Cross-Border M&As and Innovative Assets

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Abstract:

This paper provides empirical evidence on the relationship between cross-border mergers and acquisitions (M&As) and innovation. For the empirical analysis a unique firm-level data set is constructed that combines balance sheet data and a merger and acquisitions database with information on patent applications. Within three years after a cross-border M&A, patent applications filed by the merged entity increase by more than 30%. Splitting patent applications by the inventor's country it is found that the positive association with post-merger patenting is mainly driven by patents invented in the countries of the acquirers' headquarter and its previous subsidiaries while there is on average a decrease of patenting applications invented in the targets' country of more than 60%. Accounting for endogeneity of international acquisitions by estimating dynamic count data models and applying instrumental variable techniques, the results indicate that part of this correlation stems from a causal effect. The effects are especially pronounced in industries with high innovation intensity.

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1. Introduction

Foreign direct investment (FDI) flows have increased all over the world and both the value of FDI inflows as well as the stock of FDI in the European Union has fivefold within ten years to reach a volume of more than US $ 900 billion and US $ 7.5 trillion in 2007, respectively.[2] Cross-Border mergers and acquisitions (M&As) constitute a large share of FDI reaching up to 80% in the last decade (UNCTAD 2007). The growing importance of cross-border M&As has raised a controversial scientific and political debate. On the one hand, M&As can enhance productivity and technology transfer. On the other hand, politicians and employees are concerned about the possible negative effects on wages, job security and the survival probability of target firms.

Although most governments spend a lot of effort on attracting greenfield FDI (new firms or production units founded by foreign investors), they sometimes resist heavily against foreign acquisitions. 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. Five years later there was a discussion among German politicians whether to intervene against the takeover of Hochtief by the Spanish construction firm ACS. 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. A particular concern is that international acquisitions lead to a reduction of innovation activities in target firms as most multinational firms tend to cluster their innovation activities close to their headquarter or their main corporate production unit (UNCTAD 2005).

Only recently, theoretical and empirical contributions have started to analyze the determinants and motives underlying cross-border M&As (see e.g. Nocke and Yeaple 2007, 2008, Head and Ries 2008). 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.[3]

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[2] http://stats.unctad.org/FDI/TableViewer/tableView.aspx?ReportId=4031, accessed September 27th, 2010). During the financial crisis the value of the FDI stock fell by more than 10%, but it almost recovered in 2009.

[3] Bertrand (2009) analyzes the effect of cross-border acquisitions on innovation activities in French target firms. Bertrand and Zuninga (2006) analyze the impact of cross-border M&As on R&D at the industry level. Lööf et al. (2006) as well as Johansson and Lööf (2006) analyze innovation and productivity differences between foreign and domestically owned firms, but do not differentiate between greenfield investments and foreign acquisitions. Stiebale and Reize (2011) analyze the effects of cross-border M&As on R&D expenditures and innovation output in target firms.

Much less attention has been paid to the effects of cross-border M&As on the investing firm or the combined entity. The vast M&A literature rarely differentiates between cross-border and domestic acquisitions. The literature on FDI usually does not differentiate between greenfield FDI and M&As when the home country effects of outward FDI are investigated or one is concerned with the effects of acquisitions on target firms. To evaluate the global effects of cross-border M&As on innovation it is important to combine existing evidence on innovation activities in target firms with the effect on acquirers' innovation activities. If cross-border M&As induce further innovation activity in the acquirer's country or imply a reallocation of innovative activity to more efficient used, global welfare might be reduced if countries mutually prevent each other from acquiring domestic firms – even if the effect of acquisitions on target firms is negative.

The purpose of this paper is to investigate the impact of cross-border acquisitions on innovation output –measures as patent applications and citations- on the merged entity and the reallocation of innovative assets across countries and between targets and acquiring firms. This paper contributes to the existing literature in several aspects. This is - to the best of my knowledge - the first empirical study that analyzes the effect of international acquisitions on innovation activities of the acquirer and acquisition target at the firm level.

For this purpose a unique firm-level data set is constructed that combines data on patent applications for European firms with balance sheet data and an M&A database. The empirical framework accounts for unobserved firm heterogeneity and the possible endogeneity of cross-border acquisitions. The main results are based on dynamic count data models which are estimated by pseudo maximum likelihood and generalized methods of moments (GMM) techniques. Identification is achieved by exploiting unexpected shocks to foreign market growth rates and variation in 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 the paper.

2. Cross-border acquisitions and innovation

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. [4] Several studies in international trade analyze determinants and effects of FDI. Those studies, however, often focus on greenfield investments or FDI at the aggregate and only in a few cases deal with cross-border acquisitions explicitly.

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 can provide access to target firms' assets that are valuable to acquirers such as production capabilities or intangible assets (e.g. Jovanovic and Rousseau 2002). 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 induce incentives to innovate. Contrarily, R&D expenditures might be shrinking after an M&A through the elimination of duplicate innovation activities (Veugelers 2006).

Regarding the strategic aspects of M&As, a reduction in competition after an acquisition may increase the incentives to perform R&D due to a reduced risk of spillovers to competitors (d'Aspremont and Jacquemin 1988). The internalization of technology spillovers - that have previously been captured by competitors – can induce additional R&D expenditures (Kamien et al. 1992). Further, increased market power after an acquisition enables a firm to spread its innovations over a larger amount of production output.[5] Gilbert and Newburry (1982) argue that firms with monopoly power have incentives to engage in R&D due to the possibility of preemptive patenting.

In contrast, De Bondt (1997) shows that rival firms always spend more on R&D than non-competing firms if technology spillovers are not too important. 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). Reinganum (1983) argues that due to the uncertainty of innovation outcomes, large dominating firms have a lower incentive to spend a high amount on R&D than smaller competitors. This is because a firm with high market power has a smaller gain in profits from an own innovation and accepts the risk of losing market shares through entry if the probability of an innovation by an entrant is not too high. Cassiman et al. (2005) argue that the impact of M&As on R&D in the merged

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

[5]see Cohen and Levine (1989) for an overview on innovation and market structure.

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.[6]

Regarding the international component of M&As, cross-border acquisitions are a mode of FDI and might be motivated either by differences in production costs across countries, the desire to enter foreign markets or the access to country specific assets.[7] In most theoretical trade models incorporating firm heterogeneity, 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. Theoretical models 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, trade theoretical models with heterogeneous firms 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) or capabilities that are non-mobile across countries (Nocke and Yeaple 2007).[8] If the exploitation of complementary assets entails innovation activities this might increase the returns to these activities and thus spur R&D expenditures.

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).

[6] Technological complementarities might be especially pronounced for vertical M&As (see Lafontaine and Slade, 2007, for an overview on 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).

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

[8] Indeed, empirical evidence indicates that cross-border M&As are rarely associated with input-output linkages (see for instance Hijzen et al., 2008). There are several further possible motives for cross-border acquisitions. In a model of Head and Ries (2008), cross-border acquisitions arise due to the probability 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).

With regard to the location of economic activity Neary (2007) argues that cross-border M&As are induced by efficiency differences across countries and lead to a reallocation of production from less efficient foreign acquisition targets to more efficient acquirers. There are also incentives for the concentration of R&D at the acquirer's headquarter beyond the effects on general economic activity. The knowledge capital model (Carr et al. 2001) explains the existence of multinational enterprises by the existence of firm-specific assets which are costly to replicate but can be transferred to foreign acquisition targets. This induces firms to concentrate activities like R&D at their headquarter. Sanna-Raddacio and Veugelers (2007) argue that there are further benefits to centralizing R&D in multinational corporate groups such as economies of scale in R&D and a reduced risk of technology spillovers to competitors (see also Kumar, 2001).

The corporate finance literature argues that acquisitions might arise due to misvaluations in the stock market where acquirers with overvalued stocks buy targets with undervalued stocks (see Shleifer and Vishny 2003). In contrast to the previous rationale, M&As can also be attributed to the empire-building motive of managers in acquiring firms. Managers often have a preference to reinvest free cash rather than to return it to investors (Jensen 1988). In incomplete financial markets overall investments of firms might be limited by financial resources, hence investing abroad might lead to a reduction of domestic innovation projects that would otherwise be undertaken. M&As are often financed with debt and therefore lead to increased leverage for the acquirer. This may in turn increase the costs of financing R&D and may thus lead to a reduction of innovation activities.[9] M&As might increase organizational complexity and entail organizational structures with higher financial controls. Financial controls can result in a lower R&D intensity because they can induce divisional managers to focus on short-term investments and less risky projects (Hitt et al. 1991; Hitt and Hoskisson 1990).

From a theoretical point of view there are several reasons why one may either expect a reduction or an increase of innovation activities in acquiring firms after an international acquisition. Hence, the question can ultimately only be answered empirically. Cassiman et al. (2005) and Veugelers (2006) give an overview on existing studies on the impact of M&As on R&D. Most of these studies find a negative effect of M&As on R&D activities, but they usually do not differentiate between cross-border and domestic acquisitions.

[9] There is empirical evidence that especially after leveraged buyout targets display declining expenditures for capital (Kaplan 1989) and R&D (Long and Ravenscraft, 1993).

Criscuolo et al. (2010) and Wagner (2006) find that exporters, as well as multinational enterprises, display a higher R&D intensity and also generate more knowledge conditional on R&D expenditures and some other control variables than other firms. Similarly, Castellani and Zanfei (2007) find that multinational enterprises display higher innovation efforts and a higher propensity to innovate than exporters and firms that operate solely on the domestic market. None of these studies differentiates between greenfield investments and cross-border M&As. Further, they do not address whether the correlation between FDI and innovation reflects a causal relationship. Fors and Svensson (2002) find that R&D activities and sales in foreign markets are complements, but they do not differentiate between sales from exports or sales in foreign subsidiaries. Empirical studies that analyze substitution effects between FDI in general and domestic production and investment yield mixed results.[10] This may be partly driven by the missing distinction between different foreign market entry modes as well as between the extensive and the intensive margin of foreign direct investment.

Bertrand and Zuniga (2006) find that cross-border M&As have no significant impact on an industry's R&D intensity in the home country on average. Since their empirical model is estimated at the industry level, the researchers cannot distinguish between the impacts on acquiring and target firms on the one hand and the impacts on non-merging competitors and firms in related markets on the other hand.

Few empirical studies deal with the relationship between cross-border acquisitions and innovative activities at the firm level. In addition, the existing firm-level studies focus on the effects of innovation activities in target firms. Lööf et al. (2006) approximate foreign takeovers by foreign ownership and analyze the relationship between innovative activity and foreign ownership using data for Northern European countries. Their results indicate that domestic firms do hardly differ from foreign-owned firms with respect to innovation input, innovation output and productivity. However, as greenfield foreign owned firms might be quite different from acquired firms it is unclear in which way the results reflect the effect of foreign acquisitions.[11] Methodological similar papers to Lööf et al. (2006) are Johansson and Lööf (2005) and Falk and Falk (2006). Bertrand (2009) finds that foreign acquisitions are accompanied by a rise in R&D expenditures using a sample of innovative firms from France.

[10] See e.g. Pfaffermayr (2004), Konings and Murphy (2006), Becker and Mündler (2008), Desai et al. (2009).

[11] Several studies analyze differences between foreign owned and domestically owned firms empirically. Griffith et al. (2004) find that foreign-owned firms in the U.K. are less R&D intensive than domestic firms, similar to Blind and Jungmittag (2004) for German service firms. In contrast, Castellani and Zanfei (2007) report a positive correlation between foreign ownership and R&D as well as Erdilek (2005) and Love et al. (1996). Love et al. (2009) analyze differences in the relation between innovation and profitability for domestic and foreign owned firms, but do not address the effect of foreign ownership on innovation directly.

In contrast, Stiebale and Reize (2011) find that cross-border acquisitions lead to a sizeable reduction of innovation activities in German target firms once endogeneity and selection bias are taken into account. Marin and Alvarez (2009) find that acquisitions undertaken by foreign owned firms in Spain have a negative impact on innovation activities, in contrast to acquisitions by domestically owned firms, but they do not analyze the impact of cross-border acquisitions.

Existing empirical studies that analyze the impact of cross-border acquisitions on innovation activities are limited to the evidence on the impact on target firms. To the best of my knowledge, no empirical study explicitly investigates the impact of cross-border acquisitions on both acquirer's and acquisition targets' innovation activities at the firm level. This paper aims to fill this gap.

3. Empirical strategy

The empirical model of innovative activity has to account for several problems. First, the outcome variable, the number of patent applications, is a non-negative integer variable with a large share of zeros. Further, it is likely that unobserved firm attributes like managerial ability, corporate culture, attitudes towards risk, technological or product characteristics are correlated with both the decision to engage in M&As and innovative activity. Finally, I want to account for a firm-specific knowledge stock generated by lagged values of patent application to account for state dependence in innovative performance. Due to the presence of lagged values of the dependent variable, strict exogeneity of the regressors is violated by definition. It is also well possible that there is feedback from innovative activity to future decision about M&As and other variables like productivity and firm size.

The empirical model builds on a framework for analyzing innovative activity developed by Blundell et al. (1995). To account for the fact that innovation is measured as a count variable, the first moment of the model is:

$$E\left[P_{it}\right] = \exp(x_{it}^{'}\beta)$$

where $x_{it}^{'}\beta = \sum_{k=1}^{K} IMA_{i,t-k}^{'}\delta_k + \sum_{k=1}^{K} DMA_{i,t-k}\gamma_k + \theta G_{i,t-K-1} + Z_{it}^{'}\alpha + M_{it}^{'}\pi + \lambda\tau_{it} + c_i + v_t$.

P_{it} denotes the number of patent applications in year t. If a firm does not engage in M&As in the sample period, P_{it} equals the number of patent applications of firm i. If a merger or acquisition takes place, P_{it} equals the sum of patent applications of acquirer and acquisition target before the merger and the total number of patent applications in the merged entity after the M&A.[12] In an extension of the model only patent applications invented in the country of firm *i*'s headquarter are included in P_{it}. This model is estimated separately for acquirers and targets together with the sample of control firms to investigate whether cross-border M&As lead to a reallocation of innovative activity across countries.

IMA and DMA denote vectors of dummy variable variables that take the value of one if firm *i* has engaged in international and domestic M&A activity in the last three years. G_{it} measures the firms' accumulated pre-merger knowledge stock, Z_{it}, denotes a vector of firm-specific control variables, M_{it} covers market structure variables and τ_{it} accounts for knowledge capital available in firm *i*'s industry at year *t*. c_i accounts for unobserved time invariant firm heterogeneity. All explanatory variables are lagged to allow for a time lag between changes in firm- and market specific characteristics on innovative activity and to avoid including regressors that are affected by the M&A variables. Time and industry dummies enter all estimations to control for macroeconomic shocks and industry characteristics.

To address the above mentioned econometric problems a dynamic count data models is estimated. Following Blundell et al., (1995, 2002) pre sample information on firm's patent applications is used to control for unobserved firm heterogeneity[13] Compared to other panel data techniques for count data model this specification has the advantage that it does not assume strict exogeneity of the regressors. In contrast to the estimation techniques proposed by Wooldridge (1997) and Chamberlain (1992) this procedure does not rely on the validity of lags as instruments. It is particularly advantageous if the regressors are characterized by a high persistence, since in this case lagged values of the regressors can be weak instruments for quasi differenced equations.

Although the estimation techniques so far account for a variety of control variables, time-invariant unobserved heterogeneity, and feedback from innovation to future decisions about M&As it is still possible that the estimated coefficients do not reflect a causal effect of international M&As on post-merger innovation. This is because unobserved time-varying factors such as productivity and technology shocks – if not sufficiently accounted for by the

[12] This procedure is often employed in the M&A literature (see e.g. Gugler and Siebert 2007, Conyon et al., 2002).

[13] Bond et al. (2002) show that pre sample patent activity is a sufficient statistic for firm fixed effects if the regressors follow a stationary iid process. Although the formal results are only valid when the number of pre sample periods approaches infinity, Bond et al. (2002) demonstrate that the pre sample mean estimators performs well even when the number of time periods is small.

control variables – might affect the profitability of both M&As and innovation activities. To check whether these correlations drive the previous results, non-linear instrumental variable models applying GMM and non-linear least squares are estimated for the specification in which patents analyzed in the acquirer's and target's country separately.

Following Windmeijer and Santos Silva (1997), the GMM estimator is based on an additive error specification: $P_{it} = \exp(x_{it}^{'}\beta) + u_{it}$ which yields the moment condition[14]: $E\left[P_{it} - \exp(x_{it}^{'}\tilde{\beta}) \mid w_{it}\right] = 0$.

w_{it} is a vector of instrumental variables which includes the exogenous variables included in x and least one variable that is assumed to affect international M&As, but does not affect innovation activity and is uncorrelated with unobservables affecting innovation. To check the robustness of the results the estimates are compared with a linear IV estimator and the two stage estimation procedure suggested by Terza (1998) which .assumes that the error terms of the patent equation and a first stage Probit model are jointly normally distributed.[15]

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 innovation activity. The first exclusion restriction is based on foreign market growth in European countries (excluding the country of the potential target and acquirers, respectively.). This measure is defined at the two-digit industry level of a firm's main activity. The variable is likely to capture a lot of variation in international acquisitions, as more than 50% of all M&As occur within two-digit industries. This instrumental variable captures the motive of cross-border acquisitions to enter new markets. As firms might anticipate future growth and hence might adjust domestic and foreign investment in advance, 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).

The model contains several variables that capture the competitive environment and market conditions to rule out feedback from foreign growth to innovation activity. To control for the possibility that shocks on the domestic market are correlated with foreign shocks, I compute a control for domestic growth rates. To control for time invariant product and market

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[14] The moment condition contains a transformed constant term but all slope coefficients are identical to the vector β.

[15] See Winkelmann (2008) for a discussion of these models.

characteristics, industry dummies at the two-digit industry level are included in the equations next to country and time dummies.

Several time variant variables capture firm- and market specific shocks. A firms' size measured as pre-merger sales captures the potential to spread the gain from new or improved products over a larger production output[16], productivity captures the selection of more productive firms into foreign markets (Helpman et al. 2004). 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 capital intensity –measured as the capital to labor ratio- which captures differences in production technologies and a liquidity ratio, defined as net current assets over total assets to control for financial factors which might be a prerequisite to finance innovative activities and sunk costs for foreign market entry. A firm's age enters the model and serves as a proxy for experience and the stage of the product life cycle.

Foreign growth would be an invalid instrument if it induces foreign demand or competitive pressure that is not controlled for in the set of control variables. To see whether the results are driven by this correlation I checked the robustness of the estimates towards adding the growth of exports and imports at the industry level to both equations. I further checked the robustness of the results towards inserting a measure of 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).

As an alternative instrumental variable the minimum distance between potential acquirers and foreign acquisitions targets is used (Stiebale and Reize, 2011 use a similar instrumental variable to control for endogeneity of inward foreign acquisitions). This variable captures the well known proximity-concentration tradeoff (see e.g. Brainard 1997) and the effect of trade costs on cross-border M&As in particular (Hijzen et al., 2008).

4. Data

To construct the data set used in this paper several different data sources had to be merged. 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

[16] see Cohen and Levine (1989) for an overview on innovation and market structure

(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.[17]

The second data set used is the AMADEUS database, which provides information on financial data as well as ownership and subsidiary information for more than 10 million European firms.[18] 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 entry and exit of firms and a broader sample of firms to identify acquirers in cross-border acquisitions. Data from the AMADEUS database is used to gather information on firms' sales, productivity and liquid assets and to identify existing linkages between firms and their shareholders and subsidiaries. Unconsolidated accounts are chosen to separate economic activity in acquiring firms and acquisition targets and across countries. AMADEUS firms are merged with the transaction data from ZEPHYR by a common firm identifier resulting in observations. The full sample contains 7,100 firm-year observations for acquirers and acquisitions target that engage in at least one M&A in the sample period, 1,600 observations are available for firms that engage in international M&As.

Data on patent applications is taken from the PATSTAT database, which has been developed by the European Patent Office and the OECD. I extract patent applications for the years 1978-2008 for all the companies in our sample. The data on patent applications are merged with the other firm-level data sets using a computer supported search algorithm based on the firms' names, addresses and zip codes. Every match was checked manually to ensure a high data quality. A crucial point when merging the two datasets is the classification of firms. It is possible that some firms file patents via subsidiaries or parent companies. Hence, I also extracted data on subsidiaries for each company from the AMADEUS database to obtain both

[17] Calculations are available from the author upon request.
[18] AMADEUS is provided by Bureau van Dijk and Creditreform in Germany. AMADEUS updates 88-184 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 the data do not allow for a distinction between greenfield FDI and cross-border acquisitions in many cases.

a consolidated and an unconsolidated count of patent applications. Further, the data includes information on inventors and their country which enables to separate the regional creation of a patent from its ownership.

Finally, to construct regressors at the industry level, data from Eurostat and the OECD STAN database is used. The empirical analysis focuses on European firms which are active in manufacturing or knowledge intensive service sectors such as IT and telecommunication across the time period 2000-2008.

5. Results

Table 1 shows some summary statistics for firms that engage in cross-border and domestic acquisitions compared to other firms, including all variables that are used in the econometric analysis. The average innovation intensity of firms that engage in M&As is higher than in non-merging firms. More striking, firms that engage as acquirers in international M&As show much higher innovation activities than non-merging firms and the targets they acquirer. Other characteristics that are positively correlated with innovation like productivity, firm size, liquidity, and tangible capital intensity are also on average higher in these firms. Firms that take an active part in international M&As more often operate in industries with a high knowledge intensity. The figures are in line with some stylized facts from the trade and FDI literature – multinational enterprises are larger, more productive and innovative than domestic firms and they operate more often in high-tech sectors. Post merger differences in innovation activities between acquirers and targets and between merging and non-merging firms may stem from a selection effect, i.e. more innovative firms engage in international M&As. But they may also partly stem from international M&As affecting innovation activity and from a relocation of innovation activity within the merged entity.

Table 2 shows results of simple Poisson regression models with and without controls for time invariant unobserved firm heterogeneity. Without controlling for unobserved heterogeneity post-merger patenting activity in the merged entity after a cross-border acquisition increases by about 65% compared to other firms and even 70% if patent patent applications of subsidiaries are included. When unobserved firm heterogeneity is controlled for by pre sample patent activity this effects drops to some 30% but remains economically and statistically highly significant. In column (5) the effects of international M&As is estimated separately for three years. The results indicate that the effect of international M&As on innovative activity arises after two years, which seems plausible. In contrast, domestic M&As

do not seem to be associated with increased innovation output. The results for the control variables are in line with expectation. Patenting activity is positively associated with firm size, productivity, financial strength, and capital intensity, while innovation seems to be declining with a firm's age. A higher knowledge stock makes future innovations more likely. The incidence and intensity of pre sample innovation activity –which proxies for firm fixed effects- is positively associated with current innovation output and reduces as expected the correlation between past and current innovations. Knowledge capital in a firm's industry increases firms' innovation output while other market structure variables such as domestic market growth and entry rates do not seem to have a large effect on innovation output.

Despite the overall positive association between international M&As and innovation output the division of innovation activity between acquiring firms and acquisition targets is of both theoretical interest and policy relevance. Table 3 shows results from comparing the growth of patent activity invented in the country of the acquirer's and target's headquarter with those of other firms. Splitting the effect of cross-border M&As by the country of invention it is found that the positive association with post-merger patenting is mainly driven by patents invented in the country of the acquirers' headquarter (and its previous subsidiaries) while there is on average a decrease of patenting applications invented in the targets' country of about 70%.[19]

Although the results mentioned so far account for a variety of control variables, time-invariant unobserved heterogeneity, and feedback from innovation to future decisions about M&As it is still possible that the estimated coefficients do not reflect a causal effect of international M&As on post-merger innovation. This is because unobserved time-varying factors such as productivity and technology shocks – if not sufficiently accounted for by the control variables – might affect the profitability of both M&As and innovation activities. In particular it is possible that acquirers that expect future increases in innovation performance invest in targets with low expected future performance and market value. To check whether these correlations drive the previous results, non-linear instrumental variable models applying GMM and non-linear least squares are employed.

Table 4 shows first stage Probit and linear probability models from the perspective of the acquirer and the acquisition target respectively. As discussed in section 3 the decision to engage in M&As is instrumented by unexpected changes in foreign growth rates in a firm's

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[19] This effects is calculated as (exp(-1.209)-1)*100%.

main industry.[20] As anticipated, unexpected changes in foreign growth rates are positively are significantly correlated with international M&As. The F statistic of this excluded instrument in the linear model are above 30 and are thus considerably higher than the critical values of the weak identification test proposed by Stock and Yogo (2005)[21].

The first two columns in Table 5 show the GMM estimator proposed by Windmeijer and Santos Silva (2005), results from the two-step non-linear least squares estimator proposed by Terza (1997) are shown in columns (3) and (4). Since the results for the control variables are very similar to the previous models, only the coefficients for international M&As are presented. The estimated effects in the GMM model are very similar to the baseline specification, suggesting that a large part of the correlation between international M&As and innovation stems from a causal effect. The estimated effects for cross-border M&As in the Terza (1997) model are much than in the baseline estimations suggesting a positive selection of acquiring firms into international M&As. Nonetheless, the results qualitatively confirm the previous estimates. There is an economically sizable and statistically significant positive effect of international M&As on patent applications invented in the country of the acquirer's headquarter. Further, innovation activity in the acquisition targets' country is negatively affected.

The GMM estimates in contrast to the non-linear least squares models do not rely on distributional assumptions, and can thus be expected to be more robust. Nonetheless, they rely on a correct specification of the conditional expectation and assume an additive error term. As a further robustness check, I also estimated linear instrumental variable models. As dependent variable I used the arbitrary transformation $\ln(P_{it}+1)$ to deal with zeros and to retain the exponential relationship between the dependent variable and the regressors. The results only have a qualitative interpretation, as it is not possible to derive semi-elasticities from this specification. The results confirm that cross-border acquisitions - induced by unexpected changes in foreign market growth - rates have a positive effect on the innovation outcomes in the acquirer's country, which seems to be accompanied by a reallocation of innovation activities from foreign acquisitions targets to the new headquarter.

[20] In a revised version of the paper, the robustness of the results towards using alternative instruments such as the geographical distance to foreign markets and to potential merging partners will be used (see the discussion in section 3). The inclusion of additional instrumental variables will enable to test the validity of subsets of instruments using over identification tests.

[21] The critical value for a maximal bias of 10% in the IV estimator is 16.38 (Stock and Yogo, 2005).

6. Conclusion and discussion

This paper analyses the impact of cross-border mergers and acquisitions on innovation output – measured as patent applications – and the relocation of innovation within the merged entity. A first inspection of the data showed that firms engaging in cross-border acquisitions are characterized by considerably higher patent activity than other firms.

After a cross-border M&A, there is large increase in patenting activity in the merged entity. These correlations are also visible within industries and after controlling for a large set of firm-level and market characteristics, unobserved firm heterogeneity and pre-merger patent activity. Splitting the effect of cross-border M&As by the country of invention it is found that the positive association with post-merger patenting is mainly driven by patents invented in the country of the acquirers' headquarter (and its previous subsidiaries) while there is on average a decrease of patenting applications invented in the targets' country of more than 60%.

Applying a GMM estimator and non-linear equation instrumental variable techniques and exploiting unexpected changes to foreign growth rates, it is found that part of this correlation seems to arise from a causal effect of cross-border acquisitions on innovation in acquiring firms and acquisition targets.

The results are in line with recent trade theoretical model with heterogeneous firms which point at the role complementarities in firm-specific assets as a main driver for international M&As. They are also in line with and other trade theoretical models incorporating intangible assets which predict a geographical concentration of headquarter activities such as innovation. From an economic policy point of view the results suggest that policy makers might reduce global innovation - and hence long term economic growth and welfare – if they mutually prevent firms from investing in acquisition targets in their countries.

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Tables

Table 1: Summary statistics

	Non-Merging firms	Acquirers		Acquisition Targets	
		domestic	international	domestic	international
patent applications	0.020	0.186	0.730	0.026	0.035
paten stock	0.108	0.881	3.224	0.178	0.311
pre sample patent activity	0.002	0.012	0.072	0.003	0.009
D(pre sample patent activity>0)	0.011	0.037	0.131	0.020	0.044
knowledge capital industry	0.155	0.135	0.237	0.135	0.237
domestic market growth	0.155	0.056	-0.130	0.056	-0.130
entry rate	-0.065	-0.112	-0.138	-0.112	-0.138
relative productivity	-0.144	0.117	0.289	0.163	0.246
log firm size	6.759	9.449	10.474	8.675	9.223
log capital intensity	-2.400	-2.171	-1.974	-2.276	-2.127
working capital ratio	0.161	0.130	0.136	0.134	0.131
log age	2.651	2.982	3.172	2.982	3.172
high tech industry	0.176	0.137	0.261	0.137	0.261
services	0.424	0.422	0.292	0.422	0.292

Table 2: Cross-border M&As and innovation in the merged entity

	(1) unconsolidated	(2) consolidated	(3) unconsolidated	(4) consolidated	(5) unconsolidated
patent stock(t-4)	0.0056***	0.0056***	0.0026***	0.0034***	0.0023***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
IMA(t-1/t-3)	0.6547***	0.7021***	0.3234***	0.3879***	
	(0.044)	(0.042)	(0.047)	(0.044)	
IMA(t-1)					0.0162
					(0.078)
IMA(t-2)					0.5021***
					(0.078)
IMA(t-3)					-0.1475
					(0.112)
DMA(t-1/t-3)	-0.1272***	-0.0248	-0.0301	0.0581	-0.0144
	(0.048)	(0.043)	(0.047)	(0.042)	(0.006)
log firm size(t-4)	0.7957***	0.7986***	0.6593***	0.6934***	0.6660***
	(0.007)	(0.007)	(0.008)	(0.007)	(0.008)
working capital ratio(t-4)	1.0148***	1.0541***	0.5749***	0.6588***	0.6257***
	(0.040)	(0.038)	(0.040)	(0.038)	(0.041)
relative productivity(t-4)	-0.0219	-0.0404*	0.1193***	0.0611***	0.1110***
	(0.023)	(0.021)	(0.022)	(0.021)	(0.022)
log capital intensity(t-4)	0.1335***	0.0976***	0.0669***	0.0236*	0.0699***
	(0.014)	(0.013)	(0.015)	(0.014)	(0.015)
log age	-0.0769***	-0.0884***	-0.1875***	-0.1974***	-0.1826***
	(0.016)	(0.015)	(0.017)	(0.016)	(0.017)
domestic market growth	0.0646***	0.0709***	-0.0235*	-0.0181	-0.0257**
	(0.014)	(0.013)	(0.012)	(0.012)	(0.012)
entry rate	-0.0451**	-0.0631***	-0.0019	-0.0216	-0.0072
	(0.020)	(0.019)	(0.020)	(0.018)	(0.020)
knowledge capital industry	0.8075***	0.8467***	0.8746***	0.9094***	0.8721***
	(0.018)	(0.016)	(0.018)	(0.015)	(0.018)
D(pre sample patents>0)			2.3133***	2.1591***	2.3191***
			(0.033)	(0.031)	(0.033)
pre sample patents			0.4271***	0.2592***	0.4526***
			(0.038)	(0.036)	(0.038)
N	229479	229479	229479	229479	229479
Pseudo R-squared	0.561	0.567	0.627	0.621	0.627
Log likelihood	-21146.2	-23150.8	-17996.0	-20279.5	-17970.5
Wald - Test chi square	54107.5	60661.6	60408.0	66404.1	60458.9

Note: All regressions include industry, country and time dummies. Standard errors, clustered at the firm level are shown in in parentheses:

* p<0.1, **p<0.05, *** p<0.01

Table 3: Cross-border M&A and patents invented in the acquirers' and targets'countries

	(1) Acquirer Patents	(2) Target Patents	(3) Acquirer D(Patents>0)	(4) Target D(Patents>0)
patent stock(t-4)	0.0026***	0.0054***		
	(0.000)	(0.000)		
D(patents (t-4)>0)			1.4549***	1.5995***
			(0.043)	(0.046)
IMA(t-1/t-3)	0.3275***	-1.2097***	0.1771**	-0.5190***
	(0.048)	(0.143)	(0.082)	(0.147)
log firm size(t-4)	0.6554***	0.4641***	0.2047***	0.1843***
	(0.008)	(0.010)	(0.008)	(0.009)
working capital ratio(t-4)	0.4833***	-0.2441***	0.2686***	0.1910***
	(0.042)	(0.057)	(0.045)	(0.048)
relative productivity(t-4)	0.1457***	0.3879***	-0.1478***	-0.1596***
	(0.022)	(0.025)	(0.027)	(0.028)
log capital intensity(t-4)	0.0741***	0.1708***	0.0059	-0.0104
	(0.015)	(0.018)	(0.015)	(0.016)
log age	-0.1892***	-0.3116***	-0.1082***	-0.0975***
	(0.018)	(0.023)	(0.019)	(0.020)
domestic market growth	-0.0172	-0.0332**	0.0077	0.0149
	(0.013)	(0.016)	(0.016)	(0.017)
entry rate	0.0128	-0.1550***	-0.0117	-0.0456*
	(0.021)	(0.025)	(0.025)	(0.026)
knowledge capital industry	0.8972***	0.2864***	0.1883***	0.1957***
	(0.018)	(0.045)	(0.030)	(0.031)
D(pre sample patents>0)	2.2844***	2.6251***	0.7717***	0.7340***
	0.034	(0.042)	(0.042)	(0.044)
pre sample patents	0.4300***	0.2236***	0.3269***	0.0854
	0.038	0.054	(0.115)	(0.110)
N	229479	229479	229479	229479
Pseudo R-squared	0.626	0.58	0.417	0.378
Log likelihood	-17493.3	-13565.1	-4785.0	-4298.2
Wald - Test chi square	58624.3	37489.1	6855.0	5229.9

Note: All regressions include industry, country and time dummies. Standard errors, clustered at the firm level in parentheses.

* p<0.1, **p<0.05, *** p<0.01

Table 4: First stage equations

	(1) Probit Acquirer	(2) Probit Target	(3) Linear Model Acquirer	(4) Linear Model Target
foreign growth residual	0.1412***	0.1419***	0.0020***	0.0020***
	(0.038)	(0.038)	(0.000)	(0.000)
patent stock(t-4)	-0.0061**	-0.0171***	-0.0001	-0.0015***
	(0.003)	(0.004)	(0.000)	(0.000)
log firm size(t-4)	0.3569***	0.3575***	0.0038***	0.0038***
	(0.010)	(0.010)	(0.000)	(0.000)
working capital ratio(t-4)	0.3220***	0.3205***	0.0026***	0.0026***
	(0.046)	(0.046)	(0.000)	(0.000)
relative productivity(t-4)	-0.1510***	-0.1504***	-0.0030***	-0.0030***
	(0.027)	(0.027)	(0.000)	(0.000)
log capital intensity(t-4)	0.0381**	0.0385**	0.000	0.000
	(0.016)	(0.016)	(0.000)	(0.000)
log age	-0.0173	-0.0222	-0.0006**	-0.0006***
	(0.021)	(0.021)	(0.000)	(0.000)
domestic M&A	0.5949***	0.5872***	0.0561***	0.0556***
	(0.040)	(0.040)	(0.001)	(0.001)
domestic market growth	-0.0345**	-0.0342**	-0.0011***	-0.0011***
	(0.014)	(0.014)	(0.000)	(0.000)
entry rate	-0.0765***	-0.0800***	-0.0006*	-0.0006**
	(0.022)	(0.022)	(0.000)	(0.000)
knowledge capital industry	0.1283	0.1047	0.001	0.001
	(0.116)	(0.117)	(0.001)	(0.001)
D(pre sample patents>0)	0.3046***	0.3037***	0.0248***	0.0249***
	0.054	(0.056)	(0.001)	(0.001)
pre sample patents	0.0767	0.1505***	0.0075***	0.0357***
	0.058	0.058	(0.002)	(0.002)
N	229479	229479	229479	229479
(Pseudo) R-squared	0.356	0.358	0.041	0.042
F			151.6165	157.8425
F(Wald) excluded IV	14.14	14.27	34.62	34.84
Log likelihood	-3935.6401	-3925.9200		
Wald - Test chi square	4351.5017	4370.9418	6855.0	5229.9

Note: All regressions include industry, country and time dummies. Standard errors, clustered at the firm level in parentheses.

* p<0.1, **p<0.05, *** p<0.01

Table 5: Controlling for endogeneity: GMM, non-linear least squares and linear IV

	(1) GMM Acquirer	(2) GMM Target	(3) NLS Acquirer	(4) NLS Target	(5) Linear IV Acquirer	(6) Linear IV Target
IMA(t-1/t-3)	0.3276***	-1.2296***	0.0753***	-0.1361***	0.9657***	-1.0152***
	(0.125)	(0.401)	(0.018)	(0.011)	(0.260)	(0.386)

Note: All regressions include control variables. Standard errors, clustered at the firm level in parentheses. Dependent variable in (5) + (6) is ln (patents+1)

* p<0.1, **p<0.05, *** p<0.01