to the marketplace. This lack of manufacturing and distributing activity can be filled by large firms that possess a greater ability to finance large R&D as well.

In sum, we suppose that a disruption in productive efficiency in the innovation activity of firms forces them to turn outward to technological mergers. Next, we expect that a merger between accumulated absorptive capacities of firms facilitates the merging firm's ability to understand new knowledge held by its acquisitions target or partner in a pooling merger. Furthermore, we presume that relative absorptive capacity of merging firms enhances the merging firm's ability to assimilate new knowledge from its acquisition target or partner in a pooling merger. Forward, we predict that strengthening of building absorptive capacity of merging firms shapes the merging firm's ability to apply the assimilated knowledge. Finally, we propose that a merger influences the merging firm's ability to strengthen and build up its knowledge base. Herein, the R&D functions of merging firms have to be effectively integrated and coordinated through the interaction emerging in such circumstances.

4 Data Description

In order to examine the interaction between merger and innovation activity, a new firm-level database is constructed which covers all firms in the telecommunications equipment industry that operated in any year over the 18 years period, 1987 to 2004 (including lagged periods). This database is created by complex matching the information from initially four separate datasets. The first two datasets include firms' financial characteristics and the further two datasets describe firms' merger and innovation activities, respectively.

We define the telecommunications equipment firms as those with a primary activity in communications equipment Standard International Codes (SIC) 3661, 3663, or 3669. The population of firms and their financial information including R&D expenditures were drawn from Compustat and Global Vantage databases. After eliminating firms with missing financial information, we could identify a sample of 638 telecommunications equipment firms for those a data on R&D expenditures, total assets, market value, cash flow, long term debt were available.

Our patent statistics for the telecommunications equipment industry are based on the database that is compiled by the National Bureau of Economic Research (NBER, Hall et al., 2001). The database comprises detailed information on all US patents granted between 1963 and

2002 and all patent citations made between 1975 and 2002. The patent and the citations data were procured originally from the US Patent Office and from Derwent Information Services, respectively. Although this US data could imply a bias in favor of US firms and against non-US firms, the group of non-US firms in this sample represents a group of innovative and rather large firms that are known to patent worldwide. Our database includes information such as the patent number, the application and grant dates, the detailed technology field(s) of the innovation, the inventor name(s), the city and state from which the patent was filed, and citations of prior patents on which the current work builds. Following the classification in Trajtenberg *et.al* (2001), we include the patents that firms applied for in twelve International Patent Classification (IPC) main classes 178, 333, 340, 342, 343, 358, 367, 370, 375, 379, 385, or 455 in the category communication equipment. Because the distribution of the value of patented innovations is extremely skewed, we also consider for each patent the number of forward citations as an indicator of the importance or the value of innovations, thereby overcoming the limitations of simple counts (Brouwer and Kleinknecht, 1999; Griliches, 1990). During the observed period, 251 firms from our sample have applied for a total of 11,226 patents in communication equipment (including multiple applications by the same firm in the same year and for the whole period) that led to a total of 86,442 citations⁹. The most active firms in the patent intentions were Motorola, Siemens, Nortels Network, Qualcomm, and Alcatel Bell Telephone with 61.72% of the total patent applications.

M&A transaction data were obtained from the Thomson One Banker-Deals database. Updated daily, the database offers more than detailed information elements to merger transactions including target and acquirer profiles, deal terms, financial and legal advisor assignments, deal value and deal status. This database includes alliances with a deal value of more than 1 million USD ensuring that the overwhelming majority of mergers are covered. Our final sample on merger transactions contains information on 364 completed deals (including multiple deals by the same firm in the same year and during the observed period) carried out by 178 firms and announced during the period from 1988 to 2002. Using information from the initial database, we distinguished between the role that a firm played in a M&A transaction and classified the firms in our sample in generally as an acquirer, the firm which purchased the stock or other equity interests of another entity or acquired all or a substantial portion of its assets, a target, the firm which sold a significant amount or all of itself to another firm, or a partner in a pooling merger, the firm which pooled its assets with another firm or merged with another firm of approximately equal size. In the total of 364 M&A transactions, we could identify 217

⁹ The data set is truncated, which might bias downward the citation counts of recent patents.

acquirer, 25 targets and 122 partners in pooling mergers.¹⁰ Furthermore, 59.6% of the entire mergers involve innovative firms, i.e. firms that applied for at least one patent during the observed period. While 84.8% of the merger firms took part up to three times in a merger, we can observe that the merger activity of the telecommunications equipment industry is characterized by the transactions of certain firms. For instance, the large-scale firms such as Ericsson, Siemens, ADC Telecommunications, Motorola, and Alcatel carried out 17.86% of the total merger transactions. For our econometric analysis, we restrict the multiple transactions carried out by one firm in the same year to the largest transaction only.¹¹ Finally, the estimation sample consists of total 300 M&A transactions, which involve 186 acquirer, 22 targets and 94 partners in a pooling mergers.

The databases were matched on the basis of firm names, CUSIP numbers¹² and address information provided by each database. The firms with lacking or inadequate data on the matching procedure were cross-checked and completed with information reported in Dun & Bradstreet's "Who owns whom" annual issues.

5 Econometric Methodology

In this section we describe the econometric approach. The aim of the analysis is twofold: first, to investigate the impact of success in innovation activity on the likelihood that a firm engages in a merger, and second, to analyze the effect of a merger on a firm's innovation performance.

The general perspective on mergers and the technological-related reasons of merger activity both stress the importance of understanding the conditions under which the change in ownership might have a significant effect on the innovation performance of firms. Hence, the effects of a merger must be related to the reasons and expectations behind the transaction. In order to explore the link between merger and innovation performance of firms, we estimate the innovation determinants that influence the merger and may alter following a merger.

¹⁰ For transactions that involve the acquisitions mostly of a privately held and/or a relatively small firm that is not operated in the US and not listed in Global Vantage, we lack financial data on the target firm.

¹¹ The frequency of M&A transactions carried out by one firm in the same year is as follows: 294 firms with 1 deal, 44 firms with 2 deals, 6 firms with 3 deals, and 3 firms with 4 deals in a given year during the sample period.

¹² CUSIP stands for Committee on Uniform Securities Identification Procedures. A CUSIP number identifies most securities, including stocks of all registered US and Canadian companies, and US government and municipal bonds. The CUSIP system facilitates the clearing and settlement process of securities. A similar system is used to identify foreign securities (CUSIP International Numbering System).

5.1 Estimating the Propensity to Merge

We start our analysis by exploring the determinants of mergers and by investigating the attractiveness of telecommunications equipment firms as merger candidates. Employing a random utility model, we consider the firm i 's decision of whether to acquire, to be acquired, to involve in a pooling merger, or to stay outside the merger market. The utilities associated with each of these choices k are modeled as a function of firm characteristics X_i that effect the utilities differently:

$$U_{ik} = X_i \beta_k + e_{ik} \quad (1)$$

While the level of utility is not observable, we can however infer from the choices of firms how they rank each of these alternatives. If we assume that the e_{ij} are distributed Weibull, the differences in the ε are distributed logistic and a multinomial logit can be used to estimate the differences in the parameters β .

The propensity of engaging in a merger is modeled as a function of firm characteristics. We base the analysis on a panel that consists of innovation-related and financial variables on both merged and non-merged firms for which data were available during the period 1988-2002. The probability that firm i chooses alternative k is specified

$$Pr(i \text{ chooses } k) = \frac{\exp(\beta_k' X_i)}{\sum_l^m \exp(\beta_l' X_i)} = \frac{1}{\sum_l^m \exp[(\beta_l - \beta_k)' X_i]} \quad (2)$$

where β_1, \dots, β_m are m vectors of unknown regression parameters.

An important property of the multinomial logit model is that relative probabilities are independent from each other, which is the so-called independence of irrelevant alternatives (IIA) property. In order to obtain robust standard errors of estimated coefficients, appropriate tests were conducted, which are discussed in Section 5.1.

In the following, we explain the determinants of a merger¹³ captured by our analysis and assess the appropriateness and plausibility of the merger choice. Summary statistics of the variables are shown in Table 1.¹⁴

INSERT TABLE 1 ABOUT HERE

¹³ We employ hereafter the term "merger" to define both mergers and acquisitions.

¹⁴ We checked that there exists no multicollinearity among selected variables.

The innovation performance of a firm is examined with respect to its R&D input, R&D output, the stock of accumulated knowledge generated by past R&D efforts, and the research productivity. R&D input and R&D output of firms are measured by their R&D expenditure and the number of patent applications, respectively. R&D expenditures involve both current and capital expenditures, where the current expenditures are composed of labor costs and other current costs, and the capital expenditures are the annual gross expenditures on fixed assets used in the R&D projects of firms. We analyze the firms' intellectual property rights registered as patents that are actually granted. Each patent contains highly detailed information on the innovation itself (Hall, 2001). Since there exist a strong relationship between the size of firm and its R&D expenditure and its total number of patents, as suggested by common innovation studies, we took the ratios of R&D expenditures and patent counts to total assets and defined them as R&D intensity and patent intensity respectively.

In order to account not only for the quantity but also the quality of the patented inventions, we measured the patent-based characteristics of a firm using the number of forward citations of patents. As mentioned above, the number of citations received by any given patent is truncated in time because we only know about the citations received so far. In other words, the number of forward citations a patent received depends on the year of application. Therefore, we normalize the citation counts by their average value calculated over all patents belonging to the same technological subclass whose application was filed in the same year.¹⁵ We then weight each patent of a firm by the number of normalized citations that it subsequently received (Trajtenberg, 1990).

The stock of accumulated knowledge of a firm is measured using citation-based patents and calculated by applying the perpetual inventory method by assuming a depreciation rate of 15 percent per annum (Hall, 1990). Hence, the individual patents in the firm's knowledge base provide the basis for comparing the firm's own knowledge base with that of other firms. R&D productivity, defined as the ratio of citation-weighted patent to R&D expenditure, accounts for the firm's research productivity. Research productivity may be interpreted as the efficiency with which R&D brings forth new and useful knowledge.

Since financial profiles of firms are likely to influence both their innovative and merger activity, we include also the firms' financial characteristics. To express all monetary values in real terms we employ the US industry-based Producer Price Index with basis year 1999. All covariates in regressions have been lagged by one year in order to avoid potential endogeneity

¹⁵ This is the *fixed-effects* approach proposed in Hall et al. (2001)

problems as well as possible biases arising from different merger accounting methods and financial statement consolidation.¹⁶

Firm size is proxied by the book value of total assets. Some empirical evidence has shown that the purchase of larger companies is positively related to post-merger performance, since bigger targets can benefit the buyer in terms of economies of scale, a larger resource base, and a larger customer base (Seth, 1990; Loderer and Martin, 1992; Clark and Ofek, 1994; Ahuja and Katila, 2001). However, other studies have claimed that these potential benefits might not be realized if the integration of larger acquired organizations creates greater coordination problems and needs resources to be devoted to solve this at the expense of business operations, leading to a negative impact of a merger (Lubatkin 1983; Kusewitt 1985; Ahuja and Katila, 2001).

The economic performance of a firm is proxied by firm growth and Tobin's q . Firm growth is measured by the annual growth rate of market value. Firms with growing market value may appear as likely acquisition targets for mature firms looking to absorb growth opportunities. We approximate Tobin's q by calculating the ratio of the market value to book value of a firm's assets, where the former is the sum the book value of long-term debt and the market value of common equity (Danzon et al., 2004). According to the q -theory of investment capital should flow from low- q to high- q firms. Indeed, by knowledge flows, technology shocks cause a large variation in the firms' Tobin's q (Jovanovic and Rousseau, 2004). The interpretation of the effect of Tobin's q should be treated with some caution, since, apart from being a forward looking indicator, a firm's growth opportunities (Gugler et al., 2004), it is also likely to reflect stock undervaluation (Mork et al., 1990), or managerial performance (Powell, 1997).

Cash flow ratio is defined as the ratio of cash flow to total assets and represents the financial capabilities of firms. The cash-flow ratio amounts for funds available to a firm for operations, investment and acquisitions. Given the argument that R&D is primarily financed by internally generated resources, the cash-flow ratio might be an important determinant of the (inclusively) choice between internal R&D or external know-how of innovative firms.

Following the practice of previous studies (e.g. Hall, 1999) a dummy variable is included which indicates missing R&D values and equals one when R&D is missing and zero otherwise. For the firm-years observations with missing R&D intensity, we set then R&D intensity equal to zero. Moreover, to capture the difference between firms with no R&D output, we employ similarly a dummy for firms with zero (citation-weighted) patent intensity.

Table 2 depicts the t -statistics of the differences in means of the firm characteristics separately for merged and non-merged firms. Firms that actually merged are characterized by a

¹⁶ Similar methods have been widely used in the literature (Hall, 1999). We are aware, however, that lagging regressors does not control for all sources of endogeneity (Wooldridge, 2002).

greater knowledge stock expressed in accumulated intellectual property rights than firms that did not merge. In terms of total assets, there is a significant size difference between merged and non-merged firms showing that larger firms are more likely to merge.

INSERT TABLE 2 ABOUT HERE

The merged firms had, on average, a larger Tobin's q and cash-flow ratio, and were less likely to have missing R&D values and zero (citation-weighted) patent intensity, and had experienced more merger transactions in the past relative to firms that did not engage in a merger in a given year. The firms in our sample do not differ significantly in their R&D and (citation-weighted) patent intensity as well as research productivity prior to a merger.

5.2 Estimating the Impact of M&A on Innovation

Our analysis of the effects of mergers controls for endogeneity and ex-ante observable firms characteristics using a propensity score method (Dehejia and Wahba, 2002).

For each firm i in the sample, let M_i be a merger indicator that equals one when the firm engages in a merger and zero otherwise. We denote Y_{i1} as the innovation performance of merging and Y_{i0} as the innovation performance of non-merging firms and observe M_i and hence $Y_i = M_i \cdot Y_{i1} + (1 - M_i) \cdot Y_{i0}$. Accordingly, let $E[Y_{i1} | M_i = 1]$ and $E[Y_{i0} | M_i = 0]$ denote average outcomes of the technological performances of merged and non-merged firms, respectively. The effect of interest is that of merger on the technological performance of the merged firms, or the difference between the expected innovative performances of the merged firms and of the firms that would have experienced if they did not merge:

$$\tau \Big|_{M_i=1} = E[Y_{i1} | M_i = 1] - E[Y_{i0} | M_i = 1] \quad (3)$$

This denotes the expected treatment effect on the treated. Since we do not have the counterfactual evidence of what would have happened if a firm had not engaged in a merger, $E[Y_{i0} | M_i = 1]$ is unobservable. However, it can be estimated by $E[Y_{i0} | M_i = 0]$ and the effect can be then given by the difference in average outcome between the merged and non-merged innovative performances:

$$\tau^e = E[Y_{i1} | M_i = 1] - E[Y_{i0} | M_i = 0] \quad (4)$$

In fact, we have observations on the firms that did not engage in a merger, but if the merged and the non-merged firms systematically differ in their firm characteristics, (4) will be a biased estimator of (3) (Hirano et al, 2002)¹⁷.

Rubin (1997), Rosenbaum and Rubin (1983, 1984) showed that a propensity score analysis of observational data can be used to create groups of treated (merged) and control (non-merged) units that have similar characteristics so that comparisons can be made within these matched groups. The propensity score is defined as the conditional probability of receiving treatment given a set of observed covariates X_i :

$$p(M_i) = \Pr(M_i = 1 | X_i) = E[M_i | X_i] \quad (5)$$

The propensity score is a balancing score, meaning that conditional on the propensity score the distributions of the observed covariates are independent of the binary treatment assignment (Rosenbaum and Rubin, 1983; 1984). In particular, for a specific value of the propensity score, the difference between the characteristics of the means of merged and non-merged firms with that value of the propensity score is an unbiased estimate of the average treatment effect at that propensity score, assuming the conditional independence between treatment assignment and potential outcomes given the observed technological covariates (“strongly ignorable treatment assignment” assumption) (Rosenbaum and Rubin, 1983). In other words, unbiased treatment effect estimates can be obtained when we have controlled for all relevant covariates.

The treatment effect of a merger is then estimated as the expectation of the conditional effects over the distribution of the propensity score in the merged population:

$$\tau |_{M_i=1} = E_{p(M_i)} \left\{ E[Y_{i1} | p(M_i), M_i = 1] - E[Y_{i0} | p(M_i), M_i = 0] | M_i = 1 \right\} \quad (6)$$

When assessing the effect of a merger on innovation performance, we can not expect that given similar background characteristics the treatment (the merger) is randomly assigned. Nevertheless, we can use the propensity score framework to create groups of firms that have the same probabilities to engage in a merger. In these groups, there are firms that have been merged and firms that have not been merged, hence the allocation of the merger can be considered as random inside the groups of firms. The propensity score method therefore controls for selection based on observed firm characteristics.¹⁸

¹⁷ Descriptive data in Table 2 show that merged and non-merged firms in our sample suggest significant differences in the observed characteristics.

¹⁸ If there is selection into mergers based on unobserved characteristics, as it would happen in the context of managerial-decision making in general, the estimate of the impact of a merger may be biased.

We estimated the propensity scores by applying a multinomial logit model from the first stage of our analysis. We include the determinants of technological performance as well as their interaction terms. Using the computed propensity scores, we subclassify the sample into five strata according to propensity score quintiles.¹⁹ Since we are interested in estimating the effect of mergers and because there are fewer merged firms than firms that did not engage in mergers, we create strata based on the estimated propensity scores for merger events, so that each stratum contains an equal number of mergers.²⁰ This ensures an adequate number of mergers in each stratum. To check the adequacy of the propensity score model, some analyses were conducted to assess the covariate balance in the five groups of matched merged and non-merged firms that will be discussed in the next section. After applying propensity score subclassification, we can estimate the effect of a merger on innovation performance by taking the weighted average of the within-strata average differences in performance outcomes between merged and non-merged firms. This is the average treatment effect on the treated referred to in the causal inference literature.

6 Empirical Results

6.1 Technological Determinants of a Merger

In this section, we examine the merger decision of the telecommunications equipment firms in a multivariate analysis. Given that both merging and non-merging firms are included in the sample, we can attempt to distinguish between the characteristics of merging firms in transaction events and the firms outside of merger market. We estimate equation (2) using a multinomial logit model with four outcomes: to be an acquirer, to be acquired, to be a pooling merger, or to be not involved in a merger. There are substantial drawbacks associated with the use of multinomial logit estimation because it assumes that the disturbances are independent across alternatives. This assumption suggests that if a firm was choosing between the four alternatives, then there is no relationship between a firm's disturbance for being an acquirer, a target, a partner in a pooling merger or does not involvement in any merger. The test of the maintained assumption of independence of irrelevant alternatives (IIA) will indicate whether the ratio of the choice probabilities of any two alternatives is entirely unaffected by the systematic utilities of any other alternatives. In context of this analysis, it is likely that merger behavior will not fulfill this requirement. In order to examine how the estimation results are affected by this

¹⁹ Five subclasses (quintiles) constructed from the propensity scores will often suffice to remove over 90% of the selection bias due to each of the covariates (Rosenbaum and Rubin, 1984).

²⁰ In generally, strata boundaries can be based on the values of the propensity scores for both groups combined or for the treated or control group alone (D'Agostino, 1998).

property, four Hausman tests were conducted. The multinomial logit results are compared with those from a binomial logits between the non-merged firms sample and each of the samples of acquiring, acquired and pooling merged firms as well as between acquirer and pooling merger samples. The p -values associated with the resulting test statistics were .88, .93, .76, and .67 respectively, so the null hypotheses are not rejected each, which implies that IIA assumption does not affect the estimates adversely. Furthermore, the results of the binomial logit regressions were almost identical to those of multinomial logit model. This also substantiates that the independence assumption is not a concern of our analysis and we can utilize robust estimates of the variance of the estimated coefficients.²¹

Table 3 presents the marginal effects for the multinomial logit regressions. The statistics for joint hypothesis and likelihood ratio tests are also reported. All estimated models are highly significant as indicated by the likelihood ratio tests of the null hypothesis that the slope coefficients are jointly zero, which are rejected at the 1 percent level using the chi-square test statistic.

Merging firms as a whole seem to have on average a significantly different innovative profile compared to that of non-merging firms. Larger firms, as measured by the book value of total assets, are more likely to engage in merger activity. This suggests that large firms are more willing to make use their large and more stable internal funds to finance external R&D projects. A 100 percent increase in a firm's total assets is associated with a .0026 and .0005 percentage point increase in the likelihood of acquiring another firm and being involved in a pooling merger, respectively, which is a .37 and a 1.67 percent increase in each probabilities.

INSERT TABLE 3 ABOUT HERE

The significant positive effect of cash flow ratio on the likelihood to acquire another firm suggests that acquiring firms have considerable cash to run a larger firm and agency controls are imperfect. This is in accordance with the evidence that possessing the ability to finance a merger tends to precipitate acquisitions. Firms with relatively low cash flow ratio tend not to engage in a merger due to their financial constraints. Thus, either imperfect agency concerns or availability of financing are significant constraints on acquisitions.

We do not find, for the current sample, any statistically significant relation between the variables confirming the growth opportunities of firms, that are growth in market value and

²¹ Of course, alternative models could be equally well used. For instance, the nested logit model would partly overcome the limitation of the multinomial logit model (Greene, 2003). However, we do not specify a nested logit model as it requires that the choices at a given level are mutually exclusive. This is clearly not the case in our study, and we therefore remain with the multinomial logit model.

Tobin's q , and the probability that a firm engaged in a merger. This indicates that a transaction is likely to be financed with cash rather than with equity.

When we take into account the proposed determinants on innovative performance of the firms, then, at first, the merging firms are more likely to have a large accumulated citation-based patent stock. This evidence seems to be in accordance with the theoretical argument that a large stock of accumulated knowledge is essential if the acquirer (or one partner in a pooling merger) is to have the necessary absorptive capacity to identify the appropriate target (or another partner in a pooling merger). The fact that firms with a rather low accumulated knowledge stock are less likely to engage in a merger supports this evidence.

Next, firms with greater R&D and citation-based patent intensities have a greater propensity to undertake acquisitions. These results seem to mutually support the hypothesis that higher levels of relative absorptive capacity and the strengthening of its creation on the part of research-focused firms are necessary for those firms to incorporate and exploit new research into their R&D programs effectively. We also obtain a significantly negative coefficient of the dummy for acquiring firms when R&D expenditure is not reported, which are expected to have zero or low R&D intensity. Therefore, the acquirer are more likely to have non zero R&D input in the year before merger. At the same time, the non-merging firms tend to have more frequent zero R&D intensity than merging firms.

After controlling for R&D and citation-based patent intensities, we find that the likelihood of becoming an acquirer is higher the lower the R&D productivity of firms. Although the acquiring firms experienced higher input and output in R&D, they seem to carry either a low number of patents and/or relatively low-valued patents yield of R&D dollars before acquisitions. As mentioned above, large firms are often argued to have a lower R&D productivity than that of their somewhat smaller rivals as research conducted in most large laboratories is found to generate predominantly minor improvement inventions rather than major new inventions. This result suggests that there exists an enhanced desire to acquire new technology and innovation-related assets driven by declining returns from the exploitation of the firms' existing knowledge base. At this step of the analysis, we are yet cautious about this indication, since the target probability regression provides insignificant results on marginal effects. The lack of preciseness in the target estimation may due to the fact that the probability of being acquired varies a lot among the small sample of target firms. We will come back to this point as some predication regarding the target firms' pre merger performance can be derived indeed from the next step of our analysis.

An interesting result is that firms with a poor accumulated citation-weighted patent stock and, at the same time, presenting higher R&D productivity tend to not engage in a merger. We ascribe these firms to be relative young with significantly new know-how. The negative effect

of firm size on the propensity to stay outside of merger activity seems also to point toward that direction. Moreover, the coefficient estimates of the multinomial logit model, which are not reported here, indicate that acquisition targets possessed a significant large accumulated knowledge stock than the non-merged firms.

Finally, firms that experienced a low R&D output are more likely to be involved in a pooling, suggesting that the lack of innovation is an important driving force behind the merger activity. There is no significant relationship between R&D productivity and the propensity to go through a pooling merger that would confirm this evidence further.

6.2 Post Merger Innovation Performance

The full impact of mergers on the innovation performance takes time and results may not be evident immediately. In order to capture the long-run post merger performance, we examine the impact of a merger in year t on the change in outcomes from $t+1$ to $t+2$, $t+2$ to $t+3$, and $t+3$ to $t+4$.²² The outcomes of firms' innovation performance are defined as the annual growth rates of the innovation determinants, e.g., we analyze the post-merger annual percentage changes of innovation input and output, knowledge stock and research productivity. In order to derive the merger propensity score, we estimated the multinomial logit model of equation (2) with annual percentage changes of the innovation and financials variables used in our first step of analysis as well as their interaction terms. The sample shows a good overlap in the estimated propensities scores for merged and non-merged firms verifying that there are comparable firms that did and did not go into a merger. Since the overlap in the propensity scores also defines the range over which comparisons can be made (Dehejia and Wahba, 1990), data in the region of propensity score overlap were subclassified into five blocks defined by the quintiles of the propensity scores for merged firms. We then used a two-way ANOVA to assess if the propensity score balances each covariate between merged and non-merged groups of firms. Each covariate is regressed on the merger and propensity score stratum indicator and their interaction as factors. The insignificant effects of mergers and insignificant effects of the interaction between propensity score stratum and merger indicators determine that the distributions of the covariates within the subclasses are the same for merged and non-merged firms.²³ The balance in covariates of merged and non-merged firms assures an unbiased estimate of the effect of a merger on the innovation performance (Dehejia and Wahba, 1990).

Table 4 reports our findings on the effects of mergers on innovation performance. The impact of mergers appears to be more concentrated in the first year following a merger. Herein,

²² We cannot compare pre- and post-merger performance of merged firms with the matched sample of non-merging firms over the same time period, because we lack pre-merger accounting data for one component of the merged entity for a significant fraction of our mergers.

²³ Before subclassification, we found using one-way ANOVA significant effects of mergers on more covariates.

stronger results are obtained for our main variables that more strictly explain the firm's innovation performance.

INSERT TABLE 4 ABOUT HERE

First, the annual percentage change of R&D intensity displays a significantly positive sign in all three years following a merger. Hence, according to the our previous result, this indicates that the strong R&D intensity of acquiring firms influences positively the assimilation of external knowledge supplementing in-house R&D effort. Moreover, it suggests that the firms engaged in the mergers did not depreciate their investments in R&D on behalf of financing the transaction.

Next, we find that mergers are followed by an improvement in the accumulated citation-based patent stock. In addition to the partners in a pooling merger that possessed a large accumulated knowledge stock prior a merger, the targets tend also to be firms with high valued patent stock. The result in accordance with our prediction that accumulated knowledge stock confers an ability to recognize the new knowledge in environment and this ability seem to enhance the technological strengths even further.

The merged firms experience a significantly positive impact on the (citation-based) patent intensity compared to those outcome that these firms would have reached if they had not been merged. Due to the fact that the acquiring firms had a higher citation-based patent intensity prior acquisitions, this effect suggests that an intensification of high-valued patents creation relative to the firm's assets base prior an acquisition generates a significant high innovation output of the merged entity. Additionally, the pooling partners that faced some absence of innovation efficiency in terms of the innovation output seem to grow following a merger, potentially because the merger provided access to technological resources that firms lacked.

Furthermore, the insignificant result on the post-merger research productivity suggests that the marginal returns from R&D investments do not change with respect to the innovation output. At the same time, merged and non-merged firms do not differ significantly in their financial characteristics such as cash flow ratio and Tobin's q, at least for the observation period.

Finally, we find a significant increase in the following variables reflecting firms' economic performance. Firstly, there is a firm's size growth effect with respect to the annual percentage changes in total assets as typically expected. Secondly, the positive significant increase in the annual growth of market value on average confirms that, in the first year following mergers, overall returns for shareholders are above those of the non-merged firms with similar characteristics.

7 Conclusions

This paper delivers insights into the desirability of M&A for innovative performance of firms by analyzing the mergers that took place in the international telecommunications equipment industry from the late 1980s until the early 2000s. We provide evidence on strictly complementary as well as mutually supportive results. The overwhelming conclusion that arises from the analysis is that on average mergers realize significant positive changes to the innovation performance of firms following a merger. The post merger changes are in turn driven by both the success in R&D activity and the weakness in internal technological capabilities at acquiring firms prior to a merger.

The findings about the innovation-related characteristics of merging firms have interesting implications for the propositions about the rationale of mergers set out in our theoretical section. According to the absorptive capacity theory (Cohen and Levinthal, 1989; Chesbrough, 2003), firms with a greater R&D intensity and a larger stock of accumulated knowledge have a greater propensity to engage in the technological-related mergers and these underlying higher levels of absorptive capacity convincingly indicate the necessity for the identifying, assimilation, and exploiting targets' technological knowledge. The analysis suggests strong evidence according to which firms with rapid R&D and firms that apply extensively the results of scientific advances to their own R&D results, e.g. inventions, acquire better quality patents.

We find support for the view that firms experiencing decline in internal research productivity or which are more inefficient in inventive output are more likely to engage in an acquisition or a pooling merger, respectively, in an effort to boost their research pipelines. In effect, firms that face greater distress in the effectiveness of patenting activity appear to grow their invention intensity following a merger, possibly because the merger provided a rectified access to appropriate technological resources. Otherwise, however, the primary motivation for patenting may not be directly related to increasing R&D intensity and thereby protecting investment in R&D (Kortum and Lerner, 1998; Hall, 2001). Particularly, the increased (citation-weighted) patent intensity following a merger could stem from technological and managerial improvements. That is, the merged firms had redirected more of their R&D investments toward applied rather than basic research and/or improved their innovation management. Since the mergers have, however, on average, an insignificant effect on research productivity of merged firms, this interpretation is quite tentative. Nevertheless, an increase in the inventive output intensity of merged firms following a merger is suggestive of improvements to the underlying research portfolio since this is a direct measure of a firm's innovation performance.

Furthermore, we find that larger firms with strong internal funds to finance R&D are more likely to acquire and to engage in a pooling merger, whereas the firms absent on these

characteristics are more likely to pursue technology internally. Relying just on in-house R&D, non-merged firms appear to be young and rather small market challengers, which are striving to rival the market establisher with a significant new and/or advanced technology by own. Compared to these firms, the acquired firms seem to be experienced entrepreneurs, which have succeeded in the past in generating larger and high-valued inventions.

In addition, the finding that mergers did not cut the investments in R&D suggests that post-merger R&D effort does not affected by financial resource constraints induced by the integration process.

Moreover, there is evidence that mergers are on average a positive experience for shareholders, at least for some short time span, which appears to be in line with the findings that cash-financed transactions generate superior returns than those financed with equity (Andrade et al, 2001).

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Table 1. Sample Statistics (n = 9,570 firm-years)

Variable Description	Mean	Standard Deviation
R&D Intensity	0.115	0.336
(Citation-weighted) Patent Intensity	0.019	0.097
(Citation-weighted) Patent Stock (Ln)	1.441	1.504
(Citation-weighted) Patent Productivity	0.237	1.194
Total Assets (Ln)	4.001	2.120
Annual Growth of Market Value (Ln)	1.519	3.236
Tobin's Q	2.091	3.259
Cash-Flow Ratio	-0.162	1.460
Indicator for Missing R&D Expenses	0.171	0.376
Indicator for Zero (Citation-weighted) Patent Intensity	0.512	0.500

Notes: The figures refer to the sample used for the estimation of the multinomial logit model (Table 3).

Table 2. Merging versus Non-Merging Firms before Matching

Variables	Mean (Standard Deviation)		t-statistic for difference in means
	Merged Firms	Non-Merged Firms	
R&D Intensity	0.105 (0.005)	0.115 (0.005)	0.48
(Citation-weighted) Patent Intensity	0.014 (0.003)	0.02 (0.001)	0.85
(Citation-weighted) Patent Stock (Ln)	2.327 (0.152)	1.378 (0.029)	8.00***
(Citation-weighted) Patent Productivity	0.214 (0.067)	0.238 (0.024)	0.27
Total Assets (Ln)	5.344 (0.153)	3.914 (0.031)	10.89***
Annual Growth of Market Value (Ln)	1.410 (0.081)	1.611 (0.06)	0.52
Tobin's Q	2.476 (0.158)	2.037 (0.057)	2.01**
Cash-Flow Ratio	0.019 (0.016)	-0.174 (0.023)	2.10**
Indicator for Missing R&D Expenses	0.100 (0.018)	0.175 (0.005)	3.20***
Indicator for Zero (Citation-weighted) Patent Intensity	0.455 (0.030)	0.515 (0.007)	1.90*

Notes: Standard errors are given in parentheses. *** (**, *) difference in sample means is significantly different from zero at the 1% (5%, 10%) statistical level.

Table 3. Marginal Effects of the Propensity of Involvement in M&A Activity

	Acquirer	Target	Pooling Merger	No M&A
R&D Intensity	0.34E-02 ^{***} (0.11E-02)	-0.62E-05 (0.34E-04)	-0.20E-02 (0.13E-02)	-0.13E-02 (0.17E-02)
(Citation-weighted) Patent Intensity	0.76E-05 ^{***} (0.28E-05)	-0.45E-07 (0.17E-06)	-0.39E-05 ^{**} (0.21E-05)	-0.37E-05 (0.35E-05)
(Citation-weighted) Patent Stock (Ln)	0.34E-05 ^{**} (0.16E-05)	0.20E-07 (0.72E-07)	0.35E-05 ^{***} (0.11E-05)	-0.70E-05 ^{***} (0.20E-05)
(Citation-weighted) Patent Productivity	-0.79E-05 ^{***} (0.27E-05)	0.67E-07 (0.23E-06)	0.15E-05 (0.19E-05)	0.62E-05 [*] (0.34E-05)
Total Assets (Ln)	0.26E-02 ^{***} (0.41E-03)	-0.54E-05 (0.15E-04)	0.48E-03 ^{**} (0.19E-03)	-0.31E-02 ^{***} (0.45E-03)
Annual Growth of Market Value (Ln)	-0.78E-06 (0.17E-05)	-0.64E-08 (.28E-07)	0.88E-06 (0.10E-05)	-0.89E-07 (0.20E-05)
Tobin's Q	0.36E-05 (0.25E-05)	0.15E-06 (0.58E-06)	0.82E-06 (0.14E-05)	-0.46E-05 (0.30E-05)
Cash-Flow Ratio	0.17E-04 ^{***} (0.76E-05)	0.53E-05 (0.14E-04)	0.34E-05 (0.27E-05)	-0.26E-04 [*] (0.16E-04)
Indicator for Missing R&D Expenses	-0.44E-02 ^{***} (0.17E-02)	0.16E-04 (0.59E-04)	0.37E-03 (0.11E-02)	0.40E-02 ^{**} (0.21E-02)
Indicator for Zero (Citation-weighted) Patent Intensity	-0.17E-02 (0.14E-02)	-0.10E-04 (0.36E-04)	0.12E-02 (0.84E-03)	0.51E-03 (0.17E-02)
Mean of dependent variable (percentage points)	0.70	0.00	0.30	99.00
Observations	217	25	122	9,206
Log Likelihood	-1350.603			
Restricted Log Likelihood	-1590.544			
Prob > ChiSq	0.000			

Notes: The marginal effects provide percentage point changes in the probability of an outcome. Standard errors are given in parentheses. Marginal effects are computed at means of explanatory variables. *** (**, *) indicate a significance level of 1% (5%, 10%)

Table 4. Effects of M&A (Average Treatment Effects on the Treated)

	<i>First year</i> <i>(t+1 to t+2)</i>	<i>Second year</i> <i>(t+2 to t+3)</i>	<i>Third year</i> <i>(t+3 to t+4)</i>
R&D Intensity	0.139*** (0.045)	0.193*** (0.052)	0.228*** (0.039)
(Citation-weighted) Patent Intensity	0.083*** (0.004)	-0.113 (0.152)	-0.051 (0.436)
(Citation-weighted) Patent Stock (Ln)	0.0046*** (0.017)	0.004 (0.024)	0.018 (0.025)
(Citation-weighted) Patent Productivity	0.816 (0.626)	-0.006 (0.589)	0.238 (0.315)
Total Assets (Ln)	0.052** (0.026)	0.041 (0.026)	0.040 (0.028)
Annual Growth of Market Value (Ln)	0.338*** (0.103)	-0.027 (0.197)	0.124 (0.146)
Tobin's Q	2.500 (2.920)	2.076 (2.053)	1.694 (1.642)
Cash-Flow Ratio	-0.031 (0.874)	1.002 (3.016)	-1.052 (2.096)

Notes: Reported are means. Standard errors are given in parentheses. *** (** , *) indicate a significance level of 1% (5%, 10%)

