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Cross-Border M&As and Innovative Activity of Acquiring and Target Firms

by

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Abstract

This paper analyzes the effects of cross-border mergers and acquisitions (M&As) on the innovation of European firms. The results indicate a considerable increase in post-acquisition innovation in the merged entity. This is mainly driven by inventors based in the acquirer's country, while innovation in the target's country tends to decline. The asymmetry of effects between acquiring and target firms increases with pre-acquisition differences in knowledge stocks, indicating a relocation of innovative activities to more efficient usage within multinational firms. Instrumental variable techniques as well as a propensity-score matching approach indicate that the effect of cross-border M&As on innovation is causal.

JEL classification: F23, D22, G34, O31

Keywords: Multinational Enterprises, Mergers and Acquisitions, Innovation

Outline

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Non-Technical Summary

There has been a huge increase in the number of cross-border mergers and acquisitions (M&As) over the past decades especially within industries in which research and development (R&D) and innovation are of particular importance. This development has led to a controversial policy debate and to restrictions on international M&As in many countries. A particular concern is that foreign acquisitions might lead to a reduction of innovation or to a relocation of innovation activities from target firms to other countries, since multinational firms often tend to cluster their R&D activities close to the headquarters or their main corporate production unit.

This paper analyzes the following research questions: (1) What is the impact of cross-border M&As on innovation in the merged entity as a whole? (2) Do cross-border M&As induce a relocation of innovative activity across countries and between acquirers and acquisition targets?

From a theoretical point of view, the relationship between international M&As and innovation is ambiguous. On the one hand, there might be synergies between the knowledge of acquirer and target firm which lead to more innovations after acquisitions. Further, after a cross-border M&A, firms might have higher incentives to innovate if the transaction provides access to new markets. On the other hand, cross-border M&As can induce a reduction in competition and may require substantial financial resources from the acquiring firm which are then lacking for innovation expenditures.

This paper provides empirical evidence on the effects of cross-border M&As on the innovation of European firms. The results indicate that, in the merged entity as a whole, cross-border M&As lead to a large increase in innovation - measured by patenting and R&D expenditures. It seems that this can be explained to some extent by complementary knowledge in acquiring and target firms, since the effects are particularly pronounced if both firms have been engaged in successful innovation activities before cross-border M&As. It is further found that acquiring firms are characterized by higher innovative activity than target firms before acquisitions. After an acquisition, these differences are amplified. Most of the overall positive effect of cross-border M&As on innovation comes from innovative activity carried out in the country of the acquirer's headquarters, while innovation in the target's country tends to decline. This asymmetric effects are particularly pronounced if there are large differences in pre-acquisitions innovation activities between acquiring and target firms. After a cross-border M&A, innovation activities seem to be relocated towards more efficient parts of multinational firms.

At first glance, the results provide some rationale for decision makers in policy to block inward foreign acquisitions in their country, as innovation in target firms seems to decrease on average after international M&As. Restricting inward foreign acquisitions may, however, be a myopic strategy if it induces restrictions from other countries as a response. From an international point of view, restrictions on cross-border M&As may reduce global innovation activities - and therefore long-term economic growth - as they prevent a relocation of innovation activity towards more efficient usage and enhanced innovation in acquiring countries.

1. Introduction

It is a well documented empirical fact that multinational companies outperform other firms and that they are responsible for much of the world's research and development (R&D) expenditures and innovative activities.¹ A large part of the foreign direct investment (FDI) of multinational companies takes the form of cross-border mergers and acquisitions (M&As), especially among developed countries and in industries with a high R&D intensity (UNCTAD, 2005, 2007).

The effects of international M&As on R&D and innovation have important policy implications since innovative activity is regarded as a key factor for productivity and growth. Although most governments spend a lot of effort on attracting greenfield FDI (new firms or production units founded by foreign investors), there is a controversial policy debate regarding the effects of foreign acquisitions in many countries (see, for instance, Motta and Ruta, 2012; Bertrand et al., 2012). A particular concern is that international acquisitions might lead to a reduction or relocation of innovation activities. For instance, speaking about foreign takeovers in the UK, Bob Bischof, vice-president of the German-British Chamber of Industry and Commerce, recently stated: "I think there's every reason to be worried. Very often the R&D goes abroad and the rest follows . . . It's a recipe for disaster and a slow hollowing out of our industrial base here."²

Moreover, restrictions on international M&As are common. For instance, under the Investment Canada Act, the Canadian government can block foreign takeovers over a certain size if they do not pass a "net benefit test". In 2005, the French government decided to impose restrictions on foreign acquisitions in several strategic sectors - including industries with high knowledge intensity like the automotive sector, information systems and biotechnology. Similar plans to thwart foreign takeovers, which have been regarded as a response to restrictions in France, have been discussed among Italian politicians recently.³

¹ See, for instance, Benfratello and Sembenelli (2006), Criscuolo et al. (2010), Criscuolo and Martin (2009), Greenaway and Kneller (2007), Helpman et al. (2004) to name a few.

² See "Foreign takeovers revive talk of UK decline", *Financial Times*, September 8, 2013 (<http://www.ft.com/cms/s/0/a0ea0bb8-08d7-11e3-8b32-00144feabdc0.html#axzz2vkXLXFso>, accessed March 19, 2014). Further policy debates include the impact of foreign takeovers in the US and the potential protectionist characteristic of China's "anti-monopoly law" (see, for instance, <http://www.nytimes.com/2008/04/07/business/07sale.html?pagewanted=all> and Anu Bradford, "Chinese antitrust law: The new face of protectionism?", *Huffington Post*, August 1, 2008).

³ Recent examples of policy intervention on specific takeover cases include the bid of Shuanghui International of China for Smithfield Foods, which was under review by the Committee on Foreign Investment in the US (<http://dealbook.nytimes.com/2013/05/30/running-the-national-security-gantlet-in-a-pork-deal/>, accessed March

What are the effects of cross-border M&As on innovative activity? Economic theory provides some, albeit limited, guidance on this question. On the one hand, cross-border M&As might spur innovative activity due to technology transfer or improved market access (see, for instance, Guadalupe et al., 2012). On the other hand, there might be negative effects on innovation due to a reduction of competition after M&As or debt financing of M&As raising the costs of external funds for R&D (see section 2 for details). Hence, the relationship is unclear from a theoretical point of view.

While much of the empirical literature on cross-border M&As has focused on the effects of foreign ownership on productivity (see, for instance, Chen, 2011; Arnold and Javorcik, 2009), a recent strand of the literature emphasizes innovation as a key determinant of multinationals' productivity advantage (e.g. Guadalupe et al., 2012; Criscuolo et al., 2010). Yet, existing empirical evidence on the effects of cross-border M&As is mostly limited to target firms⁴, while much less is known about the corresponding effects on acquirers and the merged entity as a whole. Evidence on the effects of cross-border M&As on investing firms and the combined entity is, however, essential to get a complete picture of the global effects of cross-border M&As on innovation and other outcomes. Moreover, I argue that the effects of M&As on target (or acquiring) firms cannot be fully understood without looking at both parties.

This paper analyzes the following research questions: (1) What is the impact of cross-border M&As on innovation in the merged entity? (2) Do cross-border M&As induce a relocation of innovative activity across countries and between acquirers and acquisition targets? This paper is, to the best of my knowledge, the first empirical study to analyze at the firm level the effects of international M&As on the innovation activities of the acquirer and acquisition target simultaneously. By focusing on both acquiring and target firms, rather than on one side of the acquisition only, this paper contributes to our understanding of the overall impact of cross-border M&As. This approach also enables an analysis of how different characteristics of acquiring and target firms, and their interaction, affect post-acquisition outcomes.

For this purpose, a unique firm-level data set is constructed that combines data on innovation activities of European firms with balance-sheet data and an M&A database.

19, 2014), the potential acquisition of Alstom of France by General Electric and the heavy discussion among politicians in the UK of whether to intervene against the takeover of Astra Zeneca by Pfizer.

⁴Recent exceptions that look at the effects on the acquiring companies are Bertrand and Betschinger (2012) and Stiebale and Trax (2011).

Measurement of innovation is mainly based on patent applications instead of survey questions on new products and processes as used in some recent papers on foreign ownership and innovation (e.g. Guadalupe et al., 2012). Therefore, the focus of this paper is on innovations new to the market rather than on the transfer of existing knowledge within multinational firms.⁵ However, alternative measures, such as R&D expenditures, are analyzed as well. Exploiting data on the location of inventors allows the location of innovation to be identified separately from the location of patent ownership.⁶

A major empirical challenge arises because foreign acquirers and acquisitions targets might differ in both observable and unobservable characteristics from other firms. Thus, the empirical framework accounts for unobserved firm heterogeneity and the possible endogeneity of cross-border acquisitions. In this paper, several alternative empirical strategies are used to identify causal effects. First, dynamic count data models are estimated, using pseudo maximum-likelihood and generalized methods-of-moments (GMM) techniques. These account for both unobserved heterogeneity and differences in a variety of observable characteristics. Further, linear and non-linear instrumental variable (IV) models are employed. In these models, identification is achieved by exploiting changes in international accounting standards - that are aimed at reducing information asymmetries in international transactions - and variation in the distance to foreign markets across firms. Finally, a propensity-score matching approach in combination with a difference-in-differences (DiD) estimator is used to construct an adequate control group.

To preview the results, all of the various alternative estimation techniques suggest that international M&As lead to a substantial increase in innovation in the merged entity (more than 20% within the first three years in most specifications). Analyzing heterogeneous effects, it is found that the impact mainly depends on pre-acquisition firm heterogeneity rather than on industry or country heterogeneity. The estimated effects on the merged entity are most pronounced if both acquirer and target firm have a large pre-acquisition innovation stock. This suggests that access to intangible assets is an important element of cross-border M&As, which is in line with recent theoretical contributions in international economics (e.g. Nocke and Yeaple, 2007, 2008).

⁵ Using patent-based measures of innovation has both advantages and disadvantages over alternative outcome measures, as discussed in detail in section 4.

⁶ For instance, Karkinsky and Riedel (2012) analyze how cross-country variation in tax rates affects the location of patent ownership within multinational firms. In section 5.3, it is shown that the results in the present paper cannot be explained by differences in statutory tax rates across countries.

It is further found that much of the increase in innovation can be attributed to inventors based in the country of the acquiring firm's headquarters, while innovation in the country of the target firm's headquarters tend to decrease. The main reason for this relocation seems to lie in the higher level of innovation in acquiring firms before cross-border M&As. The asymmetry of effects among acquirers and targets increases with pre-acquisition differences in patent stocks, indicating a relocation of innovative activities towards more efficient usage within multinational firms across countries.

The estimated effects cannot be explained by cross-country variation in statutory corporate tax rates, suggesting that the role of transfer pricing is limited for the effects of M&As on innovation estimated in the present paper. This result, together with the fact that similar effects are found for citation-weighted patents and R&D expenditures, suggests that the estimated effects indicate an overall increase in innovation activity rather than a change in intellectual property (IP) strategy. It is further found that the increase in innovation is also accompanied by a growth of sales and productivity from the perspective of the merged entity. This implies that there might be aggregate gains from cross-border M&As.

The rest of this paper is organized as follows. Section 2 summarizes the related literature, section 3 describes the empirical strategy, and section 4 provides a description of the data. Results of the empirical analysis are presented in section 5 and section 6 concludes.

2. Related literature

This paper is related to several strands of literature that look at M&As from the perspective of international economics, industrial organization, corporate finance, and strategic management.⁷ It is useful to discuss the various motives for cross-border M&As identified by this literature since the effects on innovation are likely to depend on the motivation behind the deals.

Only recently, cross-border M&As started to receive more attention in the field of international economics. One implication of this literature is that the motives for international M&As can be quite different from those for greenfield investments.⁸ Cross-border M&As can, for instance, be conducted to access the complementary firm-specific assets of

⁷ The literature on cross-border M&As from the perspective of the management literature is surveyed in Shimizu et al. (2004).

⁸ E.g., Nocke and Yeaple (2007, 2008) argue that FDI that is motivated by production cost differences across countries usually takes the form of greenfield investments. See Blonigen (2005), Greenaway and Kneller (2007) or Helpman (2006) for an overview of the determinants of FDI in general.

acquisition targets (Nocke and Yeaple, 2008; Norbäck and Persson, 2007). Often, these complementary assets will be of an intangible nature, such as know-how, patents, and innovative products which increase the returns to R&D and thus spur innovation in the merged entity.⁹

Recent research argues that cross-border M&As can also be undertaken to gain access to foreign markets. For instance, foreign acquisition targets might use the acquiring firm's existing distribution channels (Guadalupe et al., 2012) or acquirers may choose target firms that have previously invested in export networks (Blonigen et al., 2012) or that possess market-specific capabilities such as marketing expertise (Nocke and Yeaple, 2007).¹⁰ Improved market access can induce innovation by increasing the incentives to invest in cost-reducing or quality-enhancing activities, since the sunk costs of these activities can then be applied to a larger production output (Guadalupe et al., 2012).¹¹

Another potentially important motive for M&As is the strengthening of market power (e.g. Kamien and Zang, 1990; Neary, 2007; Horn and Persson, 2001). M&As inducing a reduction in competition have a theoretically ambiguous effect on innovation incentives. On the one hand, reduced competition will increase market share and margins – and thus the output to which cost reductions or quality-improving innovations can be applied. On the other hand, in an oligopolistic market, a reduction in competition could decrease innovation incentives as it tends to lower the sensitivity of demand to enhanced efficiency or quality.¹²

M&As might also decrease innovation where debt financing is used, as that will tend to raise the costs of external funds for R&D (Long and Ravenscraft, 1993), or where they are non-profitable and arise only out of a manager's utility maximization (Shleifer and Vishny, 1988). In addition, M&As might also decrease innovation in the resulting entity through increased organizational complexity and a disruption of established routines (Hitt et al., 1991, Hitt and

⁹ Efficiency gains through complementary assets are also an important motive for M&As in the literature outside of international economics (e.g. Jovanovic and Rousseau, 2008; Röller et al., 2001). Since empirical evidence indicates that cross-border M&As are rarely associated with input-output linkages (see, for instance, Hijzen et al., 2008), the discussion in this section primarily focuses on horizontal M&As.

¹⁰ Several theoretical and empirical contributions argue that FDI is sometimes motivated by the desire to build an export platform (see e.g. Blonigen, et al., 2007; Ekholm et al., 2007), especially in a tariff-free block such as the European Union (Neary, 2002).

¹¹ Related to that, there is substantial evidence that market size in general, and exporting as a response to falling trade costs in particular, increases the incentives to invest in innovation. See e.g. Cohen and Levine (1989) for an overview of innovation and market structure and, among others, Bustos (2011) and Aw et al. (2007, 2008) for analyses of exporting and innovation.

¹² The overall effect of product market competition on innovation depends on market characteristics, the type of innovation, and the degree of R&D spillovers (see, for instance, Vives, 2008 and Schmutzler, 2010, for recent discussions).

Hoskisson, 1990; Ahuja and Katila, 2001). The empirical analysis in this paper indicates whether international M&As in European countries increase or decrease innovation in merging firms on average.

Besides the effects of M&As on innovation in the merged entity, both from a theoretical and from an economic policy point of view it is of interest to see where innovation takes place. Thus, this paper also studies the effects of international M&As on the relocation of innovative activity. The location of innovative activity might change for several reasons after cross-border M&As. First, M&As could be accompanied by a relocation of economic activity towards more efficient firms (Neary, 2007; Breinlich, 2008; Jovanovic and Rousseau, 2008). Further, there are incentives for the concentration of innovation activities at corporate headquarters beyond the effects on firms' general activities. For instance, the knowledge capital model (Carr et al., 2001) explains the existence of multinational enterprises by firm-specific assets which are costly to replicate but can be transferred to foreign subsidiaries. This induces multinational firms to concentrate activities like R&D at corporate headquarters. Sanna-Raddacio and Veugelers (2007) argue that there are further benefits to centralizing R&D due to economies of scale and a reduced risk of technology spillovers to competitors (see also Kumar, 2001). The empirical analysis in the present paper investigates whether acquirers and targets will be affected asymmetrically and under which circumstances a concentration of innovation activity is more likely.

The overall effect of cross-border M&As on innovation is, due to the various factors discussed above, unclear from a theoretical point of view. Thus, the research question ultimately boils down to an empirical matter. Cassiman et al. (2005) and Veugelers (2006) provide an overview of existing empirical studies on the impact of M&As on innovation which have yielded mixed results. Most of these studies analyze domestic acquisitions or do not explicitly differentiate between international and domestic M&As.¹³ In contrast to this literature, the present paper has an explicit focus on cross-border M&As.

Empirical evidence on the effects of international M&As is so far mostly limited to target firms and has yielded mixed results as well.¹⁴ For instance, Guadalupe et al. (2012) find that foreign acquisitions are accompanied by technology upgrading in acquisition targets in Spain and that this effect is mostly concentrated among firms that start exporting through the foreign parent after acquisition. Garcia-Vega et al. (2012) analyze the heterogeneous effects

¹³ See Bena and Li (2014) for a recent contribution.

¹⁴ See Stiebale and Reize (2011) for a more detailed overview of the literature on foreign ownership and innovation.

on R&D expenditures in Spanish target firms according to the investors' origin. They find negative effects on internal R&D if acquirers are located in countries with a higher technological development but positive effects if the acquirer comes from a country of lower technological development. The downsizing of internal R&D seems to be accompanied by increased R&D purchases from foreign parents located in technologically advanced countries. Stiebale and Reize (2011) find that foreign acquisitions lead to a reduction of R&D expenditures in German acquisition targets on average. In contrast, Bertrand (2009) estimates positive effects on the R&D intensity of acquired French firms, and Bertrand et al. (2012) find that acquired firms invest more in R&D than subsidiaries established through greenfield investments. All these papers lack evidence of how international M&As affect innovation in the merged entity as a whole. While the present paper includes an analysis of effects on target firms as well, it also estimates impacts on acquiring firms and the merged entity and analyzes how acquirers' characteristics affect post-acquisition innovation in target firms and vice versa. It also differs from the studies cited above as the focus is on patent-based metrics and thus on innovation new to the market rather than on innovation new to the (target) firm.

There is not much evidence on the effects of cross-border M&As on the innovation activities of acquirers. In an industry-level study, Bertrand and Zuniga (2006) find some positive effects on R&D in the acquirers' sector in the source country which mainly stem from industries with a medium technological intensity. Stiebale (2013) estimates positive effects on the R&D intensity of acquiring firms. His sample is, however, limited to small and medium-sized enterprises in Germany.¹⁵ There is, to the best of my knowledge, no empirical study that simultaneously analyzes the effects of cross-border M&As on innovation in the merged entity and on acquirers and acquisition targets involved in the same deal. This paper aims to fill this gap.

3. Empirical strategy

The aim of the empirical analysis is to estimate the effects of cross-border M&As on innovation outcomes and the relocation of innovative activity. The empirical model builds on a framework for analyzing innovative outcomes developed by Blundell et al. (1995). Since

¹⁵ Desyllas and Hughes (2010) provide some evidence that cross-border M&As have a more pronounced negative effect on the acquirer's R&D intensity than domestic M&As, but international M&As are not the focus of their study. 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 explicitly. Ahuja and Katila (2001), as well as Cloudt et al. (2006), analyze differences in a sample of merging firms according to cultural distance between acquirer and target firm, but they do not address the causal effects of international acquisitions per se.

innovation is measured as a count variable, the first moment of the model, the expected number of patents, is specified as:

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

$$\text{where } x_{it}'\beta = \sum_{k=1}^3 IMA_{i,t-k}\delta_k + \sum_{k=1}^3 DMA_{i,t-k}\phi_k + \rho G_{i,t-4} + z_{i,t-4}'\alpha + c_i + v_t.$$

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 firm is involved in M&A activity within the sample period, P_{it} equals the sum of patent applications of acquirer and acquisition target before the acquisition and the total number of patent applications in the merged entity after the M&A. An equivalent approach is used for control variables as well. This procedure is often employed in the M&A literature (e.g., Gugler and Siebert, 2007; Conyon et al., 2002a,b).

In an extension of the model, only patent applications with inventors located in the country of firm i 's headquarters are included in P_{it} . This variant of the model is estimated separately for acquirers and targets, together with the sample of control firms, to investigate whether cross-border M&As have asymmetric effects and lead to a relocation of innovative activity across countries.

IMA and DMA denote dummy variables that take the value of one if firm i has engaged in international and domestic M&A activity respectively in a given year. G_{it} is a measure of firms' lagged innovation activities. In the baseline specification, this is measured by the lagged number of patents, but alternative measures such as a lagged patent stocks and logarithmic transformations are considered as well. z_{it} denotes a vector of firm-, country-, and industry-specific control variables. c_i accounts for unobserved time-invariant firm heterogeneity, and v_t includes time dummies to capture macroeconomic changes common to all firms. All firm-specific explanatory variables are lagged to avoid including regressors that are affected by M&A variables or innovation outcomes. Industry and country dummies enter all estimations to control for permanent differences in market structure, and industry–country–pair specific trends are added to some specifications.

Several empirical challenges have to be addressed by the empirical model. First, the outcome variable, which is based on patent counts, is a non-negative integer variable with a high share of zeros. Further, it is likely that unobserved firm attributes like managerial ability, corporate culture, attitudes to risk, and technological or product characteristics are correlated with both the decision to engage in M&As and innovative activity. Finally, pre-acquisition

patent applications should be taken into account because of state dependence in innovative performance and pre-acquisition differences in innovation between acquirers, targets and other firms. Due to the presence of lagged values of the dependent variable, strict exogeneity of the regressors is violated by definition. It is also likely that there is feedback from innovative activity to future decisions about M&As and other variables like productivity and firm size.

To address these econometric problems, dynamic count data models are estimated. Following Blundell et al. (1995, 2002), pre-sample information on firms' patent applications is used to control for unobserved time-invariant firm heterogeneity.¹⁶ Compared with other panel data techniques for count data models, 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 lagged variables as instruments. It is particularly advantageous if the regressors are characterized by a high persistence (as typically found for innovation indicators – see e.g. Malerba and Orsenigo, 1999), since in this case lagged values of the regressors can be weak instruments for (quasi-)differenced equations. The baseline specification can be estimated by maximizing the pseudo likelihood based on the first moment of a Poisson model. Consistency requires only the first moment to be correctly specified and does not rely on the equality of mean and variance underlying the Poisson distribution (see, for instance, Blundell et al., 1995).

Although the estimation technique discussed so far accounts for a variety of control variables, time-invariant unobserved firm 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-acquisition innovation. This is because unobserved time-varying factors such as market and technology shocks – if not sufficiently accounted for by the control variables – might affect the profitability of both M&As and innovation activities. To check whether these correlations drive the previous results, linear and non-linear IV models are estimated in two alternative specifications. For the linear specification, the transformation $\ln(P_{it} + 1)$ is used to retain the exponential relationship

¹⁶This approach exploits the fact that patent applications are available for a much longer time span than other variables (see section 4 for details). Specifically, the average number of patent applications in the pre-sample periods and a dummy variable indicating at least one pre-sample patent are used for the baseline specification. Alternative measures are also considered as a robustness check in section 5.3. Blundell et al. (2002) show that pre-sample patent activity is a sufficient statistic for firms' fixed effects if the regressors follow a stationary iid process. Although the theoretical results on the properties of the estimator rely on an assumption that the number of pre-sample periods approaches infinity, Blundell et al. (2002) demonstrate that the pre-sample mean estimators perform well even when the number of time periods is small.

between the dependent variable and the regressors.¹⁷ The linear specification has the disadvantage that it does not account for the count nature of patent applications, but it has the advantage that standard test statistics such as weak instrument tests can be computed.

For the non-linear IV specification, following Windmeijer and Santos Silva (1997), a GMM estimator that is based on an additive error specification is applied. It is assumed that $P_{it} = \exp(x_{it}'\beta) + u_{it}$, which yields the moment condition: $E[P_{it} - \exp(x_{it}'\tilde{\beta}) | w_{it}] = 0$.¹⁸

w_{it} is a vector of instrumental variables which contains the exogenous variables included in x and at least one exclusion restriction, i.e. a variable which affects international M&As but not innovation activity and is also uncorrelated with unobservables affecting innovation. For both linear and non-linear IV models, at least one such exclusion restriction is necessary.

The first exclusion restriction used is based on changes in accounting uniformity and is measured as the yearly growth in the number of industry peers (at the two-digit industry level across countries in the sample) that use the same accounting standards (DeFond et al., 2011; Henock and Oktay, 2012). This variable is affected by the mandatory introduction of international financial reporting standards in Europe during the sample period. Suppose a firm has used a national accounting standard used by 10 industry peers in the same country in year $t-1$ and there are 50 industry peers in Europe. If all of these 50 firms adopt international accounting standards in year t , the accounting uniformity measure takes a value of 4. As argued by DeFond et al. (2011), a uniform state of accounting standards improves the comparability of financial performance across countries and thus reduces information asymmetries and facilitates cross-border investments. Evidence on the real effects of accounting is rather limited and it seems unlikely that accounting standards have a direct effect on innovation outcomes of firms.

The second IV measures the (physical) distance between potential acquirers and foreign acquisition targets. It is defined as the logarithm of the minimum distance of a firm (based on zip codes) to the closest border. This variable captures the well known proximity–concentration tradeoff (see e.g. Brainard, 1997) and the effect of trade costs on cross-border

¹⁷ This transformation is rather arbitrary but is commonly used in empirical studies (e.g. Bloom et al., 2011).

¹⁸ The moment condition contains a transformed constant term but all slope coefficients are identical to the vector β . Alternative estimation techniques are a full maximum likelihood estimator and the two-stage estimation procedure suggested by Terza (1998), both of which are based on relatively strong distributional assumptions, i.e. that the error terms of the patent equation and a first-stage Probit model are jointly normally distributed. These estimation procedures produced relatively unstable results and sometimes led to convergence problems, indicating that the distributional assumptions are not met in the present application. See Windmeijer (2008) for a discussion of alternative count data models.

M&As in particular (Hijzen et al., 2008). If acquirers use foreign acquisitions as an alternative to exporting, distance to the border should have a positive effect on the probability of undertaking a foreign acquisition. An acquirer might still choose to acquire a close-by firm within the acquisition target country to reduce transaction costs, as there is evidence that the costs of monitoring and knowledge transfer increase with distance (Blanc and Sierra, 1999; Degryse and Ongena, 2005). Hence, distance to the border should have a negative effect on the probability that a firm becomes a target for foreign acquisition.¹⁹

A potential concern with the measure of distance to foreign markets is that it might be correlated with regional characteristics that determine investment opportunities. However, most differences in regional innovativeness should be accounted for by the control variables. For the distance measure to be an invalid instrument, it would have to be correlated with the growth of patenting conditional on variables such as industry and country dummies, firm size, productivity and lagged patenting.

Several time-variant variables capture firm- and market-specific characteristics (the next section details the construction of the variables). A firm's size, measured as pre-acquisition sales, captures the potential to spread the gain from new or improved products over production output. Productivity accounts for differences in efficiency and captures the selection of heterogeneous firms into foreign markets (Helpman et al. 2004; Nocke and Yeaple, 2007, 2008). Capital intensity captures differences in production technologies. A liquidity ratio accounts for financial factors which might be a prerequisite to finance innovative activities and sunk costs for entry into a foreign market (see, for instance, Greenaway et al., 2007). A firm's age enters the model and serves as a proxy for experience and the stage of the product life cycle. The robustness of the model to the introduction of several time-variant industry- and country-specific variables is checked; these include domestic market growth rates, net entry rates, industry-level patent stocks, and industry-, country- and industry–country pair-specific trends.

4. Data and variables

Several different data sources had to be merged to construct the data set used in this paper. Data on cross-border and domestic M&As were extracted from the Zephyr database compiled by Bureau van Dijk. Zephyr provides information about the date and value of a

¹⁹ A similar IV is used, for instance, by Vannoorenberghe (2012) to instrument trade openness and by Stiebale (2013) to instrument foreign acquisitions. There is evidence that distance indeed plays an important role in the selection of acquisition targets (see e.g. Chakrabarti and Mitchell, 2013; Stiebale and Reize, 2011).

deal, the stake owned by the acquirer before and after acquisition, the source of financing, as well as a description of the transaction and of the firms involved in the deal. Compared with 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. A comparison of aggregate statistics derived from own calculations using the Zephyr database with those from the Thompson financial data reported in Brakman et al. (2007) shows that the coverage of transactions with a deal value above US\$10 million is very similar.²⁰

The second data source used was the Amadeus database, which provides information on financial data as well as ownership and subsidiary information for European firms.²¹ Different updates of the database have been merged to capture the entry and exit of firms and a broader sample to identify acquirers and acquisition targets. The Amadeus database was used to gather information on firms' industry affiliation, location (zip codes), sales, productivity, capital intensity and liquid assets. Unconsolidated accounts were used in order to separate economic activity in acquiring firms and acquisition targets and across countries. Amadeus firms were merged with the transaction data from Zephyr by a common firm identifier.

The main estimation sample contains 229,479 firm-year observations on 62,511 firms and 941 international M&As. A 50% ownership threshold is used to define M&As, which is common in the literature (e.g. Guadalupe et al., 2012). This sample is restricted to M&As within Europe and to transactions for which information on both acquirer and target are available. To isolate the effect of cross-border M&As, firms that engage in multiple acquisitions are excluded, which again is common in the M&A literature (e.g. Conyon et al., 2002a,b). This leaves 941 cross-border acquirers and 941 foreign acquisition targets in the main estimation sample. However, in section 5.3, the empirical framework is extended to include multiple acquisitions as well as acquisitions in which either the acquirer or the target firm (but not both) are located outside Europe.

Data on patent applications were taken from the Patstat database, which has been developed by the European Patent Office and the OECD. Patent applications were extracted for the years 1978–2008 for all the companies in the sample. The data on patent applications are merged with the other firm-level data sets using a computer-supported search algorithm

²⁰ US\$10 million is the minimum threshold for M&As to be included in the Thompson database. Calculations are available from the author upon request.

²¹ Amadeus is provided by Bureau van Dijk as well. In this paper, update numbers 88 to 184 are used. The Amadeus database has been used in numerous empirical studies on international trade and FDI (see, for instance, Budd et al., 2005; Helpman et al., 2004; Konings and Vandenbussche, 2005). 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. For this reason, it is combined with the Zephyr database in the present paper.

based on the firms' names, addresses, and zip codes. Every match was checked manually to ensure high data quality.

As it is possible that some firms file patents via subsidiaries or parent companies, data on subsidiaries for each company from the Amadeus database were extracted as well. Further, the data include information on inventors and their location, which enables the separation of the regional creation of an innovation from patent ownership. The main outcome variable is the number of patent applications filed with the European Patent Office per year. The focus on European patents avoids international differences in patenting procedures affecting the results. Only patents that were ultimately granted were used but they are dated back to the application year to account for the time lag between application and grant of a patent. A firm's patent stock is defined as the cumulative number of patent applications between 1978 and the current year, assuming a 15% yearly depreciation rate (following the procedure used by, e.g., Griliches, 1998; Hall et al., 2005).

Using patents as an innovation indicator has both advantages and disadvantages over alternative measures (see e.g. Griliches, 1998). In contrast to R&D expenditures, patents are (at least an intermediate) innovation output indicators and thus also account for the effectiveness with which innovation is pursued. Further, as the number of patents is derived from administrative data, this indicator does not have to rely on self-reported measures of new products and processes, which are often used in innovation studies. Patenting is costly and a granted patent requires a certain degree of novelty, and this reduces the risk of counting innovations of little relevance. Finally, the number of patents is a well established indicator of innovation which has been used in several recent studies²² and patent applications seem to be highly correlated with other common indicators of innovative performance (e.g. Hagedoorn and Cloudt, 2003; Griliches, 1998).

The downside of taking patents as an innovation indicator is that not every invention becomes patented, and - depending on firms' innovation strategies - firms may make more or less use of formal IP rights protection (e.g. Hall and Ziedonis, 2001; Ziedonis, 2004). It can also be expected that there will be substantial variation in the value of patented innovations. To address these problems, two alternative measures are used. First, the results for patent counts are compared with those using citation-weighted patents, which are likely to be correlated with the importance of innovations. If cross-border M&As induce an increase (decrease) in patenting for strategic reasons, we should see a decline (rise) in the average

²² See, for instance, Aghion et al. (2005, 2009, 2013), Bena and Li (2014) and Seru (2014).

number of citations per patent (cf. Bloom et al., 2011). Second, R&D investments are used as an alternative outcome variable, although, unfortunately, most companies in Amadeus do not disclose their R&D expenditures. This information is therefore complemented with data from the European R&D scoreboard (European Commission, 2011), but it was possible to collect this information for only 2,638 firms and 9,600 observations. Hence, this variable is used only in a robustness check on a reduced sample. Finally, to construct regressors at the industry level, data from Eurostat and the OECD STAN database are used.

The empirical analysis focuses on European firms which are either active in manufacturing or in knowledge-intensive (non-financial) service sectors such as information technology, telecommunications, transport, R&D, and business-related services (NACE Rev1.1 / ISIC Rev 3.1 codes 15-37, 62-64, 72-74). This is to ensure a focus on industries in which innovation and patenting are particularly important. The time period spans the years 1997-2008. Summary statistics and descriptions of variables used in the empirical analysis can be found in Table 1. The statistics in Table 1 are based on consolidated measures, that is, the sum of acquirer and target characteristics before the acquisition and merged entities after an M&A.²³ Table 2 compares pre-acquisition statistics for firms that engage in cross-border M&A with statistics for the remaining (control) firms. The average innovation intensity of acquiring firms engaging in international M&A is considerably higher than in non-merging firms and in acquisition targets. This holds for the number of patent applications, patent stocks, citation-weighted patents and R&D expenditures. However, acquirers, targets, and control firms also differ in other dimensions which are likely to affect innovation.

Total factor productivity (TFP) is computed as a residual from a productivity regression using the method proposed by Olley and Pakes (1996). Firm size is measured by sales. Working capital is defined as current assets less current liabilities relative to total assets. Capital intensity is measured as tangible fixed assets relative to sales. The figures are in line with some stylized facts from the trade and FDI literature (e.g. Greenaway and Kneller, 2007) – multinational enterprises are larger and more productive than domestic firms. In the present data set, this is true for both acquirers and international acquisitions targets even before acquisitions take place. Further, acquirers are on average multiple times larger than acquisition targets and they are characterized by higher TFP.

²³ Consolidated measures are constructed from individual unconsolidated accounts of acquirers and targets rather than from the consolidated accounts reported in Amadeus. For variables such as firm age and distance, as well as industry- and country-level variables, indicators for merging firms are based on the larger entity (in most cases the acquiring firm).

Table 3 shows the sample distribution of cross-border acquisitions across regions. The largest share of acquirers and acquisition targets is located in Western Europe. It seems that most international M&As take place within rather than across regions. For instance, there are relatively few cases where acquirers from Western or Northern Europe invest into Eastern European targets and vice versa. Trade theory provides a plausible explanation for this observation. As argued by Nocke and Yeaple (2008), FDI that is motivated by exploiting cross-country differences in production costs usually takes the form of greenfield investment, while international M&As are often conducted to access new markets or complementary firm-specific assets. Table A1 in the appendix shows the distribution of international M&As across industries. The share of acquisitions is above average in knowledge-intensive industries such as chemicals, machinery and equipment, and IT services, but a high share of international acquisitions also takes place in the food industry and in business-related services.

5. Results

5.1 Main results

Table 4 shows the results from the dynamic Poisson regression models (as described in section 3) of patent counts on a dummy variable taking on value one if there was a cross-border M&A between $t-1$ and $t-3$ and further controls for consolidated companies. In column (1), only controls for lagged patenting, pre-sample patenting (to capture unobserved heterogeneity), domestic M&As, country, industry and time dummies are included. Further selection controls, as described in the previous section, are added to the specification in column (2). Column (3) uses citation-weighted patents as the outcome variable, and in columns (4) and (5), separate effects for each year after an M&A are estimated. Full estimation results including control variables are contained in Table A2 in the Appendix.

Without selection controls (column 1), post-acquisition patenting activity in the international merged entity is more than 80 log points higher than in control firms. When selection controls are added, this difference drops substantially (column 2) but remains economically and statistically highly significant, indicating an increase of about 30% in innovation measured by patenting after a cross-border M&A.²⁴

A potential concern with the use of patents as an innovation indicator is that M&As might increase the incentives to patent innovations more than the incentives to create new knowledge. However, if that was the case, we should see a fall in citations per patent and thus

²⁴ Due to the exponential relationship between the dependent variable and the regressors, this is computed as $\exp(0.274)-1$.

a smaller association between international M&As and citation-weighted patents compared with non-weighted patents. As column (3) shows, using citation-weighted patents instead of simple patent counts yields very similar results. Hence, the estimates are clearly not in line with cross-border acquisitions contributing solely to changes in IP strategies.²⁵ In section 5.3, it is verified that there is a positive association between international M&As and innovation input, measured by R&D expenditures, as well.

In column (4), the effects of international M&As are estimated separately for three years. The results indicate that the effect on innovative activity is increasing over time. Column (5) shows that the coefficient of the lead variables (IMA_{t+1} , IMA_{t+2} , IMA_{t+3}) as well as the contemporaneous effect (IMA_t) of international acquisitions are insignificant. This shows that increases in innovation materialize after rather than before the acquisition and that it takes some time for international M&As to affect innovation. The time lag of one year seems to be a plausible result since previous research finds the highest correlations between R&D and patenting in the contemporaneous year (e.g. Hall et al., 1986). The absence of a time lag between R&D and patents can be explained by the fact that the largest part of innovation activities is related to development rather than to basic research. All in all, the results indicate a considerable increase in innovation activity starting one year after an international M&A.

Results for control variables, depicted in Table A2 in the Appendix, are largely as expected. Lagged TFP, size, capital intensity and working capital are positively correlated with innovation, younger firms seem to be more innovative, and there is state dependence in innovation activities, as indicated by the positive coefficients for lagged patenting and pre-sample patents. Interestingly, in contrast to international M&As, domestic M&As seem to have a negative impact on innovation. A possible explanation is that domestic M&As are more often undertaken to increase market power, while international M&As might be predominantly undertaken to gain access to foreign markets or to firm- and country-specific assets, as discussed in section 2.

Despite the overall positive association between international M&As and innovation output, the allocation of innovation activity between acquiring firms and acquisition targets is of both theoretical interest and policy relevance. Table 5 compares results using only patents

²⁵ Column (6) in Table A2 in the Appendix shows that the estimated effect on simple patent counts is even more similar, and below the coefficient for citation-weighted patents, if the estimation sample is restricted to time periods for which citations are available. The reduction in sample size is due to the restriction of a 2-year period for citations to be available. Due to the reduction in sample size and the truncation problem for citations at the end of the sample period, the remaining results presented are based on patent counts. However, all results of this paper are robust to the use of citation-weighted patents. Several additional robustness checks such as alternative estimation methods and dynamic specifications are discussed in section 5.3.

in which at least one inventor was located in the country of the acquirer's and target's headquarters with those of control firms. Control variables are based on unconsolidated companies and either acquirers or targets are included in the estimation sample together with non-merging controls. Columns (1) and (3) control only for previous patenting, time, country and industry dummies, while (unconsolidated) selection controls are included in columns (2) and (4). The table shows that the effects of international M&As are highly asymmetric. While patents with inventors based in the country of the acquirer's headquarters increase by more than 35% (column 2), patenting in the target's country is reduced by about 40% (column 4). Note that, as shown in Table 2, acquiring firms have much higher rates of pre-acquisition patenting than target firms. Hence, this translates into an overall positive effect of cross-border M&As on innovation.²⁶ The results indicate a relocation of innovation activity from foreign acquisition targets to acquirers - which are in most cases the more innovative and productive part of the merged entity.

Although the results discussed so far account for a variety of control variables, time-invariant unobserved heterogeneity, and feedback from innovation to future decisions about M&As, one might still be concerned that the estimated coefficients do not reflect a causal effect of international M&As on post-acquisition innovation. There could be unobserved time-variant factors such as productivity and technology shocks – if not sufficiently accounted for by the control variables – which affect the incentives for 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 innovation outcomes. To check whether these correlations drive the previous results, IV techniques are employed, as described in section 3.

Table 6 shows linear first-stage regressions for consolidated firms as well as for the probability of becoming an international acquirer or target. As discussed in section 3, international M&As are instrumented by distance to the closest foreign market and changes in accounting uniformity. As expected, accounting uniformity increases both the probability of being acquired and the propensity to engage in an international acquisition. For instance, an increase in accounting uniformity by one standard deviation increases the probability of being

²⁶ These numbers are computed as $\exp(0.309)-1$ for acquiring firms and $\exp(-0.548)-1$ for target firms. Note that the overall effect on the merged entity is not exactly equal to the (size-weighted) sum of target and acquirer effects, as some (although relatively little) innovation is undertaken in countries other than the location of target's and acquirer's headquarters. Full estimation results including control variables can be found in Table A3 in the Appendix. Also note that since the estimation sample is restricted to M&As for which information on both acquiring and target firm is available, and excludes firms with multiple acquisitions, the number of observations for acquirers and targets is identical. The number of observations in regressions for the merged entity is the same as well, since merging pairs are treated as one firm both before and after the M&A in these specifications. In all specifications, the comparison group consists of non-merging firms.

acquired by 0.106 percentage points.²⁷ This may sound like a small effect, but it is about equal to a quarter of the yearly acquisition probability among all firms (which is equal to 0.42%). Distance to the border has a negative impact on the propensity of being acquired but a positive effect on the likelihood of acquiring a foreign firm. For instance, an increase in the logarithm of distance by one standard deviation (about 60 log points or 190 kilometers / 118 miles) decreases the probability of being acquired in a given year by about 0.11 percentage points, more than a quarter of the yearly acquisition probability as well.

Besides the economic significance, both excluded instruments are individually and jointly highly significant. The Kleibergen-Paap statistic - which can be regarded as an approximation of the distribution of the weak-instrument test with non-iid errors - yields values between 24 and 32. This is higher than the critical value for a maximum IV bias of 10% of the weak identification test proposed by Stock and Yogo (2005).²⁸ The overall F statistic of the first stage is highly significant as well.

Results of the linear second stage are presented in columns (1)-(3) of Table 7, and results of the non-linear GMM estimator are presented in columns (4)-(6). The results of previous regressions are confirmed. There is a sizeable and highly significantly positive effect on innovation in the merged entity. This is accompanied by a positive effect on patents with inventors located in the country of the acquirer's headquarters but a decline in innovation activity that involves inventors in the country of the target firm's headquarters. Due to the transformation of the dependent variable, marginal effects on the number of patents cannot be derived from the linear specification. The estimated effects in the GMM model for the merged entity and acquirers (columns 4 and 5) are quite similar to the baseline specification, suggesting that a large part of the previously estimated positive correlation between innovation and cross-border M&As stems from a causal effect of international M&As on innovation. The estimated effect for target firms (column 6) is negative and in absolute terms larger than in the baseline estimation but less precisely estimated. The use of two different exclusion restrictions allows the application of over-identification tests. Results of the Hansen test statistics, depicted in Table 7, show that the null hypothesis of orthogonality between the residuals and the IVs cannot be rejected at conventional levels of significance in both linear and non-linear IV models. Hence, once we accept accounting uniformity as a valid IV, the test indicates exogeneity of distance to foreign markets and vice versa.

²⁷ This is calculated as 3.652×0.00029 based on the standard deviation of uniformity (reported in Table 1) and the coefficient estimate in column (3) of Table 6.

²⁸ The critical value for a maximum IV bias of 10% is 19.93 in the present case (Stock and Yogo, 2005).

All in all, the results confirm that cross-border acquisitions - possibly induced by variation in accounting uniformity and distance to foreign markets - have a positive effect on patent outcomes in the merged entity and are accompanied by a relocation of innovation activities from foreign acquisitions targets to the acquiring firm's country.

5.2 Heterogeneous effects: industry, country and firm characteristics

From a theoretical and from an economic policy point of view, it is important to understand whether there are positive impacts of international M&As in general or only under specific conditions. In this section, heterogeneous effects according to industry, country and firm characteristics are analyzed. As the previous results do not indicate that endogeneity problems are severe in the baseline Poisson regressions, heterogeneous effects are estimated using this specification.

The first dimension of heterogeneity is variation across industries. Previous research has mostly analyzed effects of M&As on innovation of manufacturing firms. To ease comparison with these studies, column (1) in Panel A of Table 8 shows separate effects across manufacturing (the base group) and service industries. Market access could be a more important motive for services, since the latter are usually less easily traded across borders. However, the results do not reveal significant differences across the two types of industry. Another aspect of industry heterogeneity refers to the type of innovation typically undertaken in an industry. For this purpose, industries are classified by whether process innovations are likely to be of more importance than product innovations.²⁹ As column (2) shows, the effects of international M&As in predominantly process innovating industries is a bit less pronounced, but the difference is not statistically significant. Hence, the overall positive effect of international M&As on innovation seems to hold across different types of industry.

In column (3), the second dimension of heterogeneity, cross-country differences, is analyzed using the classification from Table 3. Only a dummy variable indicating M&As from Northern and Western Europe to Southern or Eastern Europe (or vice versa) is included. The limited number of patenting firms that are affected by international M&As prevents a more detailed analysis. It seems that international M&As between similar countries have a larger impact on post-acquisition innovation outcomes. However, this effect disappears once a

²⁹ Tobacco (NACE Rev 1.1. code 16), basic metals (27), fabricated metals (28), transport (62), post and telecommunications (64) and various business related services (741, 745, 746, 747) were classified as predominantly process innovating industries (process industry = 1) and all others as product innovating industries (process industry = 0, the base group).

third aspect of firm heterogeneity - pre-acquisition differences in patent stocks between acquiring and target firms - is controlled for (column 4).

The results in column (4) also show that the positive effect of international M&As on innovation seems to increase with both the acquirer's and the target firm's pre-acquisition patent stock. Interestingly, the coefficient for *IMA* - which measures the effect of international M&A if both the acquirer's and the target's patent stock is 0 in this specification - becomes negative. This indicates that international M&As are unlikely to induce innovation if no innovative activity has been carried out before the acquisition and may even decrease the probability of starting to innovate. For a positive impact on the merged entity, the pre-acquisition stock of the acquirer (target) has to be large if the target (acquirer) has not been innovative previously. For instance, if the target's pre-acquisitions patent stock is 0 and the acquirer's patent stock is equal to the average for all investing firms (12.98; see Table 2), the predicted effect on the merged entity is approximately 0. The results show a positive and significant coefficient for the interaction term for acquirer's and target's patent stock. Thus, the effect of the acquirer's patent stock on post-acquisition innovation increases with the target's pre-acquisition patent stock and vice versa. This might indicate complementarities in acquirers' and targets' pre-acquisition technology.³⁰

The role of pre-acquisition firm characteristics is analyzed in further detail in Panel B of Table 8. As column (1) in Panel B shows, heterogeneous effects according to pre-acquisition patent stocks (and their interaction) cannot be explained by variation in firm size within acquirers and acquisition targets. In columns (3) and (4), separate effects on innovation carried out in the country of the acquirer's and the target firm's headquarters are depicted. The results show that pre-acquisition characteristics have an asymmetric effect on acquirers and targets. For instance, the larger the pre-acquisition knowledge stock of the acquirer, the more pronounced is the positive (negative) effect of international M&As on post-acquisition innovation in the acquirer's (target's) country. Similarly, a larger pre-acquisition knowledge stock of the target firm diminishes the asymmetric effect. Hence, relocation of innovation activities seems to be most pronounced for large pre-acquisition differences in capabilities. This indicates that innovation activities are not relocated from targets to acquirers per se but to the more efficient part of the multinational firm (which is in most cases located in the acquirer's country.)

³⁰ Although the patent data include information about technology classes, it is not straightforward to identify complementarities or substitutability within and across technology fields. It is thus left for future research to analyze this aspect in more detail.

While the asymmetric effects between acquirer country and target country are not in line with complementarities in *post*-acquisition innovation, it is possible that the target firm's *pre-acquisition* knowledge stock is valuable to the acquirer's research program and that this acquired knowledge is exploited in the acquirer's country rather than in both countries. Large technology-based firms often acquire small innovative companies whose technologies are integrated into the acquirer's research programs afterwards. A prominent example is the acquisition of the Australian company Where2, whose mapping software became the basis for Google Maps.³¹ Further, target firms might own patents which have previously blocked innovation on the part of acquiring firms.³²

5.3 Extensions and robustness checks

5.3.1 Cross-border M&As involving non-European countries and multiple acquisitions

So far, the analysis has been limited to acquisitions within Europe and to firms that have carried out only one acquisition. This restriction cannot be relaxed for estimates for the consolidated entity, as balance sheet data are limited to European firms and innovation indicators are constructed from patent applications at the European patent office. However, the effects of acquisitions on innovation carried out in the country of acquiring (target) firms based in Europe can be estimated even if the target (acquirer) is located in another part of the world.

Similarly, separate effects for the acquirer's and the target's country for firms involved in multiple deals can be estimated.³³ Therefore, the *IMA* dummy is recoded to take a value of one if a firm has acquired at least one foreign firm within the last three years. For target firms, *IMA* takes a value of one if they have been acquired at least once.³⁴ The number of acquisition targets increases not only because of non-European acquirers but also due to acquisition

³¹ See, for instance, "The new GE: Google, everywhere", *Economist*, January 18, 2014 (<http://www.economist.com/news/business/21594259-string-deals-internet-giant-has-positioned-itself-become-big-inventor-and>) and David (2013) for further examples.

³² For an analysis of the blocking potential of patents, see, for instance, Ziedonis (2004) and Grimpe and Hussinger (2009).

³³ In principle, multiple deals could be analyzed for the merged entity as well by constructing consolidated patent counts and balance sheet indicators using all firms that have been acquired by a particular (group of) firm(s) at any time. However, since all firms that ever acquired a firm with a missing value in one of the accounting items would have to be excluded, as would acquirers that ever invested outside Europe and their target firms, the increase in the number of cross-border M&As would be very limited. While it would be possible to collect balance sheet and patent data for some non-European firms, it would be difficult to construct comparable variables due to institutional differences in patent systems and different balance sheet reporting standards across countries and databases.

³⁴ Only a few targets had been acquired more than once and excluding them did not change the results notably.

targets that were acquired by firms that engaged in several acquisitions as these were excluded from the baseline specification.

Results using this alternative approach are shown in Table 9. The table confirms a statistically significantly positive effect on acquiring firms (columns 1 and 2). This positive effect for acquirers is even larger than in the baseline specification, which seems plausible, since *IMA* now picks up multiple acquisitions as well. Column (2) shows that the effect of non-European M&As is somewhat smaller, but the overall effect (0.641-0.121) is still large and statistically significant. For target firms, the effects are smaller in absolute terms than in the baseline regressions. A likely explanation is that acquirers which invest in multiple acquisition targets may not relocate innovation activities every time they invest in a new target firm.

Unfortunately, it is not possible to analyze the worldwide effect of this extended sample of M&As due to a lack of information on non-European firms. However, the estimated coefficients, together with the fact that acquirers are characterized by a much higher degree of pre-acquisition patent activity than acquisition targets, indicate that firms within Europe can still benefit from inward and outward international M&As on aggregate.

5.3.2 Alternative outcome variables, identification strategies and robustness checks

As discussed in section 4, the use of patent-based innovation indicators has both advantages and disadvantages over alternative measures. Therefore, as a further robustness check, logarithmic R&D expenditures are used as an innovation (input) indicator for a reduced sample, as described in section 3. Table 10 shows the results from linear fixed-effects regressions. Unfortunately, this regression can be run only for the merged entity, since R&D expenditures have to be constructed from consolidated information to end up with a reasonable number of observations. The table shows that there is a positive association between international M&As and R&D which is of similar magnitude to the results for patenting.³⁵

As an additional robustness check, a propensity-score matching combined with a DiD estimator is used to check robustness to the identifying assumptions of Poisson and IV regressions. An advantage of this approach over the use of IVs is that it does not rely on the

³⁵ Although only a small fraction of the original number of observations can be used, the number of M&As is nonetheless 330 (more than a third of the original sample). The substantially larger loss in the number of observations in the control group is because small firms rarely report R&D expenditures. Ideally, one would like to study the effects of M&As on R&D, and of M&As on patents conditional on R&D. However, it would need more observations on firms with a longer time series of R&D expenditures to construct a reasonable measure of an R&D stock and to estimate a knowledge production function, as, for instance, in Aghion et al. (2013).

validity of exclusion restrictions to identify a causal effect. Further, it does not require a linear relationship between control variables and innovation, and restricts the analysis to firms that are similar before the acquisition.

However, while the approach allows the selection into M&As to be based on time-invariant unobservables, it imposes the strong assumption of selection on time-variant observables. Both nearest-neighbor matching and propensity-score reweighting estimations are conducted.³⁶ To implement the propensity-score matching, a Logit model for the propensity score is estimated for the consolidated merged entity (before the M&A) and the control group. The dependent variable in the Logit model takes a value of one if two firms merge in the particular year. The matching procedure is performed with replacement and imposing common support. The change in $\log(\text{number of patents} + 1)$ compared with the pre-acquisition period is used as the outcome variable and all control variables from the baseline regression are employed as covariates.³⁷ In addition, the lagged patent stock is included to make sure that merged firms and matched controls have a similar knowledge stock and a similar trend in patenting before acquisition.

The results of the matching approach can be found in Table 11. The estimated coefficients, average treatment effects on the treated, are somewhat smaller than in the baseline and IV estimates. However, they have only a qualitative interpretation, due to the transformation of the dependent variable. The matching estimates confirm the positive effect of international M&As on innovation in the merged entity. A drawback of the matching estimator in the present application is that matching cannot be conducted within industry–country pairs due to a lack of the number of M&As and patenting firms for some industries and countries. Nonetheless, as Table A5 in the Appendix shows, the balancing property holds for the treatment and control group (this is also true for industry and country dummies not displayed in the table), although unmatched samples are very different. Results for the estimation of the propensity score can be found in Table A6 in the Appendix.

Table A7 shows the results of several further robustness checks using patent counts for the merged entity. It can be seen that the positive association between international M&As and innovation also holds for alternative estimation techniques such as a negative binomial model with pre-sample patenting or fixed effects as a control for unobserved heterogeneity, a fixed-effects Poisson model, and a linear fixed-effects model using the patent stock rather

³⁶ See e.g. Caliendo and Kopeinig (2008) for an overview of these methods and Busso et al. (2014) for an analysis of their finite-sample properties.

³⁷ Exclusion restrictions from the IV models are not used as conditioning variables in the matching approach, as recent research suggests that matching on variables which satisfy IV assumptions increases the amount of inconsistency of matching estimators (Wooldridge, 2009).

than patent counts as the outcome variable.³⁸ In Table A8, results from dynamic Logit regressions, estimating the probability of a least one patent application per year, are depicted. The table confirms the main results obtained from count-data regressions.

Alternative dynamics, such as controlling for a lagged patent stock and logarithmic transformations of pre-acquisition and pre-sample patenting, do not affect the main conclusion either, as columns (1)-(3) of Table A9 in the Appendix show. The results are also robust to controlling for time-variant industry- and country-specific variables such as industry-wide patenting, sales growth, and entry rates (column 4) and to industry- and country- (column 5) and industry–country pair-specific trends (column 6).

A possible concern is that innovation and patenting could be affected by transfer pricing and differences in tax rates across countries (see, for instance, Karkinsky and Riedel, 2012; Griffith et al., 2011). Although transfer pricing might be of relatively low importance in this paper, as the location of inventors rather than the location of ownership is analyzed, it is still possible that tax rates affect the location of R&D activities within firms. If the results obtained were affected by taxes, we should see that relocation of innovative activity is particularly pronounced for M&As in which the statutory corporate tax rates are lower in the acquirer's than in the target's country. For this purpose, differences in statutory corporate tax rates (from the Eurostat website) between acquirer and target firm were computed for each merging pair and interacted with *IMA*. Results including this additional regressor are reported in Table A10 in the Appendix. It seems indeed that higher tax rates in the acquirer's country are associated with fewer patents in the merged entity (column 1) and the acquirer's country (column 2) and more patents in the target's country (column 3). However, this does not explain the previous results, as the coefficient for *IMA* - which measures the effect of international M&As if the tax rate differential equals 0 in this specification - is (in absolute terms) even larger than in the baseline specification for all three specifications. Further, the role of tax rates for the relocation of innovation in the estimation sample is limited, as, for the merging pairs, the average statutory tax rate in the acquirer's country is (slightly) higher than in the target's country (the difference is equal to 0.53 percentage points on average).

Finally, some preliminary evidence on other outcome variables, sales growth and productivity growth, is provided. The results are presented in Table 12. For the consolidated entity, there seems to be a positive, although only weakly significant, effect on productivity (column 1) and a large and highly significantly positive effect on sales growth (2). Similar

³⁸ The estimated coefficient for the patent stock is much smaller than for patent counts but indicates a similar increase in patenting, as yearly patent counts are on average equal to about a fifth of the patent stock (see Table 1).

effects are estimated for acquiring firms: the effect on sales growth is large and significant (column 4) but the effect on productivity is insignificant (column 3). However, this does not seem to be accompanied by a relocation from target firms. In contrast, targets display higher growth of both productivity (column 5) and sales (column 6) after acquisition. Hence, it seems that there are specific features to innovation activities distinct from the overall organization of production. As discussed in section 2, there are incentives for a geographical concentration of headquarter activities such as R&D and innovation which do not necessarily apply to general production.

A possible explanation for the lack of significant productivity effects in acquiring firms might be that it takes more time for innovations to affect productivity. Target firms seem to benefit in terms of higher sales and productivity, indicating that part of the knowledge generated in the acquirer's country (possibly before the acquisition) is transferred to acquisition targets. This interpretation is in line with recent empirical contributions which argue that foreign target firms adopt new machines and implement organizational changes after being acquired by a foreign firm (e.g. Guadalupe et al., 2012). In the present paper, the focus is on patents, which capture innovations new to the market. Hence, the relocation of innovative activity is not at odds with a transfer of existing knowledge after foreign acquisitions.

6. Conclusion

The effects of cross-border M&As are subject to a controversial debate in economic policy, especially if they take place in knowledge-intensive industries. This paper analyzes the impact of cross-border M&As on measures of innovation output – constructed from patent data – of European firms and the relocation of innovation activity within multinationals across countries. After a cross-border M&A, there seems to be a large increase in patenting within the merged entity of more than 20% within three years. This correlation is also visible within industries and countries and after controlling for a large set of firm-level characteristics, including pre-acquisition patent activity and unobserved firm heterogeneity.

Applying variants of instrumental variable techniques which exploit variation in distance to foreign markets across firms and variation in accounting standards across industries, countries and time, it is found that these correlations seem to arise from a causal effect of cross-border M&A on innovation. The results are robust to alternative innovation indicators such as citation-weighted patents and R&D expenditures and the application of a

variety of alternative estimation methods, including propensity-score matching and reweighting approaches combined with a difference-in-differences estimator. The overall positive effect seems to hold across industries and countries with different characteristics. The largest impact of cross-border M&As on innovation is found when the pre-acquisition patent stocks of acquiring and target firms are both large. This indicates that access to innovative assets in target firms is an important factor for post-acquisition innovation outcomes.

Splitting the effect of cross-border M&A by country of invention, it is found that the positive association with post-acquisition patenting is mainly driven by innovations generated in the country of the acquirer's headquarters, while there is on average a decrease in innovations generated in the target's country of more than 40%. This implies that cross-border M&As are accompanied by a relocation of innovative activity across countries. The main reason for this relocation seems to lie in the higher degree of innovation in acquiring firms before cross-border M&As. The asymmetry of effects among acquiring and target firms is most pronounced if pre-acquisition differences in patent stocks are large. This implies that innovation activity is relocated towards more efficient parts of the multinational company rather than from target to acquiring firms per se.

At first glance, the results provide some rationale for decision makers in policy to block inward foreign acquisitions in their country, as innovation in target firms seems to decrease on average after international M&As. This is particularly the case if spillovers from innovative activity are localized. However, the results also suggest that restrictions on cross-border M&As may reduce global innovation activities - and hence long-term economic growth and welfare - as they prevent a relocation of innovation activity towards more efficient usage and enhanced innovation in acquiring countries. Therefore, restricting inward foreign acquisitions may be a myopic strategy if it induces restrictions from other countries as a response.

For future research, it might be interesting to analyze a sample of firms which contains information on innovation indicators about acquirers and targets around the world. It would also be interesting to look at other outcome variables in more detail and to link empirical results to a theoretical model that analyzes the matching between acquiring and target firms and heterogeneous effects of cross-border M&As among them.

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Tables

Table 1: Summary statistics

Variable		Mean	SD
patent stock	cumulated number of patents, 15% depreciation	5.271	32.676
patents	number of patent applications per year	1.031	7.729
patent cite	number of patents, weighted by forward citations	7.178	65.461
sales	sales in €1,000	15,383	131,739
working capital	(current assets - current liabilities)/total assets	0.165	0.329
TFP	total factor productivity, relative to industry mean	-0.039	1.003
capital intensity	tangible fixed assets / sales	0.577	18.483
age	firm age in years	18.425	21.631
pre sample patents	average number of pre-sample patents (1978-2000)	0.095	0.845
IMA	= 1 if international M&A in current year	0.004	0.064
DMA	= 1 if domestic M&A in current year	0.015	0.121
R&D	R&D expenditures in €1,000 (reduced sample)	20,510	234,688
distance	distance to closest foreign market in 100km	2.744	1.547
accounting uniformity	growth #industry peers with same accounting practice	2.533	3.652

Notes: Statistics are based on 229,479 observations of consolidated companies.

Table 2: Mean values of key variables: merging firms and controls

	international M&A		
	control firms	acquirers	targets
patent stock	4.186	12.980	2.566
patents	0.783	3.081	0.236
patent citations	6.996	51.069	4.929
sales	9,694	181,917	47,818
working capital	0.161	0.136	0.128
TFP	-0.053	0.259	0.219
capital intensity	0.588	0.789	8.013
age	17.963	32.634	27.730
pre-sample patents	0.081	0.251	0.089
R&D	18,181	49,228	13,790

Notes: Statistics are based on unconsolidated companies. Values for acquirers and targets are based on pre-acquisitions periods. See Table 1 for definitions of variables.

Table 3: International M&As across regions

acquirer region	target region				all
	west	north	south	CEE	
western	203	40	66	53	362
northern	46	126	10	39	221
southern	135	8	88	30	261
CEE	8	1	6	82	97
All	392	175	170	204	941

Notes: Western Europe includes Germany, UK, Netherlands, Ireland, Belgium, France, Austria, Switzerland, Luxemburg. Southern Europe includes Spain, Italy, Portugal, Greece, Malta, Cyprus. Northern Europe includes Sweden, Norway, Finland, Denmark, Iceland. Central and Eastern Europe (CEE) includes Estonia, Latvia, Lithuania, Croatia, Czech Republic, Romania, Russia, Serbia, Slovakia, Ukraine, Slovenia.

Table 4: Cross-border M&As and innovation in the merged entity

	(1)	(2)	(3)	(4)	(5)
	patents	patents	cite weighted	patents	patents
IMA(t-1/t-3)	0.865*** (0.045)	0.274*** (0.046)	0.262*** (0.059)		
IMA(t-1)				0.236*** (0.077)	0.239*** (0.077)
IMA(t-2)				0.263*** (0.072)	0.266*** (0.072)
IMA(t-3)				0.384*** (0.078)	0.386*** (0.079)
IMA(t)					0.034 (0.089)
IMA(t+1)					-0.010 (0.107)
IMA(t+2)					0.042 (0.129)
Selection controls	No	yes	yes	yes	yes
Observations	229,479	229,479	191,451	229,479	229,479
Pseudo R squared	0.629	0.702	0.780	0.703	0.703
Pseudo log likelihood	-17,886	-14,358	-51,128	-14,321	-14,321

Notes: *** (**,*) denotes significance at the 1% (5%, 10%) level. Table shows the results from count-data regressions for consolidated companies. The dependent variable is the number of patents per year. In column (3), patents are weighted by forward citations. IMA is an indicator variable taking a value of one if two firms in different countries merged in the respective years. t refers to the year in which patent applications are measured. IMA(t-1)(t-2, t-3) therefore measures the correlation between IMA and patenting one (two, three) years after the international M&A, while IMA(t+k) measures the correlation between IMA and patenting k years before the M&A. Standard errors (clustered by firm) are shown in parentheses. All regressions include industry, country and time dummies and control for pre-merger and pre-sample patenting and domestic M&As. Results for selection controls can be found in Table A2.

Table 5: Cross-border M&A and innovation in the acquirer's and target's countries

	(1)	(2)	(3)	(4)
	acquirer	acquirer	target	target
IMA(t-1/t-3)	0.429*** (0.053)	0.309*** (0.047)	-0.947*** (0.188)	-0.548*** (0.184)
Selection controls	No	yes	no	yes
Observations	229,479	229,479	229,479	229,479
Pseudo R squared	0.433	0.602	0.395	0.543
Pseudo log likelihood	-26,522	-18,630	-19,557	-14,759

Notes: *** (**, *) denotes significance at the 1% (5%, 10%) level. IMA is an indicator variable taking a value of one if a firm acquired a foreign firm (was acquired by a foreign firm) in the respective year. Standard errors (clustered by firm) are shown in parentheses. All regressions include industry, country and time dummies and controls for pre-merger and pre-sample patenting and domestic M&As. Results for selection controls can be found in Table A3. Only patents with inventors located in the firms' headquarters are counted. Patent counts and control variables are based on the acquirer in columns (1) and (2) and on the target in columns (3) and (4).

Table 6: First-stage regressions

	(1)	(2)	(3)
	consolidated	acquirer	target
accounting uniformity	0.00019*** (0.00006)	0.00021*** (0.00006)	0.00029*** (0.00007)
ln(distance)	0.00213*** (0.00049)	0.00215*** (0.00049)	-0.00171*** (0.00027)
Observations	229,479	229,479	229,479
R squared	0.040	0.048	0.118
F-test	14.78	15.10	17.25
Kleinbergen Paap rk Wald F	28.94	32.19	24.53
Hansen (p value)	0.105	0.585	0.192

Notes: *** (**, *) denotes significance at the 1% (5%, 10%) level. Standard errors (clustered by industry) are shown in parentheses. All regressions include industry, country and time dummies as well as selection controls. Results for selection controls can be found in Table A4. In column 1 (2, 3) variables are based on the merged entity (acquirer, target firm).

Table 7: Controlling for endogeneity: GMM and linear IV

	(1)	(2)	(3)	(4)	(5)	(6)
	linear IV	linear IV	linear IV	GMM	GMM	GMM
	consolidated	acquirer	target	consolidated	acquirer	target
IMA(t-1/t-3)	0.610*** (0.236)	0.454** (0.213)	-0.435*** (0.138)	0.270** (0.119)	0.509*** (0.138)	-1.567* (0.876)
Observations	229,479	229,479	229,479	229,479	229,479	229,479
(pseudo) R squared	0.227	0.239	0.184	0.616	0.312	0.287
F-test	20.923	19.712	14.479	-	-	-
Hansen (p-value)	0.105	0.585	0.192	0.796	0.154	0.748

Notes: *** (**, *) denotes significance at the 1% (5%, 10%) level. Standard errors (clustered by industry) are shown in parentheses. IMA is an indicator variable taking a value of one if two firms in different countries merged in the respective years. All regressions include industry, country and time dummies, and further selection controls. In columns 1&4 (2&5,3&6), variables are based on the merged entity (acquirer, target firm).

Table 8: Heterogeneous effects

<i>Panel A: Country and industry characteristics</i>				
	(1)	(2)	(3)	(4)
IMA(t-1/t-3)	0.260*** (0.050)	0.314*** (0.048)	0.365*** (0.053)	-0.269*** (0.071)
IMA *service industry	0.071 (0.105)			
IMA * process industry		-0.109 (0.122)		
IMA(north/south, east/west)			-0.264*** (0.087)	-0.042 (0.104)
IMA *patent stock acquirer (t-4)				0.020*** (0.001)
IMA *patent stock target (t-4)				0.015*** (0.002)
IMA * patent stock acquirer (t-4) * patent stock target (t-4)				0.011*** (0.001)
Observations	229,479	229,479	229,479	229,479
Pseudo R squared	0.702	0.705	0.702	0.707
Pseudo log likelihood	-14,358	-14,241	-14,353	-14,120
<i>Panel B: Firm characteristics</i>				
	(1)	(2)	(3)	(4)
	consolidated	consolidated	acquirer	target
IMA(t-1/t-3)	0.366*** (0.107)	-0.254*** (0.059)	-0.027 (0.061)	-0.558*** (0.216)
IMA *patent stock acquirer (t-4)	0.019*** (0.001)	0.021*** (0.001)	0.012*** (0.001)	-1.377* (0.810)
IMA *patent stock target (t-4)	0.014*** (0.002)	0.014*** (0.001)	-0.062* (0.035)	0.218*** (0.040)
IMA * patent stock acquirer (t-4) * patent stock target (t-4)	0.012*** (0.001)	0.010*** (0.001)	0.010*** (0.001)	0.203 (0.127)
IMA *size acquirer (t-4)	-0.033 (0.024)			
IMA *size target (t-4)	-0.007 (0.040)			
IMA * size acquirer (t-4) * size target (t-4)	-0.003 (0.005)			
Observations	229,479	229,479	229,479	229,479
Pseudo R squared	0.705	0.702	0.702	0.707
Pseudo log likelihood	-14,241	-14,358	-14,353	-14,120

Notes: *** (**, *) denotes significance at the 1% (5%, 10%) level. Table shows the results from count-data regressions. The dependent variable is the number of patents per year. IMA is an indicator variable taking a value of one if two firms in different countries merged in the respective years. Standard errors (clustered by firm) are shown in parentheses. All regressions include industry, country and time dummies as well as selection controls.

Table 9: Inclusion of multiple acquirers and acquisitions outside of Europe

	(1)	(2)	(3)	(4)
	acquirer	Acquirer	target	target
IMA(t-1/t-3)	0.613*** (0.042)	0.641*** (0.043)	-0.151** (0.061)	-0.163*** (0.062)
IMA non-Europe		-0.121*** (0.045)		0.053 (0.051)
Observations	232,179	232,179	251,721	251,721
Pseudo R squared	0.649	0.649	0.598	0.598
Pseudo log likelihood	-18105	-18101	-16925	-16924

Notes: *** (**, *) denotes significance at the 1% (5%, 10%) level. Table shows the results from count-data regressions. The dependent variable is the number of patents per year. IMA is an indicator variable taking a value of one if two firms in different countries merge in the respective years. "IMA non-Europe" takes a value of one if a European firm acquired a non-European firm (columns 1 and 2) or a non-European firm acquired a European firm. Standard errors (clustered by firm) are shown in parentheses. All regressions include industry, country and time dummies as well as selection controls.

Table 10: Cross-border M&As and R&D in the merged entity

	(1)	(2)	(3)	(4)
IMA(t-1/t-3)	0.219*** (0.056)		0.224*** (0.056)	
IMA(t-1)		0.127 (0.100)		0.127 (0.100)
IMA(t-2)		0.148* (0.079)		0.147* (0.079)
IMA(t-3)		0.262*** (0.082)		0.271*** (0.082)
Selection controls	no	No	yes	yes
Observations	9,607	9,607	9,607	9,607
R squared	0.014	0.014	0.016	0.016

Notes: *** (**, *) denotes significance at the 1% (5%, 10%) level. Table shows the results from linear fixed-effects regressions for consolidated companies. The dependent variable is the logarithm of R&D expenditures. IMA is an indicator variable taking a value of one if two firms in different countries merged in the respective year. Standard errors (clustered by firm) are shown in parentheses. All regressions include firm and time fixed effects. Selection controls in columns (3) and (4) include all time-variant control variables from the patent regressions.

Table 11: Propensity-score matching and DiD: average treatment effects on the treated

	(1)	(2)	(3)	(4)	(5)	(6)
	t+1	t+1	t+2	t+2	t+3	t+3
matching approach	1-to-1	reweighting	1-to-1	reweighting	1-to-1	reweighting
IMA(t-1/t-3)	0.084*** (0.031)	0.087*** (0.024)	0.112*** (0.035)	0.111*** (0.028)	0.133*** (0.038)	0.126*** (0.031)
Observations	1,759	220,316	1,759	220,316	1,759	220,316
R squared	0.005	0.003	0.006	0.004	0.008	0.004

Notes: *** (**,*) denotes significance at the 1% (5%, 10%) level. Standard errors (clustered by firm) are shown in parentheses. IMA is an indicator variable taking a value of one if two firms in different countries merged in the respective years. The outcome variables is $\ln(\text{patents}(j)+1) - \ln(\text{patents}(t-1)+1)$, based on consolidated firms, where t is the year of the merger and $j=t+1, t+2$ or $t+3$. All regressions include time dummies.

Table 12: Alternative outcome variables

	(1)	(2)	(3)	(4)	(5)	(6)
	TFP	sales	TFP	sales	TFP	sales
	consolidated	consolidated	acquirer	acquirer	target	target
IMA(t-1/t-3)	0.047* (0.025)	0.172*** (0.033)	0.038 (0.029)	0.176*** (0.040)	0.164*** (0.037)	0.269*** (0.051)
Observations	163,134	187,273	165,784	189,487	164,241	188,115
R squared	0.150	0.069	0.154	0.070	0.150	0.068

Notes: *** (**,*) denotes significance at the 1% (5%, 10%) level. Table shows the results from linear logarithmic growth regressions. IMA is an indicator variable taking a value of one if two firms from different countries merged in the respective year. Standard errors (clustered by firm) are shown in parentheses. All regressions include industry, country and time dummies as well as selection controls.

Appendix: Additional tables

Table A1: International M&As by industry

Industry	Share of M&As in %
Manufacture of food, beverages & tobacco	10.2
Manufacture of textiles	3.08
Manufacture of wearing apparel	0.32
Manufacture of leather and leather products	0.11
Manufacture of wood and wood products	1.38
Manufacture of pulp, paper and paper products	2.23
Publishing, printing and reproduction of recorded media	2.98
Manufacture of coke, refined petroleum products and nuclear fuel	0.43
Manufacture of chemicals and chemical products	9.78
Manufacture of rubber and plastic products	5.31
Manufacture of other non-metallic mineral products	2.66
Manufacture of basic metals	3.83
Manufacture of fabricated metals	4.68
Manufacture of machinery and equipment n.e.c.	7.97
Manufacture of office machinery and computers	0.64
Manufacture of electrical machinery and apparatus n.e.c.	2.55
Manufacture of radio, television and communication equipment	1.28
Manufacture of medical, precision and optical instruments	2.34
Manufacture of motor vehicles, trailers and semi-trailers	2.34
Manufacture of other transport equipment	0.64
Manufacturing n.e.c.	2.23
Air transport	0.43
Supporting and auxiliary transport activities	3.61
Post and telecommunication	0.74
IT-related services	5.31
Research and development	0.53
Business-related services	22.42

Table A2: Cross-border M&As and innovation in the merged entity

	(1) patents	(2) patents	(3) Citations	(4) patents	(5) patents	(6) patents
IMA(t-1/t-3)	0.865*** (0.045)	0.274*** (0.046)	0.262*** (0.059)			0.261*** (0.051)
IMA(t-1)				0.236*** (0.077)	0.239*** (0.077)	
IMA(t-2)				0.263*** (0.072)	0.266*** (0.072)	
IMA(t-3)				0.384*** (0.078)	0.386*** (0.079)	
IMA(t)					0.034 (0.089)	
IMA(t+1)					-0.010 (0.107)	
IMA(t+2)					0.042 (0.129)	
patents(t-4)	0.025*** (0.001)	0.010*** (0.000)	0.002*** (0.000)	0.010*** (0.000)	0.010*** (0.000)	0.020*** (0.001)
D(pre-sample patents)	5.374*** (0.041)	3.906*** (0.043)	5.065*** (0.020)	3.909*** (0.043)	3.909*** (0.043)	3.984*** (0.046)
pre-sample patents	0.041*** (0.003)	0.066*** (0.003)	0.021*** (0.000)	0.067*** (0.003)	0.067*** (0.003)	0.043*** (0.003)
DMA(t-1/t-3)	0.222*** (0.049)	-0.361*** (0.048)	-2.168*** (0.150)	-0.271*** (0.055)	-0.271*** (0.055)	-0.271*** (0.055)
log sales(t-4)		0.521*** (0.008)	0.496*** (0.005)	0.523*** (0.008)	0.522*** (0.008)	0.489*** (0.009)
working capital(t-4)		0.694*** (0.043)	0.142*** (0.028)	0.698*** (0.043)	0.697*** (0.043)	0.416*** (0.047)
TFP(t-4)		0.343*** (0.024)	-0.015 (0.011)	0.343*** (0.024)	0.343*** (0.024)	0.305*** (0.025)
capital intensity (t-4)		0.241*** (0.016)	0.064*** (0.008)	0.243*** (0.016)	0.243*** (0.016)	0.197*** (0.017)
log age		-0.165*** (0.017)	-0.684*** (0.009)	-0.162*** (0.017)	-0.161*** (0.017)	-0.120*** (0.019)
Observations	229,479	229,479	191,451	229,479	229,479	191,451
Pseudo R squared	0.629	0.702	0.780	0.703	0.703	0.708
Pseudo log likelihood	-17,886	-14,358	-51,128	-14,321	-14,321	-12,514

Notes: *** (**, *) denotes significance at the 1% (5%, 10%) level. Table shows the results from count-data regressions for consolidated companies. The dependent variable is the number of patents per year. In column (3), patents are weighted by forward citations. IMA is an indicator variable taking a value of one if two firms in different countries merged in the respective year. t refers to the year in which patent applications are counted. Standard errors (clustered by firm) are shown in parentheses. All regressions include industry, country and time dummies.

Table A3: Cross-border M&As and innovation in the acquirer's and the target's country

	(1) acquirer	(2) acquirer	(3) target	(4) target
IMA(t-1/t-3)	0.429*** (0.053)	0.309*** (0.047)	-0.947*** (0.188)	-0.548*** (0.184)
patents(t-4)	0.047*** (0.001)	0.024*** (0.001)	0.041*** (0.001)	0.027*** (0.001)
D(pre-sample patents)	3.568*** (0.041)	1.971*** (0.040)	2.361*** (0.100)	1.202*** (0.099)
pre-sample patents	0.349*** (0.013)	0.256*** (0.014)	1.221*** (0.050)	0.679*** (0.050)
DMA(t-1/t-3)	0.063 (0.057)	-0.535*** (0.052)	-0.086 (0.131)	-0.801*** (0.131)
log sales(t-4)		0.806*** (0.008)		0.754*** (0.010)
working capital(t-4)		0.463*** (0.059)		0.289*** (0.070)
TFP(t-4)		0.121*** (0.020)		0.236*** (0.024)
log capital intensity (t-4)		0.236*** (0.015)		0.256*** (0.018)
log age		-0.161*** (0.017)		-0.162*** (0.017)
Observations	229,479	229,479	229,479	229,479
Pseudo R squared	0.433	0.602	0.395	0.543
Pseudo log likelihood	-26,522	-18,630	-19,557	-14,759

Notes: *** (**, *) denotes significance at the 1% (5%, 10%) level. IMA is an indicator variable taking a value of one if a firm acquired a foreign firm (was acquired by a foreign firm) in the respective year. Standard errors (clustered by firm) are shown in parentheses. All regressions include industry, country and time dummies and controls for pre-merger and pre-sample patenting and domestic M&As. Only patents with inventors located in the firms' headquarters country are counted. Patent counts and control variables are based on the acquirer in columns (1) and (2) and on target in columns (3) and (4).

Table A4: Instrumental variable estimation first-stage results

	(1) merged entity	(2) acquirer	(3) target
accounting uniformity	0.00019*** (0.00006)	0.00021*** (0.00006)	0.00029*** (0.00007)
log distance	0.00213*** (0.00049)	0.00215*** (0.00049)	-0.00171*** (0.00027)
patents(t-4)	0.00021 (0.00056)	0.00005 (0.00026)	-0.00021*** (0.00007)
D(pre-sample patents)	0.02176*** (0.00282)	0.17707*** (0.01872)	-0.11353*** (0.00359)
pre-sample patents	0.00308 (0.00395)	0.02488 (0.02068)	0.17484*** (0.04372)
DMA(t-1/t-3)	0.05617*** (0.00444)	-0.02548*** (0.00105)	-0.11499*** (0.00359)
log sales(t-4)	0.00372*** (0.00017)	0.00490*** (0.00019)	0.00058*** (0.00010)
working capital(t-4)	0.00263*** (0.00059)	0.00349*** (0.00059)	-0.00095* (0.00057)
TFP(t-4)	-0.00279*** (0.00026)	-0.00375*** (0.00027)	-0.00033 (0.00024)
log capital intensity (t-4)	0.00006 (0.00011)	0.00004 (0.00011)	-0.00007 (0.00011)
log age	-0.00050 (0.00031)	-0.00098*** (0.00030)	0.00016 (0.00029)
Observations	229,479	229,479	229,479
R squared	0.040	0.048	0.118
F test	14.78	15.10	17.25
Kleinbergen Paap rk Wald F	28.94	32.19	24.53
Hansen (p-value)	0.105	0.585	0.192

Notes: *** (**, *) denotes significance at the 1% (5%, 10%) level. Standard errors (clustered by industry) are shown in parentheses. All regressions include industry, country and time dummies. In column 1 (2,3) variables are based on the merged entity (acquirer, target firm).

Table A5: Test of the balancing property

Variable	Sample	Treated	Control	t-test, $p> t $
propensity score	Unmatched	0.15956	0.00362	0.000
	Matched	0.15956	0.15949	0.993
log patent stock (t-1)	Unmatched	2.2482	0.07881	0.000
	Matched	2.2482	1.8861	0.448
log patents(t-1)	Unmatched	0.51541	0.01972	0.000
	Matched	0.51541	0.45909	0.650
log sales(t-1)	Unmatched	10.978	6.7585	0.000
	Matched	10.978	11.039	0.459
working capital(t-1)	Unmatched	0.25506	0.16052	0.000
	Matched	0.25506	0.24649	0.599
TFP(t-1)	Unmatched	0.36316	-0.05294	0.000
	Matched	0.36316	0.35728	0.891
log capital intensity (t-1)	Unmatched	0.29887	0.58816	0.639
	Matched	0.29887	0.35927	0.143
log age	Unmatched	3.1184	2.6514	0.000
	Matched	3.1184	3.1185	0.999
D(pre-sample patents)	Unmatched	0.17747	0.01551	0.000
	Matched	0.17747	0.15728	0.241
pre-sample patents	Unmatched	0.09513	0.034	0.000
	Matched	0.09513	0.07552	0.419

Notes: Table shows mean values of variables for merging (treated) firms at the year before the M&As and control firms. Unmatched and matched refers to samples before and after matching. T-test is a test for the equality of mean values for each variable across groups.

Table A6: Propensity score estimation

log patent stock (t-1)	0.605*** (0.149)
log patents(t-1)	-0.516*** (0.165)
D(pre-sample patents)	0.085 (0.172)
pre-sample patents	-1.213*** (0.319)
log sales(t-1)	1.171*** (0.025)
working capital(t-1)	1.956*** (0.142)
TFP(t-1)	-0.471*** (0.062)
log capital intensity (t-1)	0.178*** (0.040)
log age	-0.001 (0.051)
Observations	219,465
Pseudo R squared	0.410
Pseudo log likelihood	-3579

Note: *** (**,*) denotes significance at the 1% (5%, 10%) level. Table shows the results from a Logit regression. The dependent variable takes a value of one if an international M&A takes place in year t. Standard errors (clustered by firm) are shown in parentheses. Regression includes industry, country and time dummies.

Table A7 : Alternative estimation methods

	(1) Neg.bin. Patents	(2) Poisson patents	(3) Neg.bin. patents	(4) OLS ln(pat. stock+1)
IMA(t-1/t-3)	0.565*** (0.217)			
post IMA(t-1)		0.354*** (0.075)	0.445*** (0.148)	0.041*** (0.003)
log sales(t-4)	0.704*** (0.022)	0.054 (0.043)	0.023 (0.044)	0.003*** (0.000)
working capital(t-4)	0.560*** (0.111)	-0.459*** (0.070)	-0.137 (0.124)	0.001 (0.001)
TFP(t-4)	-0.240*** (0.064)	0.217*** (0.073)	0.079 (0.098)	-0.002*** (0.001)
log capital intensity (t-4)	0.108*** (0.038)	0.071** (0.034)	0.127** (0.057)	0.000 (0.000)
log age	-0.278*** (0.050)	-0.186** (0.076)	0.089 (0.095)	-0.001 (0.001)
patents(t-4)	0.831*** (0.047)			
pre-sample patents	2.058*** (0.332)			
DMA(t-1/t-3)	0.178 (0.159)			
post DMA(t-1)		-0.465*** (0.065)	-0.016 (0.141)	0.009*** (0.001)
Firm fixed effects	no	yes	yes	yes
Observations	229,479	229,479	229,479	229,479
Pseudo R squared	0.275	0.702	0.780	0.003
Pseudo log likelihood	-8,425	-3,129	-2,737	

Notes: *** (**,*) denotes significance at the 1% (5%, 10%) level. Table shows the results from count-data regressions for consolidated companies. The dependent variable is the number of patents per year. IMA is an indicator variable taking a value of one if two firms in different countries merged in the respective years. Standard errors (clustered by firm) are shown in parentheses. All regressions include industry, country and time dummies.

Table A8: Alternative outcome variable: Logit model for number of patents>0

	(1)	(2)	(3)
	consolidated	acquirer	target
IMA(t-1/t-3)	0.638*** (0.157)	0.581*** (0.160)	-0.549* (0.318)
sales(t-4)	0.513*** (0.019)	0.556*** (0.018)	0.442*** (0.021)
working capital(t-4)	0.775*** (0.108)	0.786*** (0.109)	0.599*** (0.125)
TFP(t-4)	0.030 (0.057)	0.060 (0.055)	0.062 (0.064)
log capital intensity (t-4)	0.198*** (0.037)	0.206*** (0.037)	0.175*** (0.041)
log age	-0.181*** (0.045)	-0.230*** (0.045)	-0.206*** (0.052)
D(patents(t-4))	3.005*** (0.081)	2.433*** (0.139)	3.151*** (0.094)
D(pre-sample patents)	2.361*** (0.112)	2.433*** (0.139)	2.641*** (0.123)
DMA(t-1/t-3)	-0.018 (0.139)	-0.481*** (0.155)	-0.570** (0.221)
Observations	229,479	229,479	229,479
Pseudo R squared	0.413	0.360	0.378
Log likelihood	-5,060	-5,257	-4,299

Notes: *** (**, *) denotes significance at the 1% (5%, 10%) level. Table shows the results from Logit regressions. The dependent variable takes a value of one if at least one patent was filed in year t. IMA is an indicator variable taking a value of one if two firms in different countries merged in the respective year. Standard errors (clustered by firm) are shown in parentheses. All regressions include industry, country and time dummies.

Table A9: Cross-border M&As and innovation: alternative dynamics

	(1)	(2)	(3)	(4)	(5)	(6)
IMA(t-1/t-3)	0.265*** (0.046)	0.183*** (0.047)	0.276*** (0.047)	0.265*** (0.046)	0.237*** (0.046)	0.227*** (0.051)
patent stock(t-4)	0.002*** (0.000)					
log patents(t-4)		0.696*** (0.018)				
D(patents(t-4)>0)		1.272*** (0.054)				
log patent stock(t-4)			1.058*** (0.017)			
D(patent stock(t-4)>0)			2.653*** (0.083)			
patent count (t-4)				0.005*** (0.001)	0.011*** (0.001)	0.010*** (0.001)
log pre-sample patents		0.319*** (0.027)	-0.255*** (0.031)			
pre-sample patents	0.005*** (0.000)			0.079*** (0.003)	0.064*** (0.003)	0.112*** (0.006)
D(pre-sample patents)	3.934*** (0.043)	2.780*** (0.058)	0.193*** (0.074)	3.849*** (0.043)	3.906*** (0.043)	3.827*** (0.044)
DMA(t-1/t-3)	-0.331*** (0.048)	-0.233*** (0.049)	-0.385*** (0.049)	-0.281*** (0.048)	-0.403*** (0.049)	-0.419*** (0.050)
log sales(t-4)	0.527*** (0.008)	0.337*** (0.009)	0.312*** (0.009)	0.505*** (0.008)	0.519*** (0.008)	0.498*** (0.009)
working capital(t-4)	0.733*** (0.043)	0.183*** (0.040)	0.009 (0.040)	0.500*** (0.043)	0.714*** (0.044)	0.437*** (0.046)
TFP(t-4)	0.361*** (0.023)	0.084*** (0.023)	0.016 (0.023)	0.342*** (0.025)	0.341*** (0.023)	0.399*** (0.025)
log capital intensity (t-4)	0.217*** (0.016)	0.140*** (0.016)	0.085*** (0.016)	0.265*** (0.017)	0.251*** (0.016)	0.282*** (0.017)
log age	-0.224*** (0.018)	-0.065*** (0.018)	-0.003 (0.018)	-0.100*** (0.018)	-0.152*** (0.018)	-0.258*** (0.020)
industry patents				0.502*** (0.024)		
market growth				-0.012 (0.014)		
entry rate				-0.044** (0.018)		
Ind.& country trends	no	no	no	no	yes	no
Ind-country pair trends	no	no	no	no	no	yes
Observations	229,479	229,479	229,479	229,479	229,479	229,479
Pseudo R squared	0.705	0.768	0.773	0.707	0.707	0.743
Pseudo log likelihood	-14,203	-11,164	-10,938	-14,121	-14,113	-12,383

Notes: *** (**,*) denotes significance at the 1% (5%, 10%) level. Table shows the results from count-data regressions for consolidated companies. The dependent variable is the number of patents per year. IMA is an indicator variable taking a value of one if two firms in different countries merged in the respective year. Standard errors (clustered by firm) are shown in parentheses. All regressions include industry, country and time dummies.

Table A10: Controlling for differences in statutory corporate tax rates

	(1)	(2)	(3)
	consolidated	acquirer	Target
IMA(t-1/t-3)	0.345*** (0.047)	0.424*** (0.048)	-0.672*** (0.206)
IMA*tax rate differential (acquirer - target country)	-0.065*** (0.009)	-0.082*** (0.008)	0.117*** (0.028)
Observations	229,479	229,479	229,479
Pseudo R squared	0.703	0.603	0.543
Pseudo log likelihood	-14306	-18546	-14750

Note: *** (**,*) denotes significance at the 1% (5%, 10%) level. Table shows the results from count-data regressions. The dependent variable is the number of patents per year. IMA is an indicator variable taking a value of one if two firms in different countries merged in the respective year. "IMA*tax rate differential" measures the difference in statutory corporate tax rates between the acquirer's and the target's country. Standard errors (clustered by firm) are shown in parentheses. All regressions include industry, country and time dummies as well as selection controls.