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The Role of Technology in M&As: A Firm Level Comparison of Cross-Border and Domestic Deals

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Non-Technical Summary

The decision to engage in merger and acquisitions (M&As) is traditionally seen as endeavor to grow, to exploit economies of scale and scope, to lower industry competition, or to facilitate internal restructuring. Recent studies highlight the importance of M&As to reorganize intra-mural research and development. This paper investigates the importance of technology related motivations for domestic and cross-border M&As in Europe during the 1990s on the firm level: How important are technology related motivations for M&As? In which direction are firms technologically developing through M&As: are they strengthening technological core competencies or entering into new technology markets? Is there a difference between cross-border and domestic mergers with respect to technology related merger motivations?

Using a newly created firm level data set including financial information on merging firms as well as their patent history, we investigate merger formation using a simple structural model. Our results show that patents are not attractive for acquiring firms if there is no technological proximity between the merging partners. If, however, the acquisition target has innovative assets in related technology fields they are of high value to the acquiring firm. Distinguishing between cross-border and domestic M&As under consideration of country differences shows that this result holds only for cross-border M&As. There are different possible explanations for this finding: first, patents in related technology fields may reduce uncertainty and the risk of failure associated with cross-border acquisitions. Second, the result illustrates the international character of technology markets and that firms search globally for attractive technological assets.

The Role of Technology in M&As:

A Firm Level Comparison of Cross-Border and Domestic Deals[1]

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Abstract:

Technological change is often hypothesized as one of the main drivers of merger activities. This paper analyzes the role of technology in mergers and acquisitions (M&As) at the firm level. Based on a newly created data set that combines financial information and patent data for public firms in Europe as well as country level variables, we apply a structural model to investigate technology-related motivations behind merger formation. Distinguishing between cross-border and domestic M&As, we find that technological relatedness of the M&A partners reduces uncertainty and the expected risk of failure associated with cross-border acquisitions significantly, whereas there is no evidence for technological complementarities driving domestic M&As. The relevance of technology for cross-border M&As further illustrates the international character of technology markets.

Keywords: domestic versus cross-border M&As, technological relatedness, market relatedness

JEL-Classification: C25, G34, O32, O34

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1 Introduction

Technological change is often hypothesized as one of the main drivers of merger activities (e.g. Jovanovic and Rousseau, 2004). Technology shocks as drastic shocks to the economic environment change the optimal factor allocation in a market and mergers and acquisitions (M&As) are an important means to reconcile the equilibrium situation (Hall, 1988a, Jovanovic and Rousseau, 2002, 2004). In such restructuring periods, firms take the decision to engage in M&As individually in order to foster growth, to exploit economies of scale and scope, to lower industry competition and for internal restructuring.[2] Recent studies highlight the importance of M&As for reorganizing research and technology (R&D) activities and strategies (Cassiman et al., 2005). This paper investigates the role of technology in domestic and cross-border M&As in Europe during the 1990s on the firm level.

M&As can serve as an effective channel for technological restructuring, on the one hand, or for strengthening technological core competencies, on the other hand. An acquisition can enable firms to gain or regain contact to the research frontier in their field of competence (Kamien, 1992). Furthermore, overlapping research fields can necessitate the ownership of patents to continue research activities (O'Donoghue et al., 1998) and M&As can be made to acquire the patent portfolio of a rival firm (Lerner et al., 2003, Giuri et al., 2006[3]). Hence, firms can strengthen their technological competencies and enlarge or maintain their market position in certain technology fields through M&As.

Contrariwise, firms can use M&As to enter new technology markets. Diversification reduces risk. Moreover, a certain degree of technological diversification is necessary to keep up with rapid technological developments (Granstrand et al., 1997, Cantwell et al., 2004). Technological knowledge in ancillary fields on top of distinctive core competencies enables firms to adopt and integrate technologies developed by external suppliers and competitors. Knowledge in non-core technologies helps firms to understand emerging technological opportunities and to jump onto promising new

[2] While M&A decisions are taken at firm level there are common trends, aims and motivations behind merger waves. Black (2000) surveys the motivations for the US merger waves of the 20th century. Kleinert and Klodt (2002) provide a survey of European merger accumulations of the past century.

technology trends. In the presence of an increasing importance of timing in innovation and fierce technology competition it is not always possible to build up own competencies within a convenient time frame. M&As, in summary, appear as an attractive tool for both, technological restructuring and a strengthening of existing technological competencies.

Empirical evidence on R&D related merger motivations is scarce (Veugelers, 2006). Some studies focus on the impact of the R&D intensity on the likelihood of entering the M&A market. The consensus of those papers is that R&D is a relatively poor predictor of becoming acquisition target (e.g. Hall, 1988a, 1990).[4] Other studies focus on the effect of M&As on the R&D performance of the firms involved. Again, most studies do not find significant changes in the post-merger R&D output (e.g. Hall, 1988a, 1990).[5] Several studies, theoretical as well as empirical contributions, highlight the importance of partner characteristics and their interplay for the production of post-merger technologies (e.g. Seth, 1990, Capron, 1999, Cassiman et al. 2005, Banal-Estanol and Seldeslachts, 2005). There are, however, only a few studies that account for these in empirical analyses. Cassiman et al. (2005) investigate 31 merger cases with respect to changes in R&D activities after the merger. Distinguishing between M&A deals of technologically complementary and substitutive firms they find that efficiency gains and increases in R&D activities are largest for firms with complementary technological assets. For a merger sample that includes small and medium-sized firms in Germany, Hussinger (2005) analyzes the role of technological relatedness for the merger decision. She concludes that firms strengthen technological core competencies through M&As. AlAzzawi (2005) confirms this result in a patent study for US high-tech mergers.

We contribute to the literature by analyzing the importance of technology related merger motivations for large European M&As. The paper provides empirical evidence

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[3] Giuri et al. (2006) find that 20% of the patent applications at the European Patent Office (EPO) are filed to block competitors.

[4] Hall (1990) points, however, out that there is significant heterogeneity of industry sectors for the importance of R&D for M&As. In line with this, some studies on high-tech industries find that R&D is a predictor for M&As. For example, for the US sector for medical devices and photographic equipment Valentini (2004) finds that firms with significant R&D assets are more attractive acquisition targets than others.

[5] Again, there are differences for studies that focus on certain high-tech industries only. Though Valentini (2004) countersigns the weak effect of M&As on R&D outcomes, he finds that M&As significantly change the importance, generality and originality of post-merger patents.

on whether firms strengthen their technological core competencies or whether they use M&As for entering new technology fields. Further, we investigate differences in technology related motivation for cross-border and domestic M&As.

Although there exists already a significant body of research on M&As and some papers on the relationship between M&A and R&D, there is still little evidence on the differences between cross-border and domestic merger deals and the role of R&D for both types of M&As. Cross-border M&As, however, play an increasingly important role in worldwide M&A activity in terms of deal numbers and transaction value (Bertrand et al., 2004, Bertrand and Zuniga, 2006). During the 1990s, a strong increase in the number of high-value cross-border deals was observed with a significant participation of European firms (Sleuwaegen and Valentini, 2006). This occurrence is attributed to reorganization processes within European multinationals and to European integration (Cantwell, 2000), which is referred to as the realization of the "one European market project" (Kleinert and Klodt, 2000, Sleuwaegen and Valentini, 2006). To our knowledge, the only empirical study that explicitly focuses on the difference between cross-border and domestic M&As and their impact on R&D activities is provided by Bertrand and Zuniga (2006).[6] Their industry level analysis confirms significant sector heterogeneity with respect to R&D intensity for the impact of M&As on R&D activities (see also Hall, 1988a, 1990, Roeller et al., 2001) and raise doubts on the fear that foreign takeovers, in general, reduce domestic R&D activities. We are not aware of any firm level study that focuses on the role of R&D for cross-border and domestic M&As.

Previous studies clearly outline the advantages and disadvantages of cross-border M&As vis-à-vis domestic merger deals. A foreign firm can be an attractive acquisition target due to its familiarity with local consumer tastes, rules and the culture of the labor market, effective ways of advertising, the distribution network, government regulations, and market interactions between suppliers, consumers and competitors (e.g. Qiu and Zhou, 2006). However, the acquisition of firms in foreign countries implies a high risk of failure (Harris and Ravenscraft, 1991, Swenson, 1993) and significant asymmetric information (Gioia and Thomson, 2004). Accordingly, cross-border mergers are

[6] A few other studies distinguish between domestic and cross-border M&As (Capron, 1999, Cassiman et al., 2005, Gugler et al., 2003).

supposed to produce higher gains if taking place (Bertrand and Zuniga, 2006). We investigate the determinants of cross-border M&As compared to domestic acquisitions controlling for demand side factors (as the market size of the foreign market) and supply-side factors (as taxes). Our main interest is on the role of R&D for both types of M&A deals: Are cross-border mergers rather technology related than domestic M&As or vice versa? Does technological relatedness or a patent stock, in general, reduce uncertainty associated with cross-border M&As?

Based on a newly created firm level data set including financial information on merging firms, their patent activities as well as macroeconomic country characteristics we investigate merger formation. Concretely, we identify characteristics and assets of the acquired firms that make those firms attractive M&A partners following Hall (1988a). Our model describes the decision to acquire another firm as the outcome of the maximization of the expected net gain from the acquisition. Firms engage in M&As only if the net gain from the acquisition is positive and if the chosen acquisition target generates a larger benefit than the acquisition of any other potential M&A targets. Our empirical analysis uncovers characteristics (such as technological assets and skills or technological proximity to the acquiring firm) that make some firms more attractive for a certain acquirer than others. A criticism of previous studies is that synergy effects associated with a merger or acquisition are often not taken into account although they play an essential role for the acquisition decision (Valentini, 2004). This critique does not apply to the model we use. Our empirical specification accounts, among others, for expected synergy effects of a merger on the technology side (Cassiman et al., 2005, Hussinger, 2005, AlAzzawi, 2005) as well as on the output market side (Capron, 1999, Cassiman et al., 2005).

Our approach has the further advantage of focusing on the expected net gain of the merger rather than relying on the R&D performance in the immediate post-merger years. We argue that this leads to results that do not leave room for ambiguity as does an evaluation of the short-term R&D performance immediately following a merger due to its transitory character and the ambiguous prediction by the theoretical literature.[7]

[7] M&As can lead to avoiding duplicated R&D or to reducing R&D as a consequence of a decline in competition, which would lower R&D, once with a positive and once with a negative connotation. M&As can also increase R&D activities through exploitation of economies of scale and scope or simply because firms conduct duplicated R&D in the immediate post-merger years. This makes it difficult to interpret the

In summary, the contribution of the paper is twofold: First, studies on the relationship between M&A and R&D are scarce (Veugelers, 2006), especially for Europe. We investigate the direction of technological reorganization through M&As answering the question as to whether firms concentrate on technological core competencies or whether they use M&As to broaden the scope of their R&D activities. Second, we reveal the role of technological assets and knowledge for cross-border vis-à-vis domestic M&As. The theoretical as well as the empirical literature on cross-border mergers is still in an early stage and the role of technology therein has yet to be investigated in depth (Bertrand and Zuniga, 2006).

Our results reveal that there are different motivations behind cross-border and domestic M&As. The expected net value of a cross-border acquisition depends crucially on technological relatedness of the M&A partners, whereas this does not apply for domestic M&As. There are two mechanisms that can be responsible for this finding: For one, technological relatedness reduces risk associated with acquisitions abroad. Second, this result indicates the international character of technology markets and that firms are globally searching for the best technology partner.

The paper is organized as follows: the next section gives an overview of related literature. Section three describes the data and shows descriptive statistics. The fourth section presents our empirical approach and the fifth section shows the empirical results. The last section concludes.

2 M&A and R&D

The bone of contention for the early literature on M&A and R&D in the 1970s and 1980s was the fear of negative long-term consequences of M&As on the economy's competitiveness and growth through a decline in R&D investment (e.g. Hall, 1988a).[8]

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outcome of an evaluation of the effects of M&As on short-term R&D performance. Accordingly, some empirical studies find a negative impact of M&As on the post-merger R&D performance (e.g. Hitt et al., 1987, 1990), others found no significant effect (Hall, 1988a), again others found a positive impact on R&D performance (Hall, 1999, Hagedoorn and Duysters, 2000, Arora et al., 2000) for different time periods and industries.

[8] From a corporate governance point of view, cuts in R&D following a merger were regarded as responses to the need to sustain interest payments on long-term debt caused by the merger. In the presence of myopic financial markets, a decline in R&D would reflect short-term planning on part of management. R&D projects that might have been profitable are not realized if the market does not value long-term investments. However, financial markets are found to be not completely myopic with respect to

Theoretical as well as empirical contributions are, however, still limited (Veugelers, 2006).[9] This section reviews the literature on M&As and R&D and discusses studies on cross-border acquisitions.

The standard industrial organization literature identifies a potential market power effect of a merger by means of increasing barriers to entry (Comanor, 1967) and a potential efficiency effect by reducing transaction costs (Williamson, 1975). Those effects can be carried forward to post-merger R&D activities. Merging partners can profit from economies of scale and scope (Cassiman et al., 2005) and the level of spillovers from R&D investment is expected to increase through collaboration (D'Aspermont and Jacquemin, 1988, Arrow, 1962). A merger provides the opportunity to reorganize and integrate both firms' research units (Banal-Estanol and Seldeslachts, 2005). Duplicated research efforts can be avoided (Veugelers, 2006). The arising positive effects on R&D intensity are found to be stronger in case of complementary technological assets (Ahuja and Katila, 2001, Cassiman et al., 2005). The market power effect of a merger counteracts the positive efficiency effects for R&D through a decrease in technological competition and a reduction in the incentives to innovate (Arrow, 1962, Reinganum, 1983). From an organizational point of view, M&As can also have a negative impact on R&D because the implementation of a merger, which can be seen as a jump in firm size, may not only absorb financial but also managerial capacities (Arrow, 1964, Caves, 1989).

The empirical findings on the impact of M&As on R&D activities are mixed. However, most studies do not find significant changes in the R&D performance (see Veugelers, 2006). Another handful of papers investigates the importance of R&D for entering the acquisition market either as an acquisition target or as an acquiring firm (see Veugelers, 2006, or Valentini, 2004). Most of those studies focus either on the target or on the acquiring firm and ignore expected synergy effects of a merger, which are essential to explaining merger formation (Valentini, 2004). The findings of these studies are mixed.

R&D (Hall, 1990) and a decline in R&D is not necessarily bad. In the presence of efficient financial markets where managers act in the shareholder's interest and long-term debt provides managerial discipline, a decline in R&D following a merger would be privately optimal.

[9] Veugelers (2006) provides a literature survey on M&A and R&D. See Roeller et al. (2001) and Mueller (1997) for surveys on M&As covering studies on the effects of mergers on profitability, efficiency and shareholder value.

However, most studies find that R&D is a weak predictor of entering the M&A market. Exceptions are papers that focus on high-tech sectors (e.g. Valentini, 2004, AlAzzawi, 2005).

The further brief review goes on to focus on studies that take the interplay between targets' and acquirers' assets and characteristics into account when analyzing of merger formation. In her seminal study on the relationship between M&As and R&D, Hall (1988a) uses a structural model describing the choice of the acquisition partner. She finds that small firms with a low R&D intensity, which are located in non-science based industries, are likely to become acquisition targets. In Hall's follow-up paper (1999) covering the broader period 1976-1995, acquisition targets turn out to not differ much in terms of R&D expenditure from firms that leave the market or become public. Firms with no R&D activities are less likely to be subject to an acquisition. In the US sector for medical devices and photographic equipment in the period 1988-1996, R&D intensity is a significant driver of acquiring another firm (Valentini, 2004). Valentini (2004) uses a "double matching approach" to model the selectivity of both acquisition targets and acquiring firms. Analyzing the decision of whether to acquire a certain target, Hall (1988a) finds that acquiring firms value the R&D activities of their targets higher than the market does and that acquisitions, where both partners have a high R&D intensity, generate larger gains. Following Hall's (1988a), Hussinger (2005) investigates the choice of the acquisition target for a sample of domestic M&As in Germany, which includes small and medium-sized firms. In addition to knowledge capital she takes the technology relatedness of the merging firms into account. Hussinger (2005) concludes that technological proximity besides output market relatedness is the most important determinant of the decision with whom to merge. She concludes that target firms' patents are of no importance to the acquiring firm if they are not in related technology fields. AlAzzawi (2005) comes to the same conclusions based on a patent data analysis for large US high-tech M&As.

There is very limited literature on cross-border mergers, especially when looking for empirical evidence. Cross-border mergers imply a higher risk of failure (Harris and Ravenscraft, 1991, Swenson, 1993) and higher asymmetric information (Gioia and Thomson, 2004) than domestic M&As. However, there are various incentives to engage in cross-border acquisitions: a domestic firm is attractive to a foreign acquirer due to its familiarity with local consumer tastes, rules and the culture of the labor market, effective ways of advertising, the distribution network, government regulations and market interactions between suppliers, consumers and competing firms (e.g. Qiu and Zhou, 2006). Besides efficiency gains, a cross-border merger could also be undertaken to exploit foreign technological capabilities and knowledge assets (Neary, 2004, Kuemmerle, 1999). To compensate for relatively high uncertainty cross-border mergers should generate larger expected gains than domestic M&As if taking place (Bertrand and Zuniga, 2006). Bertrand and Zuniga (2006) empirically investigate the difference between cross-border and domestic mergers in OECD countries with respect to private R&D investment on the industry level. They find different results with respect to the technology intensity of the industry. Domestic M&As increase R&D activities in low-tech sectors, whereas they have the contrary effect on R&D activities in medium-tech sectors. Cross-border mergers, on the other hand, stimulate R&D activities in medium-tech sectors. Bertrand and Zuniga (2006) conclude that mainly the targets' countries profit from cross-border M&As.

This paper contributes to the existing literature by analyzing whether mergers are technology driven. We exploit the direction of technological restructuring through M&As by analyzing whether innovative M&A partners are active in similar technology fields or whether they use M&As to enter new technology areas. Further, we distinguish between domestic and cross-border M&As investigating whether technology plays a different role for both merger groups. Our findings help to better understand the determinants that reduce uncertainty and raise the net gain of cross-border M&As.

3 Data Description and Descriptive Statistics

Our main source of data is the SDC Global Mergers and Acquisitions database of Thomson Financial, which provides information on worldwide announced M&As valued at 1$ million or more. Thomson collects information on M&As and financial assets of the firms involved using a variety of sources such as financial newspapers, Reuters Textline, the Wall Street Journal, Dow Jones and others (see Gugler et al., 2003). Our sample includes the major European countries (EU 15 plus Norway and Switzerland). We linked the Thomson data to the Amadeus firm data to fill in missing information on total and intangible assets. Both databases are commercial products. The Amadeus database is provided by Bureau van Dijk and contains financial information about private and publicly owned firms in Europe.

In order to obtain information on innovative activities of the merging firms, we linked the firm data to the patent database of the European Patent Office (EPO) that contains every patent application since EPO foundation in 1977. The patent data contains names and addresses of the patent applicants as well as details on the patent itself such as the application date and the technology classes a patent matches according to the International Patent Classification (IPC). The Thomson and EPO databases (as well as the Thomson and Amadeus data) were linked based on the firm names and address information (street, zip code, city and country) provided by each database. We used a computer supported text-based search algorithm to establish the link between the different databases. Each potential match proposed by the program was checked manually.

We restrict the final sample to public firms only as the Thomson merger database does not guarantee a complete listing of private firms involved in M&As. A second reason for using public firms only is that our empirical model is based on a market value equation and, hence, requires financial information that is often not available for private firms. Large firms are responsible for the major fraction of patent applications. Giuri et al (2006) find that 70% of the EPO patents are filed by large firms.

We also have to restrict the sample to the period 1994-2000 since we do not have access to Amadeus firm data for earlier years. The Amadeus data is used to construct a control group, which is necessary for our econometric analysis (see next section for details).

The final sample consists of 422 M&A deals, where both M&A partners are public firms. Table 1 shows the descriptive statistics. There is a considerable size difference between acquiring and target firms. In terms of total assets, buying firms are, on average, three times as large as acquisition targets. The average difference in the intangible assets[10] to capital assets ratio of both firm groups is, in contrast, relatively

[10] Intangible Assets are defined according to Thomson SDC Platinum: Value of assets having no physical existence, yet having substantial value to the firm, including goodwill, patents, trademarks, copyrights, franchises and costs in excess of net book value of businesses acquired, as of the date of the most recent financial information prior to the announcement of the transaction.

small. A significant part of the mergers 59% (36%, 26%) occur between firms located in the same industry on a two- (three-, four-) digit SIC level. The share of cross-border mergers in our sample is 38%.

23% of the merger deals involve innovative firms, i.e. firms that applied for an EPO patent at least once. We exploit the patent information to measure technological proximity of the merging firms. Technological relatedness is proxied by the uncentered correlation measure introduced to the patent literature by Jaffe (1986). This measure is based on the patent stocks of each firm in different technology fields:

$$PS_{it} = PS_{i,t-1}(1-\delta) + patent\_applications_{it} \,. \tag{1}$$

The constant depreciation rate of knowledge δ is set to 0.15 as common in the literature (e.g. Hall, 1990). Based on the Fraunhofer patent classification, we distinguish 30 patent stocks per firm in 30 different technology classes of acquiring firms $i, F_i = (PS_{i1}, PS_{i2}, ..., PS_{i30})$, and acquisition targets j, $F_j = (PS_{j1}, PS_{j2}, ..., PS_{j30})$. Taken together, those patent stocks describe the firm's technology portfolio *F*. In order to abstract from the size of the patent portfolio and in order to account for the considerable skewness of the patent stocks, we measure them as percentages of the total patent stock.

Technological proximity of acquiring and target firm is now calculated as:

$$T_{ij} = \frac{F_i' F_j}{\sqrt{(F_i' F_i)(F_j' F_j)}} \,. \tag{2}$$

T_{ij} takes values between zero (geometrically, the vectors are rectangular) and one (the vectors span an angle of zero degree), where one corresponds to a 100% overlap of the technology fields in which merging partners are active. Table 1 shows that acquiring firms have a significantly larger average patent stock than acquisition targets. On average, the overlap of the patent portfolios is described by a 10 degree angle. For innovative M&A partners only, we find an average technology overlap of a 46 degree angle.

Table 1: Summary Statistics

		Acquiring Firms (422 observations)	Target Firms (422 observations)
Total assets	Mean (std. dev.)	7,213.33 (16,466.12)	1,761.96 (4,735.63)
Intangible assets over capital assets*100	Mean (std. dev.)	4.49 (8.86)	3.05 (9.07)
Patent stock	Mean (std. dev.)	132.41 (772.41)	20.46 (15.14)
Both firms have patents	Mean	.23	
Same Industry Two-digit SIC	Mean	.60	
Same Industry Three-digit SIC	Mean	.37	
Same Industry Four-digit SIC	Mean	.27	
Technological proximity	Mean	.11	
Technological proximity (patenting firms only)	Mean	.48	
Cross-border	Mean	.38	

All financial variables are measured in Mio US $ and are of the most recent date available prior to the announcement of the transaction.

Standard deviations for dummy variables equal $\sqrt{mean \cdot (1 - mean)}$.

In addition to firm and patent characteristics, we use macroeconomic variables to account for country differences in the formation of cross-border mergers. We use information on GDP (in current prices), average unit labor costs in the manufacturing sector, general expenses on R&D over GDP, a measure for openness of the economy defined as the sum of exports and import volume over GDP,[11] top statutory tax rates on corporate income[12], stock market capitalization as the value of listed shares to GDP and private credit by deposit money banks and other financial institutions over GDP[13]. The country variables are used in relative terms to map comparative advantages of the target's over the acquirer's location.

4 Empirical Model

The empirical model is based on the market value approach (Griliches, 1981) and follows Hall (1988a). M&As are viewed as restructuring activities that occur in response to external shocks (e.g. Jovanovic and Rousseau, 2004, Hall, 1988a). Through such shocks the productivity of assets might become suboptimal in their current use. It is assumed that the optimal configuration of corporate assets changes each year due to external shocks to the economic environment. M&As act as a means of reorganization towards a new equilibrium.

Firms are defined in a hedonic way as bundles of their assets and characteristics X. The value of a firm V is a function of X. In the presence of efficient markets and full information, $V(X_i)$ equals the price at which i's asset bundle is traded. However, acquisitions take place at a significant positive premium over pre-announcement stock value (Jensen and Ruback, 1983) indicating that some agents place a higher value on a firm's assets bundle X_i than the market.

It is further assumed that an acquiring firm j can acquire any other firm i. If acquisition occurs, the increment to the value of firm j is $V_j(X_i)$. Thus, j acquires i, if j 's net gain

[11] This data is taken from the OECD.
[12] Tax information is taken from the European Commission (2005). For Switzerland, Norway and Greece, tax data is provided by the Cato Institute (Chris Edwards).
[13] The latter two indicators are taken from the Database on Financial Development and Structure of the Worldbank. Both indicators are deflated.

from the acquisition of *i* is positive and larger than the net gain from a merger with any other potential target *k*:

$$\begin{aligned} &V_j(X_i) - P_i > 0 \\ &V_j(X_i) - P_i > V_j(X_k) - P_k, \ \forall\, k \in C. \end{aligned} \tag{3}$$

P_j denotes the price of *i*'s assets and *C* refers to the entire pool of firms. The acquiring firm *j* is assumed to act as a bidder. A new bid above the current trading price occurs because *j* has revealed new information about the value of *i*'s assets.

An advantage of the model is that prices are treated as endogenous, which reflects the fact that a certain target has a different value for different potential acquirers. The price at which firms evaluate the purchase is assumed to be an unobservable function of the target firm's characteristics $V(X_i)$. Separating *j*'s net profit from the acquisition into observable and unobservable components yields the estimation equation:

$$V_j(X_i) - P = f(X_i, X_j) + \varepsilon_{ij}, \tag{4}$$

where the value function *f* is specified as the difference between the valuation of the acquiring firm v_j and the equilibrium price *v*:

$$f(X_i, X_j) = (v_j(X_i) - v(X_i)), \tag{5}$$

where small letters correspond to the observable components of *V* and V_j. The value function $f(X_i, X_j)$ is specified as follows including the characteristics of acquirer and target firm as well as the distance between them in characteristics space:

$$v_j(X_i) - \mathrm{v}(X_i) = b_1 X_j + b_2 X_i + b_3 \left| X_j - X_i \right|. \tag{6}$$

The model describes the acquisition decision from the acquiring firm’s point of view. The vector of characteristics *X* includes total assets, intangible assets, industry controls and, for cross-border deals, country controls. In addition, the patent stocks of acquisition targets and the overlap of the firms’ technology portfolio is used to control for the effect of technological relatedness of the merging partners.[14]

There are two problems for the implementation of the estimation model: first, according to the model, an acquiring firm can choose the acquisition target from a huge pool of

[14] Assets and characteristics of the acquiring firm cancel out through the econometric implementation of the model.

possible acquisition targets including every (public) firm in Europe. This huge choice set causes technical problems for the estimation. For this reason, a set of alternative targets is chosen as a random subsample of the unchosen alternatives as proposed by McFadden (1978). For our application, we draw thirty alternative targets[15] for each year from a sample of public firms in Europe, which is taken from the Amadeus data base.[16] M&A firms that were involved in a merger in that same year are excluded from the pool of potential acquisition targets. The final data set contains the actual target as well as thirty alternative targets for each M&A deal.

The second problem is the choice of the estimator. The model could be estimated using a conditional logit model if the error terms ε_{ij} were assumed to be independent and homoscedastic. A conditional logit model, however, requires independence of irrelevant alternatives (IIA), i.e. that the relative odds ratios between any two outcomes are independent from the number and nature of other alternatives being simultaneously considered. In the present context, the IIA would imply that an additional firm in the pool of possible acquisition target would not influence the actual choice of the M&A partner. It is obvious that the IIA assumption is not appealing for describing merger behavior. Hausman tests approve that the IIA assumption is also not valid for our sample from a statistical point of view.[17] Hence, we proceed with a more flexible model. A straightforward way to relax the assumptions of the conditional logit model is to allow for (a certain degree of) heteroscedasticity. To do so, we group the choice set of possible acquisition targets into subgroups and allow the variance to differ across those nests. This leads us to a nested logit model specification (see e.g. Hensher, 1986 and Greene, 2003). The idea is that acquisition targets in the same nest share a common set of features for which the acquiring firms are supposed to have correlated preferences. Thus, we allow for correlation across the alternatives within a nest, which displays their

[15] Hall (1988b) investigates how the number of alternatives in the control group affects the outcome in a conditional logit setting. She finds that an increase in the number of observations from 7 to 50 leads to an efficiency gain of about thirty percent based on a comparison of the standard errors.

[16] As the number of public firms per country provided by the Amadeus database does not match the official statistics we restrict our sampling routine to randomly draw a percentage of firms from every country that corresponds to the official percentage of public firms a country has relative to the total number of public firms in Europe. The official numbers are taken from the German Central Bank.

[17] The tests are performed as follows: we estimated the conditional logit model for our random sample of thirty alternative acquisition targets and re-estimated the same model for a sample that contained only part of the alternatives. The Hausman test on the null hypothesis that the estimated coefficients of both models do not differ systematically was rejected for various subsamples of different size.

dependency. For L different subgroups denoted by l the nested logit probability for firm j acquiring firm i is the product of the probability that j chooses nest l, to which i belongs, and the probability that i is chosen given that nest l is chosen:

$$P(j \text{ buys } i \,|\, C) = P(j \text{ buys } i \,|\, l) \cdot P(j \text{ buys a firm in nest } l)$$

$$= \frac{\exp(f(X_i, X_j \,|\, l))}{\sum_i \exp(X_i, X_j \,|\, l)} \cdot \frac{\exp(f(Z_l))}{\sum_l \exp(f(Z_l))} \cdot \frac{\sum_i f(X_i, X_j \,|\, l) \cdot \sum_l f(Z_l)}{\sum_l \sum_i f(X_i, X_j \,|\, l) \cdot f(Z_l))}, \quad (7)$$

where Z is a vector of nest-specific variables. We define two nests: one covers M&A deals of two firms in the same two-digit SIC industry (horizontal M&As) and a second nest contains firms that merge with a partner in a different industry (vertical M&As). We suspect that our rough definition of horizontal and vertical M&As identifies two groups of firms that share unobservable common features among each other but not with the other group.[18] Z contains variables that describe the choice of a certain target within a nest, i.e. target specific variables, choice-specific variables and country-specific variables.

Rewriting the nested logit probability (7) yields an expression illustrating the relationship between the conditional and the nested logit model (Greene, 2003):

$$P(j \text{ buys } i \,|\, C) = \frac{\exp(f(X_i, X_j \,|\, l))}{\sum_i \exp(X_i, X_j \,|\, l)} \cdot \frac{\exp(f(Z_l) + \tau_l I_l)}{\sum_l \exp(f(Z_l) + \tau_l I_l)}, \quad (8)$$

where $$I_l = \ln \sum_i \exp(f(X_i, X_j \,|\, l)) \quad (9)$$

is the inclusive value for the lth nest. τ_l is a measure for the dissimilarity within a nest and is negatively related to the correlation coefficient ($\tau_l=(1-\rho_l)^{0.5}$). If τ_l equals one there is no heteroscedasticity, the IIA holds and a homoscedastic conditional logit can be applied. If τ_l is smaller than one, the model incorporates some degree of heteroscedasticity mapping correlated preferences of firms within nests. In order to be consistent with random utility maximization, the estimated parameters τ_l have to lie between zero and one. An estimated parameter τ_l in this range reflects a trade-off

[18] A more narrow definition of the nests is not possible as it leads to one large nest containing the vast majority of the observations and a second nest with very few firms only. The estimation results approve our assumption that there are correlated preferences for firms in each nest.

between different alternatives in one nest i.e. that if a firm in the nest is chosen it is unlikely that there is a second equally attractive firm in the same nest. A value of τ_l larger than one (smaller than zero) would indicate that the choice of a firm in a nest would make the other firms in that nest more (less) attractive.

5 Estimation Results

The estimated model describes the acquisition decision for a certain target from the acquiring firm's perspective conditional on having made the acquisition. The coefficients describe how the target's assets and characteristics affect the probability of being acquired under the assumption that the actual choice maximizes the expected net profit from the acquisition. Interaction terms of the acquirer's and target's characteristics and distances in between their characteristics map expected synergy effects from the merger. They reveal why certain targets are attractive for certain acquiring firms and why acquiring firms value certain targets higher than the market.

For the reasons explained in the previous section, we apply a nested logit model, where the nests are defined as horizontal and vertical mergers. We use a two-step procedure to estimate the model.[19] In a first step, the choice of the actual target within the nest is estimated (lower level estimation). The inclusive values are calculated based on these results. In the second step, the choice of the nest is estimated (upper level estimation). The test of our hypotheses of interest is incorporated in the lower level estimation; however, the estimation of the upper level decision is obligatory in order to check whether the estimated inclusive values are in line with the random utility maximization.

Table 2 presents the estimation results for the lower level regression. The results show the determinants of a certain firm being chosen as acquisition partner within the nests. The first column presents the results for the horizontal merger nest, i.e. M&As between firms that are active in the same two-digit SIC sector. The results for the vertical merger nest are presented in the second column. The third and fourth columns show the result for a second model specification.

[19] The two-step estimation approach has the advantage of being less sensitive to misspecification and easier to implement than the full maximum likelihood model. This comes at the cost that the two-step approach is not efficient.

The estimated coefficients are quite robust for different specifications. There are differences in the size of some coefficients across the nests. However, the 95% confidence intervals (not presented here) largely overlap so that we can conclude that the differences are not different from each other at any convenient level of statistical significance.

The results for firm size show that the probability of becoming acquired decreases with increasing size difference of target and acquirer, measured as the log difference in total assets (`diff logA`). This is in line with Hall's (1988a) finding for public mergers in the US. It is explained by the fact that the sample, as with Hall's (1988) sample, contains only large firms that exceed a size threshold of $1 million. Hussinger (2005) finds the opposite result for her sample of German M&As, which includes small and medium-sized M&A firms. The estimated effect of target firm size differs from Hall's (1988a) findings. Our results show that the probability of becoming an acquisition target increases with firm size (`logA`), whereas Hall (1988a) finds a negative relationship. The estimated coefficient is, however, plausible as it is in line with the fact that the burst of mergers in the 1990s was accompanied by an increasing value of the individual deals (Sleuwaegen and Valentini, 2006). Kleinert and Klodt (2000) refer to the 1990s as a period of 'mega mergers' in Europe. In addition, the positive relationship between firm size and the probability of becoming acquired can reflect better refinancing conditions of larger firms, which make an acquisition more feasible and more attractive. The target's intangible to total assets ratio (`I/A`) and the distance in the intangibles assets to total assets ratio between acquirer and target (`diff I/A`) does not have a significant effect.

Table 2: Nested Logit Estimation of Acquisition Choice – Results for the Lower Level Decision

Conditional logit estimation for the choice of the target within the nest

	Model I		Model II	
	Horizontal M&As	Vertical M&As	Horizontal M&As	Vertical M&As
	Coefficient std.err.	**Coefficient** std.err.	**Coefficient** std.err.	**Coefficient** std.err.
diff logA	**-2.10*** **	**-0.58*** **	**-2.14*** **	**-0.59*** **
	0.68	0.13	0.71	0.13
diff (I/A)	**8.59**	**0.45**	**9.40**	**0.48**
	10.26	2.88	10.33	2.90
logA	**0.88*** **	**0.64*** **	**0.87*** **	**0.63*** **
	0.29	0.12	0.29	0.12
I/A	**-6.91**	**-0.74**	**-4.79**	**-0.75**
	10.08	2.64	10.38	2.66
Same industry	**0.19**		**0.26**	
(3dgt)	0.91		0.94	
Same industry	**5.21*** **		**5.24*** **	
(4dgt)	1.79		1.81	
Sales dummy	**0.01**	**0.61***	**-0.05**	**0.59***
	0.72	0.32	0.72	0.33
Patent stock/100	**-0.01*** **	**-0.03*** **	**-0.01*** **	**-0.02*** **
	0.00	0.01	0.00	0.01
Cross-border dummy	**-5.60*** **	**-2.41*** **	**-5.61*** **	**-2.44*** **
	1.74	0.34	1.81	0.35
Tech. proximity	**5.90*** **	**7.73*** **		
	2.36	1.68		
Tech. proximity			**5.88*** **	**7.90*** **
crossborder			2.46	1.68
Tech. proximity			**19.40**	**5.31**
domestic			24.65	3.95
Relative ULC	**5.11**	**0.24**	**5.43**	**0.16**
	4.22	1.34	4.25	1.36
Relative R&D per GDP	**-2.59** **	**-0.84** **	**-2.87** **	**-0.84** **
	1.26	0.39	1.43	0.40
Relative GDP	**0.37** **	**0.02**	**0.36*** **	**0.02**
	0.15	0.06	0.15	0.06
Relative tax	**-7.65*** **	**-4.21*** **	**-7.63*** **	**-4.23*** **
	2.78	0.80	2.80	0.81
Relative openness	**-3.82*** **	**-3.29*** **	**-3.87*** **	**-3.30*** **
	1.49	0.54	1.53	0.54
Relative credit	**-0.78**	**-0.81**	**0.05**	**-0.81**
	2.70	0.52	3.01	0.52
Relative market cap	**0.99**	**0.30***	**0.90**	**0.29***
	0.64	0.16	0.65	0.16
LR chi2	369.59	808.97	369.95	809.47
Log L	-20.92	-167.72	-20.74	-167.47
observations	626	4.999	626	4.999

All variables, which are not interaction terms or relative measures, map the characteristics of the **target** firms.
The financial variables are measured in US$ million and are of the most recent date available prior to the announcement of the transaction.
***, **, * indicate statistical significance at the 1%, 5%, 10% level.

Focusing on the horizontal merger nest, the importance of output market relatedness is quite articulate as firms within the same four-digit SIC industry have a higher probability of being acquired than potential targets within the same two- or three-digit SIC sector. The finding that output-market relatedness is important for merger formation is in line with previous empirical findings (e.g. Hall, 1988a, Cassiman et al. 2005, Hussinger, 2005). The fact that there is no significant difference between the two- and three-digit SIC industry indicates that firms define output market relatedness very narrowly.

We further control for the size of the target firm's output-market relative to the acquiring firm's output market size using a dummy variable that equals one if the target's sales exceed 5% of the acquiring firm's sales. This variable has no significant or weakly significant impact on the target choice.

We now focus on our main variables capturing technological assets, technological restructuring, and cross-border merger activities. The results from the first specification suggest that the expected net gain from a merger increases with technological proximity.[20] It further turns out that a patent stock per se does not increase the attractiveness of a potential acquisition target. On the contrary, the larger the patent stock, the smaller the probability of becoming acquired. This finding is in line with Hall (1988a), who focuses on the R&D intensity to measure innovative assets and finds a negative relationship. One possible explanation is the relatively high price for firms with large patent stocks. The net value of an acquisition of a patent intensive firm is, hence, likely to be relatively low compared to the net value for firms with few or no patents. Our results show that acquiring firms decide to invest in such firms only if the technological assets of those firms are related to their own fields of activities. This provides acquirers the possibility of directly profiting from the technological assets by strengthening their technological competencies, benefiting from economies of scale and scope in technology and internalizing spillovers. This is supposed to be most successful in the case of similar technology portfolios as both firms have the necessary specific

[20] We tested for a non-linear relationship, but couldn't find evidence for an inversely U-shaped relationship between technological relatedness and the probability of becoming acquisition target as Ahuja and Katila (2001) report for the relationship between technological relatedness and patenting activities.

absorptive capacity to use the acquired knowledge. Moreover, a target firm active in the same technology field can be attractive as the acquiring firm can gain access to important intellectual property rights, which can be necessary to continue research on a certain technology or to gain/regain contact to the research frontier through M&A.

For cross-border deals, the results show that those are less likely to occur than domestic M&As. The major part of the acquiring firms, therefore, does not engage in M&A activities in order to enter new geographical markets or in order to stabilize existing relationships with a foreign country. Cross-border mergers are associated with a higher degree of uncertainty and a higher risk of failure than domestic M&As as the previous literature points out. Furthermore, engagement in foreign countries means that it is to cope with differences in culture, language, institutions and capital markets. The country-specific variables account for some of these differences. They show that cross-border M&As are less likely to occur if the target firm is located in a relatively R&D intensive country compared to the target firm's location. Hence, we do not find evidence for firms accessing high-technology countries through M&As (e.g. Driffield et al., 2006). Our finding is rather in line with the argument that firms siphon off profits from their advances in technology in less technology intense countries (e.g. Dunning, 1988).[21] With respect to country size, target firms in large countries appear to be more attractive than others for horizontal M&As. There is no effect for vertical acquisitions. This shows that the size of the acquired foreign market matters for M&As between firms serving the same output market. This fits the hypothesis that the 1990s were characterized by the realization of the "one market project" in Europe. As expected, the attractiveness of a target firm decreases when it is located in a country with relatively high tax rates. Also, the relative openness of the target's country decreases the probability of an acquisition in that country. Those markets can be served more easily by exports than less open economies. Market capitalization has a weak impact for vertical M&As showing that markets with a high degree of market capitalization are easier to access than others. There is no effect for the relative unit labor costs, which can be explained by the fact

[21] Dunning (1988) argues that home country advances in infrastructure enable ownership advantages through mobile endowments as for example knowledge or intermediate products that firms can exploit in less technology intense countries.

that our country sample is relatively homogeneous in this respect. Furthermore, private credit opportunities do not impact the merger decision.[22]

The second specification investigates whether there are differences in the importance of technological proximity as merger motivation for domestic and cross-border M&As. Instead of using one measure for technological proximity, we disentangle the effect of technological proximity for both merger types using one technological proximity variable for cross-border mergers and a second one for domestic M&As. The estimated coefficients and standard errors are presented in the third and fourth column of Table 2. The results reveal that technological proximity plays an important role for the decision to merge with a foreign firm, whereas there is no effect for domestic mergers. This interesting finding can have two explanations: first, technological relatedness may reduce uncertainty and the higher risk of failure associated with cross-border mergers so that they are no longer riskier than domestic acquisitions; second, this hints at the international character of technology markets. Our finding is in line with the hypothesis that many cross-border deals are technologically motivated.

The finding that national M&As seem to have no technological motivation among large firms might indicate that domestic M&As are used to strengthen output market competencies in the first place. Further, national acquisitions are subject to national competition authorities that investigate whether the national post-merger product market share is compatible with national merger guidelines. It could be the case that technologically motivated domestic M&As involving large firms in related product markets do not take place because firms anticipate that the post-merger national product market share would exceed the legal national threshold. This argument comes into play as our sample covers large firms only. For a sample of domestic M&As in Germany that includes small and medium-sized firms Hussinger (2005) finds that small firms with related patent portfolios are very attractive targets for domestic acquisitions.

Technology related M&As might also fail to appear because of rivalries of local firm so that the firms would never agree to an M&A.

[22] Di Giovanni (2005) applies a gravity model to isolate the factors that affect cross border M&A. In particular, the relevance of financial markets is found: Thereby, the stock market capitalization of the acquirer countries shows up to be more important than the credit volume of the private sector.

The focus of our analysis is on the choice of the acquisition target within the individual nests (lower level decision). To complete the analysis we conclude this section with a discussion of the estimation results for the upper decision level. We estimate the choice of the nest from the acquirer's perspective depending on its characteristics. Table 3 presents the results of the logit estimation on the decision to acquire a firm in the same two-digit industry for both model specifications. The inclusive value, calculated based on (9), enters the estimation as an additional regressor. The coefficients of the inclusive value are statistically significant and between zero and one. A Wald test shows that the nullhypothesis of homoscedasticity (coefficient equals one) can be rejected on the 1% level of statistical significance for both model specifications. Hence, our estimations are consistent with the concept of random utility maximization on which our model is based. Those tests confirm the chosen nest structure of the logit model and provide further evidence that the IIA is not valid in the present setup.

With respect to the characteristics of the acquiring firms, it turns out that there is a negative relationship between the ratio of intangible assets to total assets and the likelihood of choosing an acquisition target in the same two-digit industry sector. From a transaction cost point of view, firms with more intangible assets are more likely to acquire another firm in order to minimize transaction costs (Bloningen, 2005). Our finding shows that there is heterogeneity among acquiring firms also in the sense that firms with a high quota intangible assets are more interested in avoiding transaction costs on the vertical level. In line with this result, we find that firms located in R&D intense countries are less likely to engage in horizontal M&As.[23]

There is no evidence for a shift towards horizontal or vertical integration through M&As over time as the insignificant year dummies indicate.

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[23] We also tested whether the further country-level variables have a significant impact. A t-test on joint significance rejected the null hypothesis ($X^2(6)$=5.03 for model I, $X^2(6)$=10.57 for model II).

Table 3: Nested Logit Estimation of Acquisition Choice – Results for the Upper Level Decision

Logit estimation for the choice of the horizontal merger nest

	Model I	Model II
	Coefficient std.err.	**Coefficient** std.err.
iv	**0.122***** 0.039	**0.064***** 0.020
I/A	**-0.032***** 0.012	**-0.032***** 0.012
logA	**-0.019** 0.055	**-0.019** 0.055
Patent stock	**0.000** 0.000	**0.000** 0.000
Labor productivity	**0.001** 0.003	**0.001** 0.003
R&D intensity of country	**-0.314**** 0.154	**-0.314**** 0.154
1994	**-0.105** 0.373	**-0.105** 0.373
1995	**-0.594** 0.442	**-0.594** 0.442
1996	**-0.645** 0.427	**-0.645** 0.427
1997	**0.031** 0.425	**0.031** 0.425
1998	**-0.425*** 0.348	**-0.425*** 0.348
1999	**-0.429** 0.331	**-0.429** 0.331
2000	**0.122** 0.039	**0.064** 0.020
Wald test on homoscedasticity: H_0: coeff.(iv) = 1	X^2=694.73***	X^2=2,739.73***
Log L	-276.05	-276.04
observations	422	422

All variables map characteristics of the **acquiring** firm.
The financial variables are measured in US$ million and are of the most recent date available prior to the announcement of the transaction.
***, **, * indicate statistical significance at the 1%, 5%, 10% level.

6 Conclusion

It is often argued that merger activities are driven by technological change. Technology shocks change the optimal factor allocation in a market and M&As are an efficient means to reconciling the equilibrium situation. This paper investigates the importance of technology behind European M&As in the 1990s. Distinguishing between cross-border and domestic acquisitions we detect important differences in technology related motivations behind both types of M&As.

We apply a nested logit model to a newly created data set of European firms involved in M&As that combines financial data with the firms' patent activities in order to reveal whether technology assets and relatedness of the technology portfolios make an acquisition target attractive for the actual acquirer. Our estimation results yield some interesting insights that help to understand the role of technologies in M&As. The first result is that the patent stock of an acquisition target is not per se attractive to potential acquirers if the patented knowledge is not related to the acquirer's technology portfolio. Firms with a large patent stock are relatively more expensive than comparable firms without technological assets. If, however, the acquisition target has innovative assets in related technology fields we find that those are of high value to the acquiring firm. A merger with a target company active in related technology fields might be associated with lower uncertainty than other deals. Further, in case of similar technology portfolios acquiring firms can directly profit from the acquisition target's technological assets as those strengthen already existing technological core competencies and support the internalization of spillovers. This is expected to be most successful if both firms have the necessary specific absorptive capacity. Moreover, a target active in the same technology field can be attractive if the acquiring firm gains access to important intellectual property rights or if it enables firms to gain or regain contact to the research frontier through M&As. However, distinguishing between cross-border and domestic M&As shows that these results for the importance of technological relatedness holds only for cross-border M&As. There is no empirical evidence for domestic M&As being driven by technological motivations.

In general, domestic firms are preferred over foreign acquisition targets. This result is in line with the previous literature, which argues that cross-border mergers are associated with a higher uncertainty and a higher risk of failure. Our empirical results, however, show that technological relatedness increases the expected net gain of foreign acquisitions significantly. This result can be interpreted twofold: first, technological relatedness reduces uncertainty associated with cross-border acquisitions; second, firms that aim at strengthening their position in technology competition do so beyond national borders. The relevance of technology for cross-border M&As, hence, illustrates the international character of technology markets.

The finding that the attractiveness of national M&As is not affected by technological relatedness might indicate that domestic M&As are used to strengthen output market competencies in the first place. As our sample contains large firms only it might also be the case that national acquisitions are less attractive because they are subject to national competition authorities. It could be the case that technologically motivated domestic M&As involving large firms in related product markets do not take place because firms anticipate that the post-merger national product market share would exceed the legal national threshold. A further explanation might be that technology related M&As might fail to appear because of product market rivalries of local firms so that the firms would never agree to an M&A. It might also be the case that simply there is no technologically attractive M&A partner in the domestic market.

It should be kept in mind that our results hold for large M&A partners, where we cannot capture the fact that large firms screen the market, especially the local markets, for small high-tech companies.

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