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The Impact of Cross-Border Mergers and Acquisitions on the Acquirers' R&D – Firm-Level Evidence

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Abstract:

This paper provides empirical evidence on the relationship between cross-border acquisitions and innovation activities of the acquirer. For the empirical analysis a unique firm-level data set is constructed that combines survey data for German firms with a merger and acquisition database. After a cross-border acquisition, investing firms display a higher rate of domestic expenditures for research and development. Controlling for endogeneity of foreign acquisitions by estimating a two-equation system with limited dependent variables and applying instrumental variable techniques it is found that part of this correlation stems from a causal effect. The estimated effects are robust towards alternative identification strategies and are higher in industries with high knowledge intensity. The analysis is complemented by an investigation of the effects on tangible investment spending and by a comparison of the effects of cross-border acquisitions to those of greenfield foreign direct investments and domestic acquisitions.

Keywords: **Multinational Enterprises, Mergers and Acquisitions, Innovation**

JEL Classification: D21, F23, G34, C31, O31, O33

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1. Introduction

Foreign direct investment (FDI) flows have increased all over the world over the past decades to reach a volume of more than US \$ 1.6 trillion in 2011. Much of this increase can be attributed to the rising number of cross-border mergers and acquisitions (M&As).² From the home countries' perspective, cross-border M&As can on the one hand enable market access and the transfer of knowledge from abroad which may strengthen domestic technological capabilities. On the other hand, there might be negative effects if domestic activities are replaced with similar investments abroad. From the host countries' perspective, many policy makers try to prevent foreign takeovers of domestic firm, especially in knowledge intensive industries.³ The global effects of mutual restrictions on cross-border M&As depend on the effects on both the acquirer and the target firm. Thus, it is important to complement existing knowledge on the effects on innovation in target firms with empirical evidence on the investing firms.

Cross-border acquisitions constitute the main form of FDI in industries with a high R&D intensity (UNCTAD, 2007). The effects of international M&As on R&D have important policy implications since innovative activity is regarded as a key factor to spur productivity and growth. Existing empirical evidence on the effects of cross-border M&As is mostly limited to target firms, while little is known about the effects on the acquiring firms.⁴

Only recently, cross-border acquisitions as a type of FDI started to receive more attention in the international trade literature. Recent theoretical contributions analyze the role of firm heterogeneity and different motives that determine the choice of foreign market entry modes (Nocke and Yeaple, 2007; Norbäck and Persson, 2007). These models argue that international M&As are mainly driven by the desire to acquire complementary assets and technology while greenfield investments (new firms or production units founded by foreign investors) do not provide direct access to foreign knowledge and are rather undertaken to exploit existing firm-specific assets of the acquiring firm or factor price differences across countries. If complementarities between acquiring and target firm play a role for cross-border acquisitions and these involve innovative activities it is likely that the effects on domestic R&D are quite different from those of

² http://unctadstat.unctad.org/ReportFolders/reportFolders.aspx?sRF_ActivePath=P.5.27&sRF_Expanded=.P.5.27

³ One example is the announced acquisition of the Spanish energy company Endesa by the German energy provider E.ON in the year 2006 that was blocked by the Spanish government. Similarly, in 2005, the French government decided to impose restrictions on foreign acquisitions in several strategically important industries with high knowledge intensity like information systems and biotechnology.

⁴ The effects of cross-border M&As on *target firms* have received considerable attention with respect to productivity (Benfratello and Sembenelli, 2006; Arnold and Javorcik, 2009) and employment (Almeida, 2007). Recently, particular attention has been paid to the effects of foreign acquisitions on innovation activity (Bertrand, 2009; Bertrand et al., 2012; Guadalupe et al., 2012; Stiebale and Reize, 2011).

greenfield investments. Hence, it is not possible to derive conclusions about the effects of cross-border M&As from existing studies on greenfield investments or aggregate FDI.

It is also likely that the effects of international acquisitions are different from those of domestic transactions since previous research argues that the motives and characteristics of cross-border M&As are different (see Shimizu et al., 2004, for instance). Theory suggests that the characteristics of firms that self-select into international acquisitions are quite different from those that engage in domestic acquisitions (see e.g. Nocke and Yeaple, 2008). Market access – for instance via access to existing networks or market specific knowledge like marketing capabilities – might be a more important motive for international than for domestic M&As (see e.g. Nocke and Yeaple, 2008; Guadalupe et al., 2012; Blonigen et al., 2012). Improved market access from the perspective of the acquiring firm may increase the incentives to invest in cost reducing or quality enhancing innovations as these can be applied to a larger production output. Further, as efficiency differences within an industry are likely to be more pronounced across than within countries (Neary, 2007) it is likely that foreign and domestic acquisition targets have different characteristics. This may result in different feedback effects on the investing firm as well.

The purpose of this paper is to investigate the impact of cross-border acquisitions on R&D activities of the investing firm. This paper contributes to the existing literature in several aspects. First, empirical evidence on the effects of international acquisitions on innovation activities of the acquirer is sparse.⁵ Further, I contribute to the industrial organization and the international economics literature by comparing the effects of cross-border acquisitions to those of domestic acquisitions and greenfield foreign direct investments. Heterogeneous effects according to industries and target countries with different characteristics are provided. For this purpose a unique firm-level data set is constructed that combines survey data for German firms with balance sheet data and an M&A database. The case of Germany is in particular interesting as it is one of the most technologically advanced countries in the world and is considerably engaged in FDI and global M&As.

The empirical framework accounts for unobserved firm heterogeneity and the possible endogeneity of cross-border acquisitions. The main results are based on a non-linear two-equation model in which the decision to engage in an international acquisition as well as the decision of how much to spend on R&D is explained simultaneously. Identification is achieved by exploiting

⁵ Bertrand and Zuniga (2006) analyze effects of domestic and international M&As on R&D at the industry level. Firm-level studies that analyze differences between effects of domestic and international acquisitions on the acquirers' innovation include Desyllas and Hughes (2010), Cloudt et al. (2006) and Ahuja and Katila (2001), although analyzing effects of cross-border M&As is not at the core of their analysis.

unexpected shocks to foreign market growth rates and variation in the distance to foreign markets across firms. The robustness of the results towards alternative empirical models and identifying assumptions is checked.

This paper is organized as follows. In section 2, I summarize the related literature. Section 3 describes the empirical model and section 4 provides a description of the data. Results of the empirical analysis are presented in section 5, section 6 concludes.

2. Cross-border acquisitions and R&D

This paper is related to several strands of theoretical and empirical literature that look at M&As from the perspective of industrial organization (IO) economics, strategic management, or corporate finance.⁶ As the M&A literature often does not distinguish explicitly between cross-border and domestic acquisitions or between effects on acquiring firms and acquisition targets it is worth taking a look at the literature on international trade and FDI as well. Cross-border acquisition can affect the investing firm's innovation activities through a variety of channels. First, there might be direct effects via relocation of R&D activities. Second, acquisitions may have an impact on other determinants of R&D that have been identified in the theoretical and empirical innovation literature such as a firm's size, market share, competition, technological opportunities, external knowledge sources, market demand, and financial factors (see, for instance, Cohen and Levine, 1989 or Hall and Mairesse, 2006 for an overview on the determinants of R&D).

The main motives for M&As within the IO literature are the strengthening of market power (Kamien and Zang, 1990) and the realization of efficiency gains (Röller et al., 2001). The effects on market power and efficiency also belong to the main channels through which M&As can affect R&D. M&As might be undertaken to gain access to target firms' assets such as production capabilities or intangible assets (e.g. Jovanovic and Rousseau, 2008). Efficiency gains after an acquisition may, for instance, stem from the diffusion of know-how within the merged entity (Röller et al., 2001) or the reallocation of technology to more efficient uses (Jovanovic and Rousseau, 2008). Synergies resulting from M&As might entail an increase in the efficiency of R&D which might increase the incentives to innovate.

Regarding the strategic aspect, a reduction in competition has a theoretically ambiguous effect on innovation incentives. This effect depends on market characteristics, the type of innovation, and

⁶ The literature on cross-border M&As from the perspective of the management literature is surveyed in Shimizu et al. (2004).

the degree of R&D spillovers (see, for instance, Gilbert, 2006; Vives, 2008; Schmutzler, 2010 for a recent discussion). Reduced competition will increase a firm's residual demand – and thus the output to which cost reductions or quality improvements can be applied – but at the same time it tends to decrease the elasticity of demand and thus the impact of price reductions. However, if a merger solely reduces the number of firms in a market, it is likely that this induces a positive effect on innovation incentives (Vives, 2008). Further, the internalization of technology spillovers that have previously been captured by competitors can also increase the incentives for R&D (Kamien et al., 1992). Gilbert and Newbury (1982) argue that firms with monopoly power have additional incentives to engage in R&D due to the possibility of preemptive patenting.

Acquisitions that are motivated by strategic reasons also play a role in the international economics literature (e.g. Neary, 2007; Horn and Persson, 2001). Cost differences between firms might be more pronounced across than within countries and this may increase the incentives for cross-border M&As (Bjorvatn, 2004; Neary, 2007; Bertrand and Zitouna, 2006). In Neary (2007), for instance, cross-border acquisitions are accompanied by a reallocation of production from less efficient acquisition targets to more efficient foreign investors. If M&As are primarily motivated by efficiency differences between firms across countries we would expect an increase in economic activity in acquiring firms at the expense of target firms.⁷

The impact of cross-border acquisitions on R&D in acquiring firms can be different from the effects on efficiency and the scale of production. Acquirers might relocate R&D facilities from target firms to the corporate headquarter, but keep production sites running (or vice versa). Many firms tend to cluster their R&D activities close to their headquarter or their main corporate production unit due to the aim of managers to keep track of these activities (Howell, 1984). Sanna-Raddacio and Veugelers (2007) show in a theoretical model that centralizing R&D in the home country increases the appropriability of the results of R&D efforts as it prevents knowledge spillovers to foreign competitors in the host country. Centralizing R&D may also avoid costs of coordination and may allow a multinational enterprise to exploit economies of scale in R&D (Kumar 2001). Hence, it is well possible that relocation effects for R&D are more pronounced than for production activities.

Cross-border acquisitions are a mode of FDI and thus might in addition be motivated by differences in production costs across countries, the desire to enter foreign markets, or the access to country specific assets.⁸ In most theoretical trade models incorporating firm heterogeneity,

⁷ Stiebale and Trax (2011) provide evidence that acquirers' domestic sales and employment tend to increase after international M&As.

⁸ See Helpman (2006) for an overview on the theoretical literature on firms and FDI choices.

market access is the most important motive for FDI (for instance, Helpman et al., 2004). This type of market-seeking FDI is usually referred to as horizontal investment. Horizontal FDI might reduce domestic production if it comes along with a substitution of exports. Contrarily, FDI might spur headquarter activities such as marketing activities and R&D as these investments can be applied to a larger production output after a foreign investment (Fors and Svensson, 2002). This might in turn increase growth in the acquirers' home country. Vertical FDI in analogy to Head and Ries (2003) is motivated by differences in factor costs across countries.

However, the motives for cross-border M&As might be quite different from greenfield investments (even in a monopolistic competition framework where they are not driven by strategic aspects). Theoretical trade models with heterogeneous firms that differentiate between the modes of foreign market entry usually argue that greenfield investments are chosen for FDI motivated by production cost differences (Nocke and Yeaple, 2007, 2008). In contrast, these models argue that cross-border M&As are aimed to achieve access to complementary firm-specific assets of acquisition targets (Nocke and Yeaple, 2008), country-specific assets (Norbäck and Persson, 2007), export networks (Blonigen et al., 2012), or capabilities that are non-mobile across countries (Nocke and Yeaple, 2007).⁹ If the exploitation of complementary assets entails innovation activities this might increase the returns to these activities and thus spur R&D expenditures.

There are, however, also counterarguments regarding the effects of international M&As on acquiring firms' R&D. Cross-border acquisitions might come along with a substitution of domestic by foreign activities. There might also be a reduction of duplicate R&D activities after a merger if the overlap between the research projects of acquirer and target firm is large (Veugelers, 2006). Further, M&As may lead to a reduction in the competition in technology markets which may reduce the incentives of merging firms to engage in R&D activities further (Arrow, 1962). There are also some counterarguments which can be derived from the financial economics and the management literature. M&As are often financed with a high amount of debt which might raise the costs for raising external funds for R&D and there is empirical evidence that especially after a leveraged buyout targets display declining expenditures for capital (Kaplan, 1989) and R&D (Long and Ravenscraft, 1993). Further, M&As might also arise out of a manager's utility maximization (Shleifer and Vishny, 1988) who wants a large empire under control and conducts

⁹There are several further possible motives for cross-border acquisitions. In a model of Head and Ries (2008), cross-border acquisitions arise due to the possibility to shift ownership to a more efficient usage. Cross-border acquisitions (and FDI in general) may also be motivated by building an export platform in a tariff free block such as the European Union (Neary, 2002). Cross-border and domestic acquisitions may also involve vertical integration. However, while cross-border M&As often take place across industries they are rarely associated with input-output linkages (e.g., Hijzen et al., 2008).

M&As at the expense of other investment projects including R&D activities. Finally, M&As might reduce R&D due to increased organizational complexity and tighter financial controls (Hitt et al., 1991; Hitt and Hoskisson, 1990) or due to a disruption of established routines (Ahuja and Katila, 2001).

Hence, from a theoretical point of view the relationship between foreign acquisitions and acquirers' R&D is unclear and thus boils down to an empirical matter. Empirical studies that deal with the effects of domestic M&As (or do not explicitly differentiate between domestic and international M&As) find in the majority negative effects (Cassiman et al., 2005). But the results seem to depend on product and technology market characteristics. Cassiman et al. (2005) argue that the impact of M&As on R&D in the merged entity depends on technological and market relatedness between acquirer and target. They suggest that M&As between rival firms lead to an overall reduction of R&D efforts, while they predict the opposite when the merged entities are technologically complementary. Studies that deal with the effects on innovation activities in foreign acquisition targets have so far yielded mixed results. For instance, Guadalupe et al. (2012) and Bertrand (2009) find positive effects of foreign acquisitions on innovation, while Stiebale and Reize (2011) find large negative effects once endogeneity and selection bias is taken into account, and Bertrand and Zuniga (2006) find no significant effect on average but some positive effects in industries with a medium technological intensity. Existing empirical studies that analyze the impact of cross-border acquisitions on innovation activities at the firm level are mostly limited to the evidence on the impact on target firms.¹⁰ Marin and Alvarez (2009) find that acquisitions undertaken by foreign owned firms in Spain have a negative impact on the acquirers' innovation activities, in contrast to acquisitions by domestically owned firms, but they do not analyze the impact of cross-border acquisitions. Ahuja and Katila (2001) as well as Clodt et al. (2006) analyze differences in a sample of merging firms according to cultural distance between acquirer and target firm. Desyllas and Hughes (2010) find that cross-border M&As have a more pronounced negative effect on the acquirer's R&D intensity than domestic M&As.

3. Empirical strategy

Two main problems have to be addressed in the empirical analysis. First, structural zeros arise because a lot of firms report zero R&D expenditures. Second, endogeneity might arise from the fact that unobserved factors influencing R&D might also be correlated with a foreign acquisition.

¹⁰ A detailed discussion about studies that analyze the relationship between foreign ownership and innovation can be found in Stiebale and Reize (2011).

Thus, a model that accounts for both structural zeros and endogeneity is specified to evaluate the impact of international acquisitions on the acquirer's innovation.

To evaluate the effect of outward cross-border acquisitions on domestic R&D expenditures, a two-equation model is specified:

$$(1) RD_{it}^* = x_{it}'\beta_1 + \delta IMA_{it} + \varepsilon_{it}$$

$$(2) IMA_{it}^* = x_{it}'\beta_2 + z_{it}'\gamma + u_{it}$$

$$IMA_{it} = \begin{cases} 1, & IMA_{it}^* > 0 \\ 0, & \text{else} \end{cases}$$

$$RD_{it} = \max(RD_{it}^*, 0)$$

The error terms of the two equations are assumed to be jointly normally distributed:

$$\begin{pmatrix} \varepsilon_{it} \\ u_{it} \end{pmatrix} \sim N_{(2)}\left(\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} \sigma_\varepsilon & \rho\sigma_\varepsilon \\ \rho\sigma_\varepsilon & 1 \end{pmatrix}\right)$$

where the variance of u_{it} is normalized to one for identification.

RD_{it} denotes the domestic R&D to sales ratio, multiplied by 100, of firm i in period t . IMA_{it} is a dummy variable that takes the value of one if a firm acquired a target in an international M&A between $t-2$ and t . An acquisition is defined as an increase in the ownership share from below to above 50% of equity - either directly or indirectly through a parent or a holding company.

x_{it} is a vector of firm- and industry-level variables that enters both equations. It contains variables that are usually used in innovation studies which are likely to affect both R&D expenditures and international acquisitions.¹¹ A firm's age is measured in years and serves as a proxy for experience and the stage of the product life cycle. Firm size enters the equations as the logarithm of the number of employees. Human capital intensity is approximated by the share of employees with a university degree. Capital intensity controls for past accumulation of tangible assets. The ability to raise equity for financing investment is captured by a dummy variable that takes the value of one if the firm has financed part of its tangible investment by equity. Further, a dummy variable for incorporated enterprises is added to the model that captures differences in corporate governance and the ability to raise external finance. A dummy variable for Eastern Germany accounts for the transition process and regional differences. The model also includes a control variable for foreign

¹¹ See e.g. Cohen and Levine (1989) and Hall and Mairesse (2006) for an overview on empirical innovation studies.

ownership. Two dummy variables take the value of one if a firm cooperates with other firms or public scientific institutions, respectively.¹²

Further, x_{it} contains several variables that account for the competitive environment and market conditions. The firm's lagged domestic market share captures the potential to spread the gain from new or improved products and processes over production output. This variable also accounts for the selection of larger and more productive firms into foreign markets. The domestic market growth rate - measured at the two-digit level - controls for time-varying changes in market size at the industry level.

To account for changes in competition, a further variable measures the net entry rate on the domestic market (see Aghion et al., 2009 for an analysis on the effect of entry on innovation). It is also controlled for a firm's main regional market by a set of dummy variables that take the value of one if a firm's main market is international, national, or regional, respectively (for instance, Aw et al., 2007, 2008 analyze the role of exporting for R&D). Industry dummies at the two-digit level control for time invariant product and market characteristics and time dummies capture macroeconomic shocks.

z_{it} includes variables that are assumed to affect the propensity to engage in a cross-border acquisition but not domestic R&D expenditures. These variables are discussed in detail below.

Endogeneity of IMA_{it} , in the two equation model, stems from a non-zero correlation between the two error terms ($\rho \neq 0$). A prerequisite for logical consistency is that a recursive structure is imposed, i.e. RD_{it} does not appear in equation (2) (see e.g. Maddala, 1983). This prerequisite is met in the chosen specification and seems reasonable, as an acquisition in the past on current R&D expenditures is evaluated. The model does not contain firm-fixed effects. The reason is that introducing fixed effects in non-linear models leads to inconsistent estimates of all parameters.¹³

Estimation is carried out by full maximum likelihood. Full maximum likelihood is more demanding than a two-step control function approach as it requires specifying a joint distribution of the equation system, but it assures most efficient estimation if the model is correctly specified.¹⁴

¹² The survey questions underlying these variables refer to cooperation with firms and institutions in general and not to cooperation on R&D as in CIS innovation surveys. Hence they do not imply but might affect R&D activities.

¹³ A further problem is that many firms in the data set only appear at most twice in the sample. However, some regressions in first differences and with controls for lagged values of the dependent variable on a reduced sample are presented to convey an impression about the importance of time-invariant unobserved firm heterogeneity.

¹⁴ Estimation was carried out in Stata®, version 10.1. The likelihood function of this model and the program code for estimation are available from the author upon request. Alternative models such as the instrumental variable Tobit model developed by Smith and Blundell (1986) are not applicable as they do not allow for discrete endogenous regressors. Similarly, the fractional response estimators suggested by Papke and Wooldridge (2008) cannot deal with

The robustness of the results towards the distributional assumptions is checked by using a linear instrumental variable estimator. Standard errors are clustered as some firms appear more than once in the sample. Irrespective of the estimation procedure, it is necessary for identification that there is at least one valid exclusion restriction, i.e. a variable that affects the probability to engage in a cross-border acquisition but not domestic R&D expenditures. In the context of the two equation model, this is a variable that enters z_{it} but not x_{it} .¹⁵

Two exclusion restrictions are used in the empirical analysis. Score tests are computed to test the joint and individual validity of the two exclusion restrictions, and the results of these tests support the model's identifying assumptions. The first instrumental variable is the distance to foreign markets which is measured as the minimum distance to Western European countries. This variable captures the well known proximity-concentration tradeoff (see e.g. Brainard, 1997): In models of horizontal FDI, firms face a trade-off between exporting on the one hand and producing locally via FDI on the other hand. The former requires them to pay higher transport costs of the goods shipped to the foreign market, but exporters can benefit from concentrating production and thereby achieving scale economies. FDI, in contrast, involves paying higher sunk and fixed costs for the affiliate abroad but lower transport costs due to the proximity to consumers.¹⁶

For this instrument to be valid, it is crucial that omitted regional factors, that are correlated with distance to foreign markets, do not affect R&D expenditures. I argue that most of the systematic differences in innovativeness across regions are captured by the control variables, i.e. variables in x_{it} , like industry dummies, external knowledge sources, and other firm- and industry-level variables. One might be concerned that firms choose a certain location because they plan to engage in cross-border acquisitions. However, only a few firms change their location after foundation, and the average firm age at the time of acquisition is more than 35 years in our sample. Hence, it seems unlikely that M&As affect the location choice of firms.

binary endogenous regressors as well. Abadie (2003) proposes a semi-parametric estimator, but this estimator requires that there is a binary instrument variable available which is not the case in this application. Angrist (2001) proposes to use two-stage least squares, but this method is only consistent for censored outcome variables in special cases. Nonetheless, the robustness of the main results to using two stage least squares is checked in section 5.3.

¹⁵ Due to nonlinearity the model is identified even without exclusion restrictions, but the results are not very reliable in this case as they critically hinge on distributional and functional form assumptions.

¹⁶ Nonetheless, the relationship between cross-border acquisitions and geographic distance is not unambiguous as this variable might capture other influences like cultural distance or vertical relations. Hijzen et al. (2008) find a negative relation between cross-border M&As and distance, measured at the industry-country level, which is more pronounced for non-horizontal M&As. However, a positive correlation between a firm's distance to the border and foreign acquisitions does not rule out a negative correlation between M&As and distance on a macroeconomic level. Firms may be induced to engage in cross-border acquisitions as opposed to serve a foreign market via exports by distance, but they may (conditional on this choice) choose a close-by target firm to minimize trade and transaction costs.

The second exclusion restriction is based on market growth in Western EU countries (excluding Germany). This measure is defined at the two-digit industry level of a firm's main activity. Western European countries attract the highest share of Germany's outward M&A activities, and more than 50% of all M&As occur within two-digit industries. Thus, this variable is likely to account for a lot of variation in international acquisitions. This instrumental variable captures the motive of cross-border acquisitions to enter new markets. An increase in foreign growth rates might spur outward M&As for different reasons. First, higher foreign growth implies a larger foreign market, and market size is usually seen as one of the major determinants of FDI (see, for instance, Blonigen, 2005). Further, current foreign growth rates might convey information about future growth rates.

However, firms might anticipate foreign growth, and hence, might adjust domestic and foreign investment in advance. Therefore, I use two alternative measures of *unexpected* growth. The first measure is calculated as the residual from a regression of market growth on a linear trend which is calculated separately for each two-digit industry. The second measure is calculated as the residual from regressing foreign market growth at the industry level on its own lag (similar to the measure used by Desai et al., 2009 at the country level). These measures are based on the assumption that firms base their expectations about future growth rates on past realizations of growth.

For this variable to be a valid instrument, it is crucial that foreign growth rates only affect domestic R&D via international acquisitions. In general, a larger (domestic or foreign) market can spur R&D expenditures. However, foreign growth should affect domestic R&D expenditures only if a firm has access to the relevant foreign market. This market access can, for instance, be achieved through cross-border M&As. Foreign growth would be an invalid instrument if it is correlated with foreign market entry, foreign demand, or competitive pressure in case this is not picked up by the control variables. Therefore, I checked the robustness of the estimates towards adding the growth of exports and imports at the industry level to both equations and towards introducing a firm-specific measure of greenfield FDI. I further checked the robustness of the results towards controlling for technological distance – measured as differences between domestic and foreign labor productivity at the industry level - which may be correlated with shocks to foreign market size and the opportunities to catch up with technological leaders (Aghion et al., 2009).

4. Data and descriptive statistics

To construct the data set used in this paper several different data sources had to be merged. Data on R&D and most control variables is extracted from an annually repeated survey, the “KfW-

Mittelstandspanel”, which is representative for German firms with up to 500 million € annual sales. This survey is conducted by “KfW Bankengruppe” in Germany.¹⁷ The “KfW-Mittelstandspanel” includes information on firms’ investment and innovation activities as well as firm characteristics, such as the number of employees and sales for the current and previous years, share of skilled employees, industry, and financial indicators. Regarding qualitative innovation indicators, firms are asked whether they performed innovation activities and whether they performed own R&D activities. More specifically, they are asked whether they were engaged in continuous or occasional R&D activities in the last 3 years. As a quantitative innovation indicator they are asked to provide the ratio of R&D expenditures to sales. Further innovation indicators are successful product and process innovations and whether these innovations were new to the market. Firms are asked explicitly to answer the questions on the level of the affiliate if the firm is part of a group. Hence, the data allows identifying *domestic* R&D. For the empirical analysis, I use the waves for the years 2002 to 2007. The different waves contain between 10,000 and 15,000 observations, corresponding to a response rate between 15% and 21%.

Data on cross-border and domestic M&As is extracted from the ZEPHYR data base compiled by Bureau van Dijk. ZEPHYR includes data on M&As, initial public offerings (IPOs), joint ventures and private equity transactions and provides information about the date and the value of a deal, the source of financing as well as a description of the type of transaction, and the firms involved in the deal. Compared to other M&A data sources like Thompson Financial Securities data, the ZEPHYR database has the advantage that there is no minimum deal value for a transaction to be included in the data set. Comparing aggregate statistics derived from own calculations using the ZEPHYR database with those from Thompson financial data reported in Brakman et al. (2006), shows that the coverage of transactions with a deal value above US\$ 10 million is very similar.¹⁸

The third data set used is the AMADEUS database, which provides information on financial data as well as ownership and subsidiary information for European firms, including more than 1.000.000 German firms.¹⁹ Ownership information includes the country of origin, the type of shareholder (private investor, bank, industrial company etc.) and the percentage of equity held by each shareholder. I merged different updates of the database to consider changes in ownership and

¹⁷ For a detailed description and an analysis of the representativeness of the data set see Reize (2004).

¹⁸ Calculations are available from the author upon request.

¹⁹ AMADEUS is provided by Bureau van Dijk and Creditreform in Germany. AMADEUS updates 170, 160, 146, 136, 124, 113, 100 and 88 are used. The AMADEUS database has been used in numerous empirical studies on FDI, most of them measuring productivity and employment effects (see e.g. Budd et al. 2005, Konings and Murphy 2006, Helpman et al. 2004). Although AMADEUS contains information about foreign subsidiaries, this data base does not allow for a distinction between greenfield FDI and cross-border acquisitions in many cases. Hence, the ZEPHYR database is used in addition as well.

a broader sample of firms to identify acquirers in cross-border acquisitions. Data from AMADEUS is used to identify greenfield investments and existing linkages between firms and their shareholders and subsidiaries. A firm's greenfield investments in every year are identified as foreign subsidiaries which were not owned by the firm in the previous year and have not been identified as acquisition targets by the ZEPHYR database. All firm-level variables besides M&As and greenfield investments are constructed from the survey data, although the AMADEUS data base is used to fill some missing values on sales and employment. AMADEUS firms are merged with the transaction data from ZEPHYR and with the observations from the “KfW-Mittelstandspanel” by a common firm identifier resulting in 16,179 observations. The full sample contains 389 cross-border acquisitions and 324 firms with at least one previous cross-border transaction. The reduced sample used in some alternative specifications includes 140 firms with at least one cross-border deal. Finally, to construct regressors at the industry level, data from Eurostat and the OECD STAN database is used.

5. Results

5.1 Basic results

Table 1 shows some summary statistics for firms that engage in cross-border acquisitions compared to other firms. It also includes a description of all variables that are used in the econometric analysis. The average R&D intensity of firms conducting cross-border M&As is more than 4 times higher than the R&D intensity of other firms. Table 2 shows that this is true conditional and unconditional on a positive amount of R&D spending and within knowledge-intensive and other industries.²⁰ Other characteristics that are positively correlated with innovation like market share, human capital, tangible capital intensity, and firm size are also on average higher in these firms. The share of foreign acquisitions is considerably above average within R&D intensive manufacturing industries and knowledge intensive services. This is line with stylized facts from the FDI literature – multinational enterprises are larger, more productive, and more innovative than national firms, and they operate more often in high-tech sectors.

<Table 1 about here>

<Table 2 about here>

²⁰ R&D intensity of acquiring firms is about four times higher compared to other firms across all industries but only about three times higher within high-tech and within low-tech industries. This is due to the fact that the share of firms that operates in high tech industries is higher among acquirers than among other firms (see Table 1).

Table 3A shows the distribution of cross-border acquisitions across target countries and regions which are classified according to countries' technological development (see European Commission, 2011). The majority of acquisitions take place in developed countries and in countries with a high level of technological development like the USA, Switzerland, and the UK. This observation is in line with previous empirical evidence and with trade theoretical models. These models argue that most cross-border M&As take place between countries with similar characteristics, while FDI that is motivated by production cost differences is more likely to be conducted via greenfield investment than via cross-border M&A (see, for instance, Nocke and Yeaple, 2008). The distribution of deals across industries is depicted in Table 3B. Cross-border acquisitions are dispersed across industries, but a high share of acquisitions takes place in knowledge intensive manufacturing industries like chemicals, machinery, and transport equipment.

<Table 3A about here>

<Table 3B about here>

Table 4 shows the estimation results from simple regression models. In Panel A, results from cross-sectional Tobit regressions are shown. Column (1) displays regression results that control only for market structure variables and for a few basic exogenous firm characteristics: age and two dummies for location and legal form. Accounting for these control variables reduces the correlation between R&D intensity and cross-border acquisitions - displayed in Table 2 - substantially but still leaves a statistically significant marginal effect of 2.4 base points.

<Table 4 about here>

From column (2), it can be seen that conditional on all control variables and conditional on engaging in R&D, the R&D to sales ratio of firms that engaged in cross-border acquisitions is 1.5% points higher than that of firms without an acquisition. These correlations might appear small at first glance, but the impression changes if we compare these differences to the average R&D intensity in the estimation sample (see Table 2). 1.5 percentage points is more than 17% of the average R&D to sales ratio of all firms that engage in R&D.²¹ The estimation results for the control variables are mostly in line with expectations. Market power, human capital, tangible capital intensity, equity finance, and domestic market growth are positively associated with R&D expenditures. Younger firms, incorporated firms, and firms that are engaged in global markets spend on average more on R&D. The same is true for firms that have access to external knowledge sources by cooperating with other firms or scientific institutions. Firm size is not significantly correlated with R&D intensity which is in line with other empirical studies (see e.g. Cohen and

²¹ The estimated unconditional marginal effects (not reported in the table to save space) were equal to 2.735 for the parsimonious specification and 1.529 for the specification with the full set of control variables.

Levine, 1989). The correlation between foreign ownership and R&D is insignificant. However, this measure includes acquired firms and firms founded by greenfield entry.

Regressions shown in column (3) and column (4) control for past multinational activity and - using a reduced sample - for previous R&D activities at $t-3$. The estimation results show that these additional controls hardly change the partial correlation between cross-border acquisitions and R&D. In Panel B, I exploit the longitudinal dimension of the data set further and present some OLS estimates in differences. Time-invariant firm heterogeneity does not seem to be the unique explanation for the positive correlation reported in Panel A. Results in columns (5) and (6) ignore the censoring of the dependent variable and column (7) also ignores the endogeneity of the lagged dependent variable. Hence, these results are only descriptive. Column (8) shows the results of a Mundlak (1978) version of a random effects Tobit model which takes the censoring of the dependent variable into account.²²

Interestingly, the positive correlation between R&D and outward M&As outweighs the absolute value of the negative correlation between changes in foreign ownership (i.e. inward foreign acquisitions) and changes in R&D spending. This implies that the negative relationship between foreign ownership and R&D does not necessarily imply a global reduction of innovation activities. Unfortunately, data on R&D expenditures for the acquirers and targets outside of Germany is not available in the data set used. Hence, it is not possible to assess the “global” effect of cross-border acquisitions on R&D. This effect also depends on the size of acquirer and target firms in both countries.

In Table 5, the results from the non-linear equation system are presented. As expected, distance and foreign growth are positively associated with the propensity to engage in a cross-border acquisition. Both variables are individually and jointly significant at the 1% level. The score test for omitted variables - which tests whether relaxing the restriction that the coefficients of distance and foreign growth are zero in the R&D equation - shows that the exclusion restrictions cannot be rejected at conventional levels of significance, both individually and jointly. Firm size, market share, and human capital are positively associated with the propensity to engage in a cross-border acquisition. Acquiring firms usually operate in industries with higher entry rates and are more likely to have operated on international markets previously. Turning to the results of the R&D intensity equation, we see that the estimated partial effect of foreign acquisitions is only slightly

²² In this model, correlation between time-invariant unobserved firm heterogeneity and the covariates is allowed for by assuming that unobserved heterogeneity can be expressed as a linear combination of firm-specific mean variables of the regressors. Given this assumption the model boils down to random effects Tobit model with the firm-specific time averages as additional regressors. See e.g. Wooldridge (2002) for this method.

smaller than in the simple Tobit model. The estimate of ρ - the correlation coefficient of the two equations - is positive but very small and not statistically significantly different from zero. This suggests that endogeneity does not seriously bias the estimates of simple Tobit models.

<Table 5 about here>

In the second specification, I use an alternative growth residual as an exclusion restriction - the residual from a regression of foreign growth on its own lag. This measure might be somewhat more robust towards deviation from a long-run trend that might be anticipated by firms. This alternative measure yields a slightly higher coefficient in the acquisition equation. However, the estimated effect of a cross-border acquisition in the R&D intensity equation hardly changes by this alternative specification. Again, the score test indicates that this variable can be omitted from the R&D intensity equation. The estimated marginal effects corresponding to the regressions in Table 5 are depicted in Table 6, alongside alternative specifications. The estimated conditional marginal effects of a cross-border acquisition vary between 1.25 and 1.63 percentage points and are thus quite similar to the Tobit regressions. This is not too surprising given the small estimated correlation coefficient between the two equations.²³

The results of the score test are only an indication but not a proof of validity of the exclusion restrictions. Hence, I performed some checks to rule out the most likely reasons why the exclusion restrictions might be correlated with unobservables affecting R&D. Results in column (3) and (4) show marginal effects from regressions that use only one of the two exclusion restrictions - foreign growth and distance - as an instrumental variables. There are only minor changes to the marginal effects of interest. The results of three further alternative specifications are presented in Panel B. One concern with foreign growth rates is that they might affect domestic market conditions if they induce foreign entry or imply an increase in foreign demand which might affect expected future growth rates. In the first specification of Panel B, I add export and import growth at the industry level to the model. Export growth is only weakly significant in both equations and the import growth is insignificant. Most importantly, it can be seen that the results for cross-border acquisitions do not change notably.

<Table 6 about here>

A further concern is that shocks to foreign growth rates might reflect foreign innovations at the technological frontier. If that was the case, foreign (unexpected) growth rates might be an invalid

²³ Only the marginal effects for international M&As and newly introduced coefficients are displayed in the remaining part of the paper to save space. Full estimation results of all regressions are available from the author upon request.

instrument as technological frontier innovations can induce international knowledge spillovers or incentives to close a technological gap to foreign competitors. Therefore, I re-estimated the model controlling for a proxy variable for technological distance which is computed as differences in the log labor productivity between the USA and Germany in the firm's main market. The results show that introducing this measure even slightly increases the estimated effect of cross-border acquisitions. In an alternative regression I controlled for differences in labor productivity between industries in Germany and Western Europe which did not affect the estimates notably either.

Estimation results depicted in column (7) of Panel B in Table 6 control for previous R&D intensity. Unfortunately, potential endogeneity of previous R&D cannot be controlled for due to a lack of suitable instruments such as further lags. Controlling for previous R&D does not affect the estimated coefficient of cross-border M&As substantially, although this variable is significantly correlated with contemporaneous R&D. Again, this indicates that causality rather runs from cross-border M&As to domestic R&D than converse.

One potential concern with the measure of distance to foreign markets is that it might be correlated with regional characteristics that determine investment opportunities. Put differently, firms with high R&D productivity might choose to locate in certain areas in the home country that possibly have a high distance from the border. As from a theoretical point of view the relation between distance and cross-border acquisitions is ambiguous, it is difficult to judge whether this variable indeed reflects trade costs. If this was the case we should see a negative correlation between distance and firms' export shares. The opposite would be expected if there is a strong correlation between distance and managerial ability, as one would expect a selection of more productive and innovative firms into exporting.

To check whether this is the case, I run a Tobit regression of a firm's export share and a Probit regression with a binary export dummy on distance and all the control variables from equation (2) - except the firm's main markets. The estimated partial effects were negative (-3.1% on the probability of exporting and -0.41 base points on a firm's export share) and significant at the 1% level.²⁴ This indicates that the correlation between foreign acquisitions and distance reflects trade costs rather than a location choice of firms. I argue that systematic differences in regional innovativeness are accounted for by differences in firm size, industry composition and the other control variables used in the estimation. Differences between Eastern and Western Germany are still accounted for by a dummy variable in both regressions. The rich set of control variables - including firm size, market share and capital intensity - should account for most of the

²⁴ Full estimation results are available upon request.

differences in managerial ability across regions. By controlling for cooperation with other firms and scientific institutions, I also account for external knowledge sources that may vary across regions.

The results so far suggest that cross-border acquisitions have on average a positive causal effect on domestic innovation activities. A likely explanation is that investors acquire complementary technologies in cross-border investments that increase the returns to R&D spending or make the creation of new knowledge necessary to integrate the target firm's technology into the production process. Alternative explanations are that after an acquisition the fixed costs of R&D can be spread over a higher production output, or the effects of cross-border acquisitions reflect the general effect of foreign market access or of a reduction in competition. Finally, the results might be due to a relocation of R&D activities from the acquisition target.

In Table 2 it was shown that the differences in R&D intensity between acquirers and non-acquirers were more pronounced in knowledge intensive industries. Separate regressions are run for knowledge intensive industries and other sectors to investigate whether this also holds after conditioning on control variables and accounting for the possible endogeneity of foreign acquisitions. The results are presented in Table 7. The table shows that for Tobit regressions the estimated partial effects of cross-border acquisitions on R&D are much higher in knowledge intensive industries (about 3.5% points) than in other industries (about 0.75% points). In industries with low knowledge intensity, the estimated effect is even insignificant for the non-linear equation system. However, the insignificant and small coefficient for ρ suggests that the results from the Tobit model are more efficient. Nonetheless, the difference in the estimated effects between the two industry types is quite striking, and the difference in the estimated coefficients is also higher compared to the average R&D intensity in these industries. A possible explanation for these different effects might lie in the different motives for acquisitions across industries. Previous research suggests that while technological motives are not a major determinant of M&As on average, they are quite important in high-tech sectors (Hall, 1990; Haagedorn and Duysters, 2002; MacDonald, 1985). Acquisitions in high tech industries might be specifically targeted towards targets with complementary technologies while innovation targets in low tech industries might be characterized by low or no innovative activity.

<Table 7 about here>

Explaining the mechanisms behind the positive effect on R&D intensity in more detail is of theoretical interest, but it may also be interesting from an economic policy point of view. These mechanisms suggest in which way cross-border acquisitions have a different effect on innovation activities compared to other forms of internationalization or corporate strategies that may be

encouraged or discouraged by economic policy. To assess some of these issues, model extensions are presented in the next section in which the effects of cross-border acquisitions are compared to those of greenfield FDI and domestic acquisitions. Further, I investigate the effect of cross-border acquisitions on tangible investment spending.

5.2 Model extensions

For a reduced sample of firms, I was able to calculate greenfield investments from the AMADEUS database. The reduction in sample size stems from the fact that information on subsidiaries is not available in the sample for all firms in all years. Panel A of Table 8 shows estimation results of regressing R&D intensity on greenfield investment - measured as a dummy variable taking value one if there was at least one new foreign subsidiary - and other control variables. The estimates for the effects of cross-border M&As do not change notably after the inclusion of greenfield investments and show that greenfield investments are not significantly correlated with R&D intensity. Hence, it seems that the estimated effects for cross-border acquisitions are not a pure effect of internationalization or FDI.

<Table 8 about here>

One possible explanation for this finding may be found in the motives underlying these different investment types. Trade theoretical models with heterogeneous firms predict that greenfield FDI is conducted to exploit existing firm-specific assets or to take advantage of differences in production costs, while cross-border M&As enable a firm to access firm-specific assets of target firms and to exploit complementarities in technologies (see e.g. Nocke and Yeaple, 2007, 2008). Feedback effects to domestic activities are probably higher for cross-border acquisitions since they usually involve the integration of new production processes and technologies, while greenfield investments are often accompanied by a duplication or relocation of existing production processes only. Controlling for the share of sales that a firm generates in international and local markets, it is found that these measures are significantly associated with R&D, but they only slightly affect the estimated effect of international acquisitions.²⁵

For comparison, I estimated an equation with the (tangible) investment to sales ratio as the dependent variable to investigate whether cross-border acquisitions spur domestic growth in general. The results - displayed in Panel B of Table 8 - show that the effect of cross-border acquisitions and greenfield FDI on domestic investment in tangible assets is not significantly different from zero. Hence, it seems that the estimated effects on R&D are not a pure growth effect.

²⁵ In robustness checks available upon request I found similar results when I treated cross-border acquisitions as exogenous and instrumented greenfield investments or export share with the foreign growth residuals and distance.

The results indicate that cross-border acquisitions have a distinct effect on innovation incentives or imply a reallocation of R&D activities.

I also assessed whether the effect stems from a reduction in competition induced by an acquisition. First, I control for a self-assessed measure of size relative to a firm's competitors (which may be national or international). Particularly, the firms were asked whether the relative size of their competitors compared to themselves is small, similar, large, or whether there are no competitors. I re-estimate the model including three dummy variables for self-assessed competition. The estimates shown in Panel C indicate a non-linear relationship between competition and R&D.²⁶ The point estimate for international acquisitions remains quite stable. This suggests that the effect of international acquisitions on R&D is not a pure result of the - usually socially undesired - reduction in competition.

In columns (11) and (12) in Panel C of Table 8, I add a dummy variable for domestic acquisitions. Surprisingly, domestic acquisitions are negatively correlated with R&D intensity. Although the estimated marginal effects are statistically significant at the 5% level, the economic significance is quite low as the estimates suggest that the R&D intensity of firms engaging in domestic acquisitions is - all else being equal - 0.06% points lower than the R&D intensity of other firms. The results do not necessarily have a causal interpretation as there are no good instrumental variables for domestic acquisitions in the data set used. However, when estimating panel Tobit and OLS regressions in first differences, I found negative although small and sometimes insignificant partial correlations between domestic acquisitions and changes in R&D spending as well (results are available upon request). An explanation for the different impacts of domestic and cross-border acquisitions may be found in the different characteristics and motives for these deals. For instance, access to complementary assets might be more pronounced in international acquisitions. Frey and Hussinger (2011) find that technological relatedness between acquirers and potential target firms is a significant predictor for cross-border M&As, but not for domestic transactions. Further, as argued before, international acquisitions might provide access to new markets - which domestic acquisitions may not provide - and this can increase the incentives to invest in cost reducing or quality enhancing innovations as these investments can be applied to a larger production output.

²⁶ Theoretical and empirical studies often find a non-linear relationship between competition and innovation as discussed in section 2. However, in contrast to Aghion et al. (2005) who find an inverted U shape relationship, the results in this paper indicate a U shape relationship. A possible explanation for the difference is that the sample used in Agion et al. (2005) consists of large and listed firms while the sample used in this paper is dominated by small and middle sized firms. Sacco and Schmutzler (2011) show that both a U shape and an inverted U shape relation between competition and R&D are plausible outcomes in a Cournot oligopoly depending on market characteristics and provide experimental evidence for a U shape relationship.

An increase in domestic R&D activities after a cross-border acquisition could also be due to a relocation from foreign acquisitions targets to acquirers. Since data on R&D expenditures in target firms is unfortunately not available, several heterogeneous effects are estimated to indicate whether this is a likely explanation. First, instead of analyzing the effect of international M&As for three years on average, I estimated the effects for each year separately. If the effects are due to a pure relocation effect, it is likely that there is a shift in R&D at a certain time period rather than a gradual increase over time which may indicate complementarities.

Results displayed in column (1) in Panel A of Table 9 show that there is an insignificant effect in the year of the acquisition, a positive and significant effect one year after the acquisition, and a slightly higher effect two years after the acquisition. It might also be expected that relocation is more likely to take place towards corporate headquarters than towards subsidiaries as many multinationals tend to cluster their R&D activities close to their headquarter or main corporate production unit (UNCTAD, 2005). Hence, I estimated separate effects for domestically owned and foreign owned firms in column (2) and separate effects for firms which are subsidiaries of a corporate group (domestic or foreign) in column (3). The results show higher effects for domestically owned and independent firms, but the interaction terms between international M&A on the one hand and foreign owned firms or subsidiaries on the other hand are statistically significant and positive as well. This indicates that the effects are higher for firms that are assumed to be affected more from relocation, but this does not seem to explain the average effect of international M&As fully. The analysis of heterogeneous effects indicates that both complementarities and relocation from target firms explain the overall positive effects of international acquisitions.

<Table 9 about here>

It is possible that the effects are different for R&D that is related to product development compared to R&D that is undertaken to introduce process innovations. While product innovation is often undertaken at corporate headquarters, process innovation might be more specific to individual subsidiaries or plants. Unfortunately, it is not possible to separate R&D expenditures into product and process R&D. However, the survey data provides information on whether a firm has introduced new products or processes in the last three years. To proxy which type of R&D seems to be more important for a firm, I introduced interaction terms between international M&As and dummy variables taking the value of one if the firm has - within the last three years - introduced new products, new processes, or neither a new product or process, respectively.

Product and process innovations can of course be affected by M&A and R&D activity, but it is likely that a longer time series is necessary to measure these effects accurately. Hence, I refrain

from using product and process innovations as outcome variables. As an alternative approach, I classified industries according to whether the amount of firms introducing product innovations or process innovations is higher. The industry classification proxies the importance of product and process innovations for individual firms less accurately but might be less affected by endogeneity problems. Results displayed in column (4) in Panel A and column (5) in Panel B of Table 9 indicate that the overall positive association between international M&As and R&D mainly stems from firms and industries for which product innovations are of higher importance. Domestic R&D of process innovators seems to be either insignificantly or negatively affected. A possible explanation for the negative effects for firms without product or process innovations is that these firms are characterized by low innovation performance and might therefore rather relocate R&D activities to the newly acquired subsidiary.

Another dimension of heterogeneity refers to different target countries. It is, for instance, possible that complementarities are more pronounced for target countries with a high level of technological development. Given that German firms operate quite close to the technological frontier in many industries (see e.g. Griffith et al., 2004) it is likely that they have the absorptive capacity to benefit from access to technology in these countries. I used two alternative classifications of target countries. The first simply splits target countries into developed countries on the one hand and developing and transition countries on the other hand. In the second classification, firms are separated by their technological development according to the R&D scoreboard (European Commission, 2011) in four different groups. In this classification, region 1 has the highest and region 4 is characterized the lowest technological development (see Table 3A for the mapping of countries to regions). In addition, separate effects for US target firms are estimated, as the US provide access to a large target market and represent the technological frontier in many industries. Results depicted in Panel B of Table 9 indicate that positive effects are more likely for investments into target countries with a higher level of technological development. Significantly negative effects show up for investments into transition and less technologically advanced target countries.

A reason for this result may be that technology sourcing is more pronounced for target countries with a high technological development. Previous research indicates that external knowledge acquisition and internal R&D are often complements (see, for instance, Cassiman and Veugelers, 2005). In contrast, investments into transition countries might be undertaken to exploit existing knowledge of the investing firms and might thus be accompanied by a technology transfer. Combining the target country differentiation with the interaction terms for product and process innovations depicted in column (8) of Panel B shows significantly positive effects for investments of product innovators in developed countries and significantly negative effects for process

innovators in transition countries. The latter effect indicates that resources are shifted towards a technology transfer and the adaptation of existing processes in acquisitions targets.

5.3 Robustness checks

I performed several robustness checks to investigate the sensitivity of the main results.²⁷ First, I estimated the model for incorporated firms only, as missing data might be a more severe issue for non-incorporated firms which are not very likely to engage in M&As. A further check was to estimate the model only for firms with at least 10 employees, which is the minimum size of firms that engaged in cross-border M&As, as R&D determinants might be different for very small firms. Imposing these sample restrictions did not change the results notably. A caveat of this study is that although the data set is representative for a large part of the population of firms (those with annual sales up to €500 million) the data set does not include the largest firms which account for a large share of acquisitions and R&D activity. About 20% of acquiring firms in the ZEPHYR data base have an annual turnover above €500 million at the time of acquisition (based on unconsolidated accounts from the AMADEUS database). Nonetheless, it was found that the major result holds across firms of different size classes and industries, hence it seems likely that the results at least qualitatively apply to the whole population of firms. I also checked that the results were not driven by a negative correlation with the denominator in the R&D to sales ratio – hence, by a negative effect of foreign acquisitions on domestic sales - and found that there was a large and highly significant effect on the absolute height of R&D expenditures.

Some further robustness checks investigate the sensitivity of the results towards the identifying assumptions. The results of the non-linear equation system are robust towards letting either the European growth residual or the distance variable enter both the acquisition and the R&D equation. To check the sensitivity of the results towards the distributional assumptions, I estimated a linear IV regression instead of the non-linear equations system.²⁸ Again, a considerable and highly significant positive impact of cross-border acquisitions on the acquirers' R&D intensity was found and this effect mainly stems from high-tech industries.

As an alternative approach that does not rely on the validity of exclusion restrictions, I implement a propensity score matching procedure that comprises a comparison between the actual outcome of an acquirer and the situation had the investor not acquired a foreign firm.²⁹ The matching

²⁷ Most of these results are not reported to save space but are available upon request.

²⁸ Although the formal prerequisites for consistency of linear IV are quite restrictive in the case of limited dependent variables, Angrist (2001) shows that linear IV can be a good approximation for the unconditional local average treatment effect.

²⁹ See e.g. Caliendo and Kopeinig (2008) for this method. Although the estimation procedure does not rely on exclusion restrictions, the validity of the approach crucially depends on the assumption of selection on observables.

procedure is combined with a difference-in-differences approach to account for a potential correlation of time invariant unobserved firm heterogeneity and the outcome variables. As outcome variables, the changes in R&D intensity up to two periods after the acquisition with respect to the pre-acquisition period are calculated. The matching procedure was performed with replacement and standard errors were calculated using the method proposed by Lechner (2001). After imposing the common support condition, I deleted 4 acquiring firms from the sample. As covariates I used all regressors from the standard specifications of the non-linear equation system and the pre-acquisition R&D intensity but excluded the instrumental variables.³⁰

The results of the matching procedure are depicted in Table 10 (results for the estimation of the propensity score are available upon request). It can be seen that the balancing property holds, as t-tests cannot reject the equality of means for each covariate.³¹ The results of the propensity score matching confirm that firms that engaged in cross-border acquisitions display a higher R&D intensity after the acquisition and that this positive association seems to be increasing over time. While the estimated average treatment effect on the treated (ATT) is insignificant in the period of the acquisition, it is significant in period $t+2$ and weakly significant in period $t+1$. All in all, the sensitivity checks confirm the main results of this paper.

<Table 10 about here>

6. Conclusion and discussion

While there is a large literature that analyzes the effects of cross-border acquisitions on productivity and innovation in target firms, there is a lack of evidence of how these outcomes are affected in investing firms. This paper analyzes the impact of cross-border acquisitions on domestic R&D expenditures of the acquiring firms. The data shows that firms engaging in cross-border acquisitions are characterized by a considerably higher R&D intensity than other firms. These differences are also visible within industries and after conditioning on a large set of firm-level and market characteristics. Applying a non-linear equation system and exploiting unexpected changes to foreign growth rates and variation in distance to foreign markets across firms, it is found that a large part of the partial correlation seems to arise from a causal effect of cross-border

A further crucial assumption is that the comparison group is not affected by cross-border acquisitions. This assumption might be violated in oligopolistic product markets. Nonetheless, the propensity score matching is often used to assess the causal effect of international acquisitions on target firm performance (see e.g. Arnold and Javorcik, 2009; Salis, 2008).

³⁰ Recent research shows that including covariates that satisfy IV assumptions cause bias in matching estimators (see, Wooldridge, 2009, for instance).

³¹ This also holds (individually and jointly) for industry and time dummies which are not displayed in the table. Estimation is carried out on the reduced sample of firms for which R&D intensity is available for all years between $t-1$ and $t+2$.

acquisitions on domestic R&D. The estimation results suggest that a cross-border acquisition raises the average R&D to sales ratio in acquiring firms by about 1.5 percentage points. This is more than 17% of the average R&D to sales ratio of all firms that spend a positive amount on R&D and still more than 8% of the average R&D intensity of acquiring firms that engage in R&D. This effect is especially driven by knowledge intensive industries where a conditional marginal effect of about 3.5 percentage points was estimated. A further analysis of heterogeneous effects indicates that positive effects are more likely if acquiring firms engage in product rather than process innovation and if firms invest in countries with high technological development.

The results are robust towards several alternative specifications that rule out the most likely cases that would invalidate the exclusion restrictions, and the main results show are confirmed in alternative empirical models with different identifying assumptions including a propensity score matching approach. The results do neither show up for domestic acquisitions nor for greenfield investments. This suggests that the effects of cross-border acquisitions do not reflect the general effect of FDI or market power enhancing acquisitions but rather the access to complementary foreign technologies and new markets and possibly a partly reallocation of R&D from the target to the acquiring firm. Further, no significant effect of both greenfield FDI and cross-border acquisitions on tangible investment spending was found.

The results indicate that policy measures that increase the incentives for firms to acquire foreign acquisition targets can be beneficial to the source countries' domestic technology base. Mutual restrictions on inward international M&As can have negative effects on global innovation as they might prevent acquiring firms from increasing their domestic R&D activities.

A shortcoming of this paper is that the analysis is restricted to firms with up to €500 million annual turnover. A significant amount of M&As are undertaken by very large firms and it has to be left for future research whether the effects of M&As undertaken by these firms are different. For future research it might also be interesting to investigate post-acquisition innovation activities in both acquirer and target companies involved in the same cross-border M&A. These results might then be compared to the outcomes of firms conducting greenfield FDI and their foreign affiliates and to the results of domestic M&As. Further, it might be interesting to investigate whether the results of this paper hold in other countries with different technological capabilities or industry structures.

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Table 1: summary statistics

variable	description	acquiring firms	other firms
R&D intensity	R&D expenditures/ sales *100	8.481	1.905
foreign ownership	=1, if owned by a foreign company	0.071	0.024
log size	log number of employees	4.825	3.418
share of high skilled	share of employees with university degree *100	32.32	18.42
log market share	logarithm of sales relative to total sales on 3 -digit NACE level *100	-2.857	-4.990
capital intensity	log investment in tangible assets per employee	8.350	7.446
cooperation firms	=1 if firm cooperates with other firms	0.443	0.273
cooperation science	=1 if firm cooperates with public scientific institutions	0.164	0.067
log firm age	logarithm of firm age in years	2.639	2.833
east	=1 if firm has headquarter in former GDR	0.471	0.402
entry	net domestic entry rate at two-digit industry level	0.034	0.002
equity finance	=1 if firm financed part of its tangible investment by equity	0.764	0.580
main market regional	=1 if firm generates the highest share of sales in region <50 km around headquarter	0.421	0.594
main market international	=1 if firm generates the highest share of sales within regional markets	0.207	0.067
domestic growth	domestic growth rate at two-digit industry level	0.009	0.018
eu growth	EU growth rate at two-digit industry level	0.048	0.045
eu growth residual	detrended EU growth rate at two-digit industry level	0.004	-0.001
size	number of employees	233.9	64.0
age	firm age in years	35.74	35.75
investment rate	tangible investment / sales *100	0.079	0.087
labor productivity	sales per employee in 1000€	254.1	188.7
sales growth	logarithmic one year sales growth	0.125	0.051
employment growth	logarithmic one year employment growth	0.048	0.013
distance to border	distance to closest border of EU countries in 100 kilometres	1.830	1.549
greenfield fdi	=1, if firm founded at least one foreign subsidiary in the last 3 years	0.165	0.012
knowledge intense	=1, if firm operates in knowledge intensive industry (average R&D intensity >3.5%)	0.407	0.151

Table 2: R&D intensity in acquiring firms

	acquiring firms		other firms	
	all	RD>0	all	RD>0
all industries	8.481	18.268	1.905	7.283
high-tech	14.739	22.108	5.027	10.100
low-tech	4.184	12.863	1.348	6.143

Table 3 A: Distribution of acquisitions across target countries:

Region	% of deals	Countries
USA	23%	
technology region 1	22%	Switzerland: 10%, Finland: 4%, Japan: 4%, Sweden: 4%
technology region 2	33%	United Kingdom: 10%, Austria: 8%, France: 7%, Netherlands: 4% Denmark, Canada, Belgium, Norway: 4%
technology region 3	10%	Italy: 6%, Czech Republic: 2%, Spain: 1%, Hong Kong: 1%
technology region 4	12%	Poland 5%, China 4%, other countries: 3%
developed	85%	technology region 1-3, excluding Czech Republic
transition/developing	15%	non-developed countries

Note: Classification of countries is based on European Commission (2011).

Table 3 B: Distribution of acquisitions across target industries:

NACE rev 1.1	Description	% of deals
24	chemicals and chemical products	11%
29	machinery and equipment	8%
34	transport equipment	7%
22	publishing and printing	6%
33	medical, precision and optical instruments	6%
40	electricity, gas and water supply	6%
51	wholesale trade	5%
28	fabricated metal products	4%
72	computer and related activities	4%
74	business services n.e.c.	4%
32	radio, television and communication equipment	3%
52	retail trade	3%
65	financial intermediation	3%
15	food products	3%
21	pulp, paper and paper products	2%
31	electrical machinery and apparatus	2%
37	recycling	2%
45	construction	2%
60	transport, storage, communication	2%
26	manufacture of non-metallic mineral products n.e.c.	2%
	remaining industries (each <2%)	15%

Table 4: Basic regression results

Cross-sectional Tobit regressions								
Panel A	(1)		(2)		(3)		(4)	
IMA	2.4156***	(0.458)	1.5024***	(0.371)	1.5348***	(0.411)	1.5096***	(0.429)
size			-0.0463	(0.039)	-0.0458	(0.039)	0.0658	(0.042)
share high skilled			0.0138***	(0.001)	0.0138***	(0.001)	0.0075***	(0.002)
market share			0.0577**	(0.024)	0.0578**	(0.024)	0.0652**	(0.026)
capital intensity			0.0436***	(0.009)	0.0436***	(0.009)	0.0213**	(0.010)
cooperation firm			0.7639***	(0.076)	0.7640***	(0.076)	0.3930***	(0.075)
cooperation science			2.3468***	(0.149)	2.3463***	(0.149)	0.7985***	(0.131)
equity finance			0.1956**	(0.095)	0.1954**	(0.095)	0.1727*	(0.101)
main market regional			-1.9382***	(0.081)	-1.9385***	(0.081)	-1.1541***	(0.082)
main market international			0.9711***	(0.125)	0.9718***	(0.126)	0.2865**	(0.115)
foreign ownership			-0.1167	(0.170)	-0.1149	(0.171)	-0.0009	(0.177)
age	-0.1843***	(0.034)	-0.1356***	(0.033)	-0.1354***	(0.033)	-0.0744**	(0.035)
limited liability	0.5154***	(0.084)	0.2330***	(0.078)	0.2335***	(0.078)	0.0587	(0.082)
east	-0.0003	(0.076)	-0.4133***	(0.071)	-0.4136***	(0.071)	-0.1857***	(0.071)
entry	1.0282**	(0.467)	0.4539	(0.417)	0.452	(0.417)	0.2106	(0.394)
domestic growth	8.7934***	(0.985)	3.2157***	(0.885)	3.2154***	(0.885)	-1.2242	(1.107)
previous multinational					-0.0474	(0.252)	0.1965	(0.240)
previous R&D intensity							0.1812***	(0.004)
sigma	14.918	(0.176)	13.681	(0.158)	13.680	(0.159)	10.275	(0.160)
Log likelihood	-21589.15		-20557.5		-20557.5		-9796.8	
Wald test joint significance	2978.2 (0.000)		5041.6 (0.000)		5041.6 (0.000)		4471.7 (0.000)	
N	16179		16179		16179		10771	
Regressions in differences and correlated random-effects Tobit model								
Panel B	(5)		(6)		(7)		(8)	
estimation method	OLS		OLS		OLS		Correlated RE-Tobit	
IMA	1.4236**	(0.558)	1.6539***	(0.560)	2.3934***	(0.512)	1.7676***	(0.623)
size			-0.0203	(0.059)	-0.0838	(0.054)	0.1344	(0.121)
share high skilled			-0.0088***	(0.002)	0.0099***	(0.002)	-0.0027	(0.002)
market share			0.0627	(0.038)	0.0356	(0.035)	0.0204	(0.080)
capital intensity			-0.0009	(0.014)	0.0102	(0.013)	0.0098	(0.010)
cooperation firm			-0.0868	(0.110)	0.0954	(0.101)	0.0311	(0.095)
cooperation science			-0.6658***	(0.199)	1.0591***	(0.187)	0.1548	(0.139)
equity finance			-0.0610	(0.148)	-0.0353	(0.135)	-0.0121	(0.104)
main market regional			0.0320	(0.106)	-0.5374***	(0.098)	-0.2422*	(0.127)
main market international			-0.7645***	(0.204)	-0.1247	(0.187)	0.0631	(0.150)
foreign ownership	-0.9192***	(0.307)	-0.6553**	(0.311)	-0.5606**	(0.284)	-0.7254**	(0.300)
entry	-0.2087	(0.454)	0.2991	(0.588)	0.5979	(0.538)	0.0638	(0.319)
domestic growth	3.0618***	(1.055)	-1.4935	(1.416)	-0.6332	(1.296)	-0.0336	(0.771)
previous R&D intensity					-0.3019***	(0.007)		
F test / Wald test	5.93 (0.000)		109.37 (0.000)		8.82 (0.000)		1453.6 (0.000)	
N	10771		10771		10771		10771	

Notes: *** (**, *) denotes significance at the 1% (5%, 10%) level. Standard errors are shown in parentheses. Estimates in (1-4) and (8) are marginal effects conditional on a positive value of R&D expenditures that are calculated at the sample means of the regressors. Test statistics are shown with p-values in parentheses. All regressions include industry and time dummies.

Table 5: Coefficient estimates for non-linear equation system

dependent variable	cb-acquisition		R&D intensity		cb-acquisition		R&D intensity	
IMA			5.5133***	(1.820)			5.4997***	(1.819)
size	0.3282***	(0.045)	-0.2158	(0.187)	0.3358***	(0.045)	-0.2157	(0.187)
share high skilled	0.0069***	(0.002)	0.0669***	(0.006)	0.0069***	(0.002)	0.0669***	(0.006)
market share	0.1490***	(0.030)	0.2815**	(0.118)	0.1432***	(0.029)	0.2815**	(0.118)
capital intensity	0.0182	(0.011)	0.2107***	(0.046)	0.0180	(0.011)	0.2108***	(0.046)
cooperation firm	0.1120	(0.081)	3.5592***	(0.340)	0.1130	(0.081)	3.5592***	(0.340)
cooperation science	-0.1083	(0.120)	9.4117***	(0.500)	-0.1055	(0.120)	9.4117***	(0.500)
equity finance	-0.0837	(0.107)	0.9428**	(0.463)	-0.0821	(0.107)	0.9427**	(0.463)
main market regional	0.1401	(0.087)	-8.9579***	(0.355)	0.1490*	(0.087)	-8.9579***	(0.355)
main market international	0.3112***	(0.114)	4.3285***	(0.515)	0.3057***	(0.114)	4.3287***	(0.515)
foreign ownership	-0.1118	(0.160)	-0.5707	(0.841)	-0.0977	(0.160)	-0.5707	(0.841)
age	-0.1118***	(0.041)	-0.6576***	(0.161)	-0.1167***	(0.041)	-0.6577***	(0.161)
limited liability	0.3787***	(0.115)	1.1426***	(0.385)	0.3762***	(0.114)	1.1427***	(0.385)
east	-0.4729***	(0.152)	-2.0125***	(0.349)	-0.4841***	(0.152)	-2.0125***	(0.349)
domestic entry	0.7546***	(0.256)	2.2329	(2.012)	0.7673***	(0.255)	2.2335	(2.012)
domestic growth residual	-0.4154	(1.067)	15.556***	(4.271)	0.2336	(1.039)	15.552***	(4.271)
distance to border	0.2004***	(0.064)			0.2014***	(0.064)		
eu growth residual - trend	4.9327***	(1.538)						
eu growth residual - lag					6.1083***	(2.110)		
rho (correlation coefficient)	0.0271	(0.041)			0.0275	(0.041)		
sigma	13.682	(0.159)			13.682	(0.159)		
Log likelihood	-21157.7				-21153.5			
Wald test (joint significance)	3606.04	(0.000)			3607.43			
Wald test (exclusion restrictions)	19.98	(0.000)			18.09	(0.000)		
Score test (omitted variables)	0.53	(0.767)			2.11	(0.349)		
Score test distance to border	0.08	(0.783)			0.08	(0.783)		
Score test eu growth residual	1.56	(0.211)			2.30	(0.130)		
N	16179				16179			

Notes: *** (**, *)denotes significance at the 1% (5%,10%) level. Standard errors are shown in parentheses. Test statistics are shown with p-values in parentheses. All regressions include industry and time dummies.

Table 6: Marginal effects for R&D intensity equation from non-linear equation system

Panel A	Alternative IVs			
	(1)	(2)	(3)	(4)
IMA	1.2884*** (0.478)	1.2849*** (0.478)	1.2769*** (0.478)	1.4168*** (0.490)
excluded IVs	distance, eu growth-trend	distance, eu growth	distance	eu growth
Wald test IVs	19.98 (0.000)	18.09 (0.000)	9.78 (0.002)	10.32 (0.001)
N	16179	16179	16179	16179
Panel B	Additional control variables			
	(5)	(6)	(7)	
IMA	1.2536*** (0.476)	1.5264*** (0.500)	1.6302*** (0.488)	
export growth	0.4533* (0.256)			
import growth	0.0037 (0.305)			
technological distance		0.1701** (0.082)		
previous R&D			0.1812*** (0.004)	
Wald test IVs	19.98 (0.000)	19.94 (0.000)	10.67 (0.005)	
N	16179	16179	16179	

Notes: *** (**, *)denotes significance at the 1% (5%,10%)-level. Marginal effects are calculated at the sample means of the regressors and conditional on a positive outcome. Standard errors are shown in parentheses. Test statistics are shown with p-values in parentheses. All regressions include industry and time dummies and additional control variables.

Table 7: High-tech and knowledge intensive industries - marginal effects

subsample	knowledge intense=1		knowledge intense=0	
	non-linear system	Tobit	non-linear system	Tobit
estimation method				
IMA	3.5214*** (1.479)	3.5988*** (1.117)	0.3771 (0.520)	0.7504** (0.370)
rho	0.005 (0.067)		0.064 (0.071)	
sigma	17.729 (0.372)	17.285 (0.361)	11.378 (0.160)	11.377 (0.160)
Log Likelihood	-6135.9	-5867.4	-14889	-14466.6
Wald test (joint significance)	650.56 (0.000)	869.36 (0.000)	2348.61 (0.000)	3485.1 (0.000)
N	2484	2484	13695	13695

Notes: *** (**, *)denotes significance at the 1% (5%,10%)-level. Marginal effects are reported that are calculated at the sample means of the regressors and conditional on a positive outcome. Standard errors are shown in parentheses. Test statistics are shown with p-values in parentheses. All regressions include industry and time dummies and additional control variables.

Table 8: Model extensions - marginal effects

Panel A estimation method	R&D intensity							
	(1) non-linear eq. system		(2) Tobit		(3) non-linear eq. system		(4) Tobit	
IMA	1.2567**	(0.513)	1.5125***	(0.403)	1.2472**	(0.507)	1.4586***	(0.399)
greenfield fdi	-0.0252	(0.252)	-0.0442	(0.249)	-0.3133	(0.232)	-0.3289	(0.230)
export share					0.0212***	(0.003)	0.0212***	(0.003)
regional sales					-0.0312***	(0.003)	-0.0312***	(0.003)
rho	0.020	(0.041)			0.028	(0.044)		
sigma	13.323	(0.155)	13.580	(0.172)	13.595	(0.173)	13.169	(0.168)
Log Likelihood	-20570.1		-16924.7		-17456.2		-16455.1	
Wald-Test (joint significance)	3730.2	(0.000)	4150.6	(0.000)	2965.2	(0.000)	4410.31	(0.000)
N	13115		13115		13115		13115	
Panel B estimation method	Tangible investment intensity							
	(5) non-linear eq. system		(6) Tobit		(7) non-linear eq. system		(8) Tobit	
IMA	-0.4053	(1.076)	0.6812	(0.650)	-0.2949	(1.086)	0.6569	(0.652)
greenfield fdi					0.2664	(0.532)	0.1817	(0.522)
rho	0.0756	(0.066)			0.066	(0.066)		
sigma	16.697	(0.127)	16.693	(0.127)	16.696	(0.127)	16.693	(0.127)
Log Likelihood	-41760.3		-41249.3		-41748.1		-41249.2	
Wald-Test (joint significance)	800.81	(0.000)	803.53	(0.000)	801.1	(0.000)	803.66	(0.000)
N	13115		13115		13115		13115	
Panel C estimation method	Competition and domestic acquisitions							
	(9) non-linear eq. system		(10) Tobit		(11) non-linear eq. system		(12) Tobit	
IMA	1.3581***	(0.480)	1.5507***	(0.372)	1.6372***	(0.529)	1.8494***	(0.418)
domestic acquisition					-0.0574**	(0.028)	-0.0617**	(0.027)
competition high	0.3777***	(0.069)	0.3777***	(0.069)				
competition low	-0.0167	(0.115)	-0.0165	(0.115)				
competition monopoly	0.4467**	(0.179)	0.4467**	(0.179)				
rho	0.024	(0.041)			0.024	(0.041)		
sigma	13.539	(0.158)	13.541	(0.158)	13.541	(0.158)	13.670	(0.158)
Log Likelihood	-20181.3		-20766.6		-21097.3		-20554.7	
Wald-Test (joint significance)	4998.1	(0.000)	3587.9	(0.000)	3825.18	(0.000)	5047.3	(0.000)
N	16179		16179		16179		16179	

Notes: *** (**, *)denotes significance at the 1% (5%,10%)level. Marginal effects are reported that are calculated at the sample mean of the regressors and conditional on a positive outcome. Standard errors are shown in parentheses. Test statistics are shown with p-values in parentheses. All regressions include industry and time dummies and additional control variables.,

Table 9: Heterogeneous effects

Panel A	(1)	(2)	(3)	(4)
IMA_t	-0.5418	(0.434)		
IMA_t-1	2.7346***	(0.801)		
IMA_t-2	3.0345***	(0.837)		
IMA*foreign ownership		1.0061**	(0.459)	
IMA*(1-foreign ownership)		2.1663***	(0.599)	
IMA*subsidiary			1.0122**	(0.448)
IMA*(1-subsidiary)			2.2403***	(0.624)
IMA* product industry				1.9496*** (0.416)
IMA* process industry				-1.5591** (0.693)
sigma	13.673	(0.158)	13.674	(0.158)
Log-Likelihood	-20556.2		-20556.1	
Wald test joint significance	5044.08	(0.000)	5044.31	(0.000)
Wald test: equal interaction terms	2.33	(0.126)	2.49	(0.114)
N	16179		16179	
Panel B	(5)	(6)	(7)	(8)
IMA * product_inno	3.2209***	(1.050)		
IMA * process_inno	0.5575	(0.715)		
IMA * non-innovator	-1.6890***	(0.455)		
IMA_developed		2.9119***	(0.517)	
IMA_transition		-2.2402***	(0.327)	
IMA_US			5.9925***	(1.404)
IMA_region1			4.4192***	(1.230)
IMA_region2			-0.8661*	(0.495)
IMA_region3			1.0983	(0.789)
IMA_region4			-2.4360***	(0.342)
IMA_developed * non-innovator				-1.7584*** (0.550)
IMA_developed * product_inno				5.0513*** (1.434)
IMA_developed * process_inno				1.4705 (0.932)
IMA_transition * non-innovator				0.5155 (1.393)
IMA_transition * product_inno				-0.6738 (1.058)
IMA_transition * process_inno				-2.8935*** (0.596)
sigma	13.628	(0.158)	13.510	(0.157)
Log-Likelihood	-20540.4		-20504.7	
Wald test joint significance	5075.71	(0.000)	5147.1	(0.000)
Wald test: equal interaction terms	38.89	(0.000)	28.54	(0.000)
N	16179		16179	

Notes: *** (**, *)denotes significance at the 1% (5%,10%) level. Standard errors are shown in parentheses. Marginal effects from Tobit regressions are reported. Marginal effects are calculated at the sample mean of the regressors and conditional on a positive outcome. Test statistics are shown with p-values in parentheses. All regressions include industry and time dummies and additional control variables.

Table 10: Propensity score matching

Outcome:	$RD_{it} - RD_{i,t-1}$	$RD_{i,t+1} - RD_{i,t-1}$	$RD_{i,t+2} - RD_{i,t-1}$		
ATT	1.618 (1.704)	3.522* (2.406)	4.711** (2.831)		
Balancing property					
	sample	acquiring firms	control firms	t-test(p-value)	
Propensity score	unmatched	0.083	0.008	0.000	
	matched	0.083	0.080	0.851	
<u>Covariates:</u>					
log size	unmatched	4.773	3.430	0.000	
	matched	4.773	4.965	0.235	
share high skilled	unmatched	29.010	13.905	0.000	
	matched	29.010	23.525	0.139	
log market share	unmatched	-2.886	-4.961	0.000	
	matched	-2.886	-2.869	0.939	
capital intensity	unmatched	7.612	4.890	0.000	
	matched	7.612	7.314	0.564	
cooperation firm	unmatched	0.455	0.285	0.000	
	matched	0.455	0.446	0.888	
cooperation science	unmatched	0.178	0.067	0.000	
	matched	0.178	0.158	0.709	
equity finance	unmatched	0.792	0.590	0.000	
	matched	0.792	0.723	0.253	
main market regional	unmatched	0.475	0.590	0.020	
	matched	0.475	0.495	0.780	
main market international	unmatched	0.168	0.067	0.000	
	matched	0.168	0.248	0.167	
foreign ownership	unmatched	0.040	0.023	0.259	
	matched	0.040	0.059	0.519	
age	unmatched	2.880	3.032	0.170	
	matched	2.880	3.028	0.349	
limited liability	unmatched	0.921	0.730	0.000	
	matched	0.921	0.901	0.623	
east	unmatched	0.485	0.418	0.170	
	matched	0.485	0.545	0.401	
entry	unmatched	0.040	0.002	0.000	
	matched	0.040	0.063	0.531	
domestic growth	unmatched	-0.013	-0.025	0.000	
	matched	-0.013	-0.022	0.049	
previous R&D	unmatched	5.143	1.792	0.000	
	matched	5.143	5.376	0.931	

Notes: *** (**, *)denotes significance at the 1% (5%,10%) level.