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Abstract

This paper considers the effect of acquisition FDI on the knowledge production function. We distinguish between acquisitions by MNEs from technologically leading countries and those behind the technological frontier. We show that both acquire similarly R&D intensive domestic firms, but there are important differences post-acquisition. Acquisitions from technologically intensive countries reduce domestic R&D effort, in favour of an increase in foreign technology transfers, which suggests complementarities in the knowledge assets of the MNE and the target firm as a reason for FDI. In contrast, consistent with technology sourcing FDI, acquisitions from non-leading countries increase internal R&D efforts.

JEL-Code: F230, O330, D220, L200.

Keywords: MNE, knowledge production function, acquisition FDI, knowledge complementarities, technology sourcing.

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1. Introduction

The important role played by technology in explanations of cross-country differences in the level of income per capita has led to academic and policy interest in the process of technology creation, its location,[1] and the channels for its diffusion. Multinational firms (MNEs) have been central within this analysis (Keller, 2010). It is now well established that MNEs are major producers of new technologies (Criscuolo et al., 2010, Dunning and Lundan, 2008; Javorcik, 2010),[2] have become increasingly globalised in the location of their R&D over time (Bloom and Griffith, 2001; NSF, 2011), [3] and are much more likely to use knowledge sourced internationally within the R&D production function[4] (Veugelers and Cassiman, 2004; Criscuolo et al., 2010).

In this paper we explore the link between the internationalisation of R&D and the knowledge production function by providing, *1)* empirical evidence on the knowledge inputs used by R&D active domestically owned firms that are targeted for acquisition by foreign MNEs; *2)* what happens to these input choices post-acquisition; and *3)* whether there are differences between MNEs from technologically leading countries and by those lagging behind the technological frontier. That the firms we examine are all R&D active, and remain so, indicates complementarities in the knowledge assets of the MNE and the target firm as a possible motive for FDI (Nocke and Yeaple, 2008). The foreign MNE acquires the domestic firm in the expectation that there are economic gains from combining the knowledge assets held by each party (Dunning, 1981). That suggests that the firms selected for acquisition are likely to differ from non-acquired firms, but how? If complementarities are important we might anticipate that those firms that generate most of their new knowledge internally, rather than buying in R&D from others, will be more likely to be acquired.

If complementarity in knowledge assets between the MNE and the target firm are indeed an important motive for FDI, as well as evidence of a pre-acquisition difference in the knowledge inputs used by acquired and non-acquired firms, we might also anticipate finding post-acquisition changes to the knowledge production function in the target firm.[5] Moreover, because the acquisitions we study occur

[1] The location of R&D is of importance if the spillovers from R&D are localised. For evidence supportive of this view see Jaffe (1986) and Henderson et al. (1993).

[2] According to Javorcik (2010); in 2002, 700 firms, 98% of which are multinational corporations, accounted for 46% of the world's total R&D expenditure and 69% of the world's business R&D.

[3] Bloom and Griffith (2001) provide detailed evidence on the internationalisation of R&D amongst the G5 countries. According to the NSF (2011) around 13 per cent of all expenditures on R&D by US MNEs is conducted outside of the United States.

[4] We use the term R&D production function interchangeably with the term knowledge production function throughout the paper. The term knowledge production function is usually credited to Griliches (1979) and describes how new knowledge creation depends on the people and capital applied to discovery and the stock of existing knowledge.

[5] Given our focus on the knowledge inputs used by acquired firms in the pre- and post-acquisition periods we consider only firms that are R&D active throughout the sample period. In our study of the post-acquisition changes that occur we therefore capture the effect the treatment (foreign-acquisition) on the treated.

in a country (Spain)[6] that would not typically be viewed as on the technological frontier, we might expect that these post-acquisition changes will differ across MNEs. For instance, MNEs from more technologically advanced countries can be expected to have superior stocks of internal knowledge. The extent of any ex-post transfers of technology by these MNEs might therefore be greater compared to those MNEs from countries that are less technologically intensive. The knowledge production function of the affiliate will be altered to be more reliant on within-MNE knowledge when FDI is from technologically intensive countries. The intellectual property (IP) reforms that took place in Spain just prior to the time period of study (2004-2009) provide further support for this view.[7] Branstetter et al. (2006) show in a cross-country panel setting that periods of IP reform stimulated increased transfer of technology from US multinationals to their affiliates, along with increased R&D expenditures and patenting. They also find that these effects were strongest for firms with the most to gain from IP reforms, as measured by their pre-reform US patenting behaviour, and that they are not mirrored for domestic firms.

For the majority of the acquisitions that occur in our data, technology levels in the country of origin of the MNE are relatively similar or lower than in Spain. For acquisitions by MNEs from these countries it is less obvious that complementary knowledge assets between the acquirer and the target are the motive for FDI, and as a consequence the expected post-acquisition changes in the knowledge production function are harder to predict. For example, for MNEs from countries further behind the technical frontier, FDI is more likely to contain technology sourcing motives (van Pottelsberghe de la Potterie and Lichtenberg, 2001; and Griffith et al., 2006). But, does that imply there will be a greater relative expansion of internal R&D capabilities post acquisition, or will the MNE try to tap-into the R&D efforts of local firms by outsourcing R&D within Spain? Will there also be evidence of knowledge transfers from the parent firm, or alternatively, does it affect the type of firms that are acquired?

By studying the role of knowledge complementarities as both a determinant and outcome from acquisition FDI we contribute to three separate strands of the literature on the R&D behaviour of MNEs. Harris and Robinson (2002), Benfratello and Sembenelli (2006), Chen (2011), Balsvik and Haller (2010) and Guadalupe et al. (2010) have previously shown that foreign MNEs are more likely to select domestic firms that are more productive, larger and more likely to conduct R&D. We build on that analysis to include the knowledge inputs used by firms. There also exists from Veugelers and Cassiman (2004), Criscuolo et al. (2010) and Wagner (2006) cross-sectional evidence of differences in the type of knowledge inputs used by MNEs and non-MNEs. Here, as well as describing the changes that occur to

[6] According to the European Commission Spain is considered a moderately innovative country (European Innovation Scoreboard, 2009). Similarly, using OECD data on the ratio of business enterprise R&D expenditures over GDP, Spain ranks 20th out of 27 countries (including Spain) in our sample.

[7] We use the reform period as a motivation and do not provide a test of whether IP reform stimulated the observed FDI inflows. We do so because the reforms do not offer the opportunity to apply a clear treatment versus control approach: they were contained in a number of pieces of legislation, involved the establishment of courts with different remits to look at IP issues and were spread across a number of years.

the choice of knowledge inputs in newly acquired firms we provide new evidence of differences in the knowledge production function between MNEs from different countries. [8]

Finally, we also build on the literature that has considered the effects of foreign acquisition on various aspects of firm performance. Here Harris and Robinson (2002), Girma et al. (2007) and Chen (2011) have all found that productivity in the target firm improves post-acquisition, while Conyon et al. (2002) and Girma and Görg (2007) have demonstrated a similar impact on employment and wages. In their recent review of the empirical literature Stiebale and Reize (2011) conclude that the effects of foreign acquisition on total R&D expenditure, or R&D intensity, of the target firms are more mixed. As an example, Bandick et al. (2010) and Bertrand (2009) find that R&D expenditures rose following foreign acquisition, while Stiebale and Reize (2011) report they fell. More recently Guadalupe et al. (2010) have shown that the type of innovation (product or process) as well as other firm investments, including efforts to assimilate foreign technologies and purchases of new machinery and organisation practices, change in the post-acquisition period. Our evidence contributes to this literature by offering a more disaggregated study of the effects of acquisition FDI on R&D and in so doing sheds some light onto why the post-acquisition improvement in productivity in the target firm might occur. As Veugelers and Cassiman (2004) write, without direct evidence on technology transfer such as offered in this paper, it becomes difficult to evaluate what sorts of FDI have positive economic effects and which have negative effects.

In combining these questions we view though, the main contribution of the paper to be the empirical insights it provides for theoretical models that emphasise complementarities as a motive for acquisition FDI, such as that by Nocke and Yeaple (2008).[9] As those authors emphasise, acquisition FDI is the dominant form of FDI (Barba Navaretti and Venables, 2004) and is often assumed to occur because it allows firms to exploit complementarities in their assets. Yet, they cite no direct empirical evidence to support the role of complementarities in acquisition FDI. In this paper we use evidence on the pre-acquisition knowledge production function of the acquired firms along with any changes that occur and post-acquisition to infer whether knowledge assets were an important determinant of FDI.

The data we exploit is an annualised version of the Spanish Community Innovation Survey (CIS) which covers 4,295 innovating firms over the period from 2004 to 2009. This dataset provides detailed information on the R&D behaviour of firms, distinguishing knowledge inputs by provider and between national and international origins, alongside information on the ownership structure of the firm in an annual panel setting. The methodology we apply is that used to investigate other effects of acquisition-

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[8] A second difference with this paper is that where they explore the relationship between knowledge inputs and knowledge outputs (such as patents) we explore how the inputs change across time. The information on inputs also differs however. In the UK version of the CIS there is qualitative information on the 'use' and 'importance' of a particular source of knowledge input. Here we use data on expenditures.

[9] Guadalupe et al. (2010) provide evidence on a different complementarity; that between innovation and market scale.

FDI on target firm performance by Chen (2011), Girma and Görg (2007), Girma et al. (2007) and Guadalupe et al. (2010). In order to control for the selection effects on the firms chosen for acquisition we combine propensity score matching with difference-in-differences.

To preview our findings, we find from our analysis strong evidence of cherry-picking of the best domestic firms for acquisition. Even though all of the firms we examine are R&D active, acquired firms are typically larger and more productive than non-acquired firms. They also differ in their R&D inputs prior to acquisition compared to non-acquired firms. Here we find the probability of acquisition is increasing in the level of internal R&D expenditures and decreasing in external expenditures. As expected, firms with greater internally generated knowledge are indeed more attractive to foreign MNEs than those that rely more extensively on external sources of knowledge inputs. Foreign MNEs are also found to more likely target firms that are already internationalised in their R&D in that they have R&D facilities located abroad. We find there are no significant differences though, in the knowledge characteristics of firms acquired by MNEs that are from the most technologically intensive countries versus those that are not. We also find no role for the new patents that Spanish firms have generated. The domestically owned firms targeted for acquisition are statistically different from non-acquired Spanish owned firms in their choice of knowledge inputs, but not outputs, and not from each other. We interpret this as evidence consistent with the view that the knowledge assets held by the acquired were an important motive behind the acquisition.

We also find an effect of the internationalisation of R&D on the knowledge production function post-acquisition. From our results we find that the effects of acquisition FDI can be characterised as belonging to one of three types. FDI inflows from the most technologically intensive countries (Germany, Japan and the US) leads to a shift away from local (within Spain) effort in the production of R&D, in favour of an increase in knowledge drawn from foreign external sources. These effects are particularly strong for those knowledge flows from within foreign parts of the same business group. We conclude from this that acquisition FDI from technology intensive countries are associated with greater technology transfers between affiliates and that this was the complementary knowledge asset held by the foreign MNE.

In comparison, when FDI inflows are from countries that have a similar technological intensity than Spain, there are no significant changes in the knowledge production function of the newly acquired firm. For this group there is evidence of the selection of the best domestic firms for acquisition, but there are no significant changes to the knowledge production function post-acquisition. It is therefore not clear from this evidence what role the knowledge assets of the foreign MNE played in the decision to acquire the Spanish owned firm. Finally, when acquisition FDI is from countries that are less technologically intensive than Spain, we find evidence consistent with technology sourcing FDI rather than complementary knowledge assets as the motive for FDI. Relative to a matched control group on non-acquired firms, and even though we have only a small number of acquisitions within this group, we find significant evidence that total innovation expenditures of the affiliate rise post-acquisition and there is a change in the input mix now towards domestic internal R&D effort. We are not aware of any similar studies that provide evidence that international technology transfers occur alongside technology sourcing FDI within the same country.

The rest of the paper is organized as follows. Section 2 reviews the literatures relating to multinational firms, acquisition FDI and R&D. Section 3 details the data that we use, while in sections 4 and 5 describes our empirical results. Section 4 considers which firms are selected for acquisition and Section 5 the changes to the knowledge production function. Finally, we draw some conclusions from the study in Section 6.

2. Literature Review

That MNEs are different from non-MNEs is a well-established empirical result found to encompass a wide range of performance measures including size (output and sales), human capital intensity, productivity and R&D (see for example the review in Greenaway and Kneller, 2007 or Keller, 2010). These differences are often interpreted as reflecting the superior technology of MNEs (Markusen, 2004), which in turn has been used as motivation to suggest MNEs will also differ in the volume and type of inputs they use to create new knowledge. In their study of the knowledge production function Criscuolo et al. (2010) generate three key findings. Firstly, they find that MNEs generate more knowledge outputs than firms that sell just to the domestic market or export. In part, this is explained by the volume of inputs these firms use. Globally engaged firms have greater expenditures on R&D and more scientists and engineers dedicated to this task. But, they also find the knowledge production function of these firms differs in other ways, in particular the number of knowledge sources used. MNEs, they claim, learn more from links with their customers and suppliers and from intra-firm worldwide pool of information. This supports evidence from Veugelers and Cassiman (2004) who find that subsidiaries of foreign multinationals located in Belgium are more likely to acquire technology internationally.

Given the importance of M&A in total FDI flows, an important question is whether these differences in the knowledge production function reflect pre- or post-acquisition differences. That is whether there is selection of the best domestic firms by acquisition by foreign MNEs, and if not, when the changes in inputs occurs. On this question the literature has focused on the volume and intensity of R&D, while indirect evidence also exists from those studies that have looked for the effects of cross-border M&A on productivity. These studies are of additional interest given that most apply matching and differences-in-differences as an empirical methodology, and therefore also study the selection of firms for acquisition. The evidence overwhelmingly suggests cherry-picking of the best domestic firms. The probability of acquisition is found to be increasing in firm size, productivity, human capital intensity and R&D. [10]

In their recent review of the available empirical evidence Stiebale and Reize (2011) find that most studies find a negative relationship between M&A and subsequent R&D, although they note that some of this general negative outcome might be explained by the fact most studies do not differentiate acquisitions that are by foreign or domestic firms, and because they usually focus on the R&D activity of the entire economy (Bertrand and Zuniga, 2006) or the acquiring company (Marin and Alvarez, 2009). There are comparatively few studies that assess the causal effect of foreign acquisitions on the subsequent restructuring process of R&D activities in the target firm. One of the exceptions is that by Bandick et al. (2010), who study the effect of foreign acquisition on Swedish target firms using a propensity score matching approach. Their results suggest that the fear of foreign takeovers resulting in a relocation of R&D to the MNE country of origin is unjustified. They find that cross border acquisitions entail increased R&D intensity in the Swedish targets. As similar conclusions is reached by Bertrand (2009). He looks at cross-border M&A in France from 1994-2004 and finds positive effects of international acquisitions on the level of R&D spending as well as sub-components such as internal and external R&D, along with measures of the type of research (basic, applied and development). In contrast, Stiebale and Reize (2011) find negative effects of cross border M&A on innovation activities of target firms in Germany, both when measured as the level of expenditure and the propensity to conduct R&D.

Finally, the possibility that differences in the motives for FDI might impact on firm performance has been a relatively little studied, with closest work being that of Griffith at al. (2006) and Chen (2011). In contrast to the work conducted here Griffith at al. (2006) evaluate how the performance of the target firm affects the investor's productivity. They show that growth of the US R&D stock had a stronger productivity impact on UK firms that had more of their inventors located in the US. They interpret this as evidence that these UK firms uses their US R&D facilities to benefit from the general growth in the stock of US, where this effect is stronger for industries for which UK technology lies further behind that in the US. It is also asymmetric in the sense that US firms do not benefit from the growth in the UK stock of R&D in the same way.

In studying the performance of the target firm, the recent work of Chen (2011) displays perhaps the most similar motivation to the work conducted in this paper, although there the distinction is between FDI from developed and developing countries. He finds that firms acquired by MNE from industrialized countries exhibit the greatest improvement in post-acquisition performance. Acquisitions from developing countries entailed lower labour productivity gains as compared to targets that were acquired by domestic firms.

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[10] See Blonigen and Taylor (2000) for evidence on the R&D intensity of the acquiring firm. They uncover a significant negative relationship between acquisition and R&D intensity, which they suggest may reflect the growth strategy of the acquiring firm. Firms choose between an internal growth strategy with high R&D intensity versus an external growth strategy with acquisitions.

3. Data

The data we use come from a yearly survey of Spanish firms called *Panel de Innovación Tecnológica* (PITEC). This survey has been conducted since 2004 by the Spanish National Institute of Statistics as an annualised version of the Spanish Community Innovation Survey (EUROSTAT). We use information for every year between 2004 and 2009. The survey is designed to be a representative, unbalanced panel sample of firms operating in the manufacturing and service sectors.[11] Each year firms are asked to provide information on a number of key performance characteristics, such as sales, number of employees, ownership and industry and, of interest in this paper, detailed answers about their innovation activities.

Given our interest in the inputs used in the knowledge production function we exclude from the sample those firms without continuous total innovation expenditures. We also exclude public firms, firms that are always foreign owned, firms that were acquired more than once, firms that exited either permanently or temporarily from the sample and[12] to control for possible outliers firms with turnover above or below the 1% and 99% tails of the distribution. Our chosen sample is an unbalanced panel of 4,295 innovating firms.

We study firm's innovation expenditures at different levels of aggregation (these are shown in Table 1 and Table A1 in the Appendix). The most aggregated measure is *total innovation expenditures*. This includes three categories of spending: *internal R&D* (R&D undertaken within the plant); spending on *external R&D* (a firm's purchases of R&D conducted by other firms); and *non-R&D* expenditures (which includes expenditures on training, market preparations of products or market research and advertising).[13] These three categories account for 73%, 11% and 16% of total innovation expenditures respectively for the average firm in our sample. Firms also report figures on *external R&D* broken down into those that are domestic purchases or imports. We label these variables *external-domestic R&D*, and *external-foreign R&D*, respectively. For the average firm, external domestic accounts for the majority of total external R&D expenditures (93% on average).

Finally, the survey also provides information on R&D spending by type of provider. With this information, we can further classify *external-foreign R&D* into the following groups: i) *external-foreign R&D within the same business group*, which includes imports from the headquarter and from other

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[11] The panel is unbalanced with 12,873 firms generating a total of 76,902 firm-year observations with an average of five observations per firm. It is a legal requirement for firms to respond to this survey.

[12] We exclude firms that exit because disturbances around the time of closure affect a firm's economic variables, which we cannot disentangle from acquisition effects.

[13] *External R&D* expenditures are defined as: *"Acquisitions of R&D services through contracts, informal agreements, etc. Funds to finance other companies, research associations, etc, which do not directly imply purchases of R&D services are excluded"*. R&D services are defined as: *"Creative work to increase the volume of knowledge and to create new or improved products and processes (including the development of software)"*. The exact definitions of all other innovation variables are documented in the Table A1 in the Appendix.

affiliates within the same business group, ii) *external-foreign R&D from other private firms*, namely imports from foreign private providers (outside of the same business group), and (iii) *external-foreign R&D from foreign non-private providers*, such as Universities, public administration, non-profit organisations (NPO) and other international organizations. These three categories account for 12%, 69% and 19% of expenditures on external foreign R&D respectively, or just 1%, 6% and 1.5% of total innovation expenditures in the average firm. Similar to Branstetter et al. (2006) we use imports of R&D from the same business group as an indicator of direct technological flows within the MNE.[14] We report evidence on all categories of expenditure except non-R&D expenditures and expenditures on external-foreign private and non-private R&D. Evidence on these can be found in the Appendix.

The data also contain information on the ownership of the firm, and specifically the location of the headquarters of the owner. Following Balsvik and Haller (2010), Bandick et al. (2010), and Guadalupe et al. (2010) among others, we identify foreign acquisition in the sample when we observe a change in the majority equity holder of the firm changes (i.e. who controls more than 50% of the equity) and the country location of the owner changes from Spanish to some other country.[15] In the data we identify 189 acquisitions of R&D active firms by foreign multinationals during the period 2004-2009. As described in the introduction we are interested in differences across MNEs, in particular whether they are headquartered in technologically intensive countries or not. We initially adopt a conservative classification of countries as technologically intensive or not and include only MNEs from Japan, Germany and USA in this group (see Acemoglu, 2009 or Griffith et al., 2004).[16] We label these as *JUG countries* and remaining countries as *non-JUG*. In Table 2 column (i), we show the number of acquisitions by country before the matching procedure that we will implement in the following sections. There are 67 acquisitions from JUG countries and 122 from non-JUG countries, mostly from the European Union.

In section 5.2 of the paper we test the robustness of our findings to various categorisations of countries as technology intensive or not. We use three alternative classifications. In column (iii) of Table 2, we report the average business enterprise R&D expenditures (BERD) as percentage of GDP using OECD data for the period 2004-2009. We use this data to identify the 10 most technologically intensive countries in the data (see column v) and the 5 least (see column vii). For the final classification we use

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[14] Branstetter et al. (2006) consider royalty payments for the use or sale of intangible assets made by affiliates to parent firms.

[15] This measure is consistent with the IMF (2009) definition of who has ultimate control of the acquired firm and is attractive for the purposes of this paper in that it allows us to assign a unique country of origin to the new affiliate. There are small number of acquisitions for which the foreign equity share moves to majority ownership but the headquarters is registered as being within Spain. Given our interest in the origin country we drop these firms from the analysis.

[16] The dataset contains information on the industry in which the acquired firm operates in but does not contain the same information for acquiring MNE. For this reason we chose against classifying industry-country combinations as on, or behind, the technical frontier.

the list of countries defined by the European Commission as technologically intensive (listed in column vi).

Table 1 presents descriptive statistics for firms that have been acquired, differentiating between acquisition from JUG and non-JUG countries, and for domestic firms that have never been acquired. For acquired firms, we show values for the year in which the acquisition takes place, along with that for the year before and the year after the acquisition. A fall in the number of observations occurs for the year after acquisition because of the effect of the end of the sample period on those acquired in 2008. To mitigate the effects of sample composition we display limited information on the level of expenditure and instead report percentages of various totals.

A comparison between acquired and non-acquired firms reveals some interesting differences. Firstly, firms that are targeted for acquisition spend more on innovation, around 2.5 times more. This would seem to indicate that the largest R&D firms are selected for acquisition and therefore help to explain why Criscuolo et al. (2010) found MNEs had more R&D inputs than non-MNEs. Secondly, acquired and non-acquired firms actually spend a similar proportion of total innovation expenditures on internal versus external R&D effort. In the period before acquisition the percentage share of internal (external) R&D in total innovation expenditure was 74% (13%) for acquired firms, compared to 73% (11%) in non-acquired firms. The table also reveals there are strong similarities in these percentages when we separate acquisitions into those by MNEs from JUG and non-JUG countries. It would seem from the evidence so far that acquired firms spend more on internal and external R&D than non-acquired firms in total, but in similar proportions.

The differences between acquired and non-acquired firms reveal themselves primarily in the share of total external R&D spent on domestic (foreign) R&D effort, with now also some difference between firms acquired by MNEs from JUG and non-JUG countries. The numbers in the table suggest that non-acquired firms spend 94% of total external R&D expenditures on purchases from other Spanish firms. For acquired firms the comparable figures are (in the pre-acquisition period) 59% when acquisitions are from JUG countries and 77% when from non-JUG countries. Acquired firms are, it seems, on average more intensive in their use of external-foreign R&D. The final three columns of the table suggest that this is almost exclusively explained by their use of knowledge purchased from elsewhere in the firm. Expenditures of this type account for about 2% of total R&D expenditures for acquired firms and 0.03% for non-acquired firms. As we describe below this variable indicates that the acquired firm is domestic (Spanish) multinational firm, at least in its R&D effort.

A comparison of the trends from pre- to post-acquisition between firms acquired from JUG and non-JUG countries suggests a few obvious patterns in Table 1. Total innovation expenditures display little trend in either case, but there is an indication that the percentage spent on internal R&D falls in the JUG group of MNEs over time, whereas there is a rise for the non-JUG group. Of the components of external-foreign R&D there is also a clear difference in expenditures on technology transfers from elsewhere in the business group. These display a much stronger rise when acquisition is from the JUG countries compared to the non-JUG group.

4. Characteristics of Acquired Firms

In this section, we examine the characteristics of firms that are acquired by foreign multinational firms with non-acquired firms, conditional on the restriction that the firms had non-zero internal R&D expenditures in period t-1.[17] For this task we estimate a probit model in which we regress a dummy variable indicator of whether the firm becomes acquired during the sample period on various innovation inputs, controlling simultaneously for a number of other factors that potentially influence this probability.[18] Formally,

$$Acquisition_{it} = \begin{cases} 1 & \text{if} \quad \alpha + X'_{it-1}\beta + d_t + \varepsilon_{it} > 0 \\ 0 & \text{if} \quad \alpha + X'_{it-1}\beta + d_t + \varepsilon_{it} \leq 0. \end{cases} \tag{1}$$

In equation (1), $Acquisition_{it}$ is a dummy variable that takes the value one if there is a change from domestic to foreign ownership. The vector X_{it-1} reflects pre-treatment firm characteristics that influence acquisition,[19] d_t denotes time dummies, and ε_{it} is the error term, which we assume is normally distributed with variance σ^2_{ε}. In all regressions we use cluster robust standard errors.

We use the results in Table 3 to test whether any of the R&D variables, the level of innovation expenditures or their intensity and the mix of expenditures on internal and external R&D, help to identify firms that were more likely to be acquired. Building on the evidence from the summary statistics in Table 1, in column (i) we include the (log of) total innovation expenditures and a measure of the innovation intensity of the firm. The evidence in Table 1 displayed clear evidence that acquired firms had greater total expenditures on innovation.

In column (ii) we include the ratio of external to internal R&D and two measures of expenditures on *external foreign R&D within the same business group*. For these variables the summary statistics suggested that acquired firms spent a similar proportion of total expenditures on internal and external R&D to non-acquired firms, whereas R&D transfers from overseas R&D facilities (*external foreign R&D within the group*) were noticeably higher. We include two measures of this type of expenditures because, while the dataset includes detailed information on the international structure of a firms' R&D, it does not include the same information on its production structure. Put differently, we do not know whether the acquired firm is a MNE in its production or not, only whether it is an MNE in its R&D or

[17] We include this restriction to avoid some outliers, which did not have internal R&D before being acquired.
[18] We use a pooled cross-sectional approach. The results also hold if we use a random effect probit model.

[19] These variables should not be affected by the treatment otherwise the conditional independence assumption is violated. This is accommodated by using pre-treatment or lagged values of the variables X (Imbens, 2004).

not. To capture possible differences we include in the regression a dummy variable equal to one if the plant had overseas R&D facilities alongside the level of these expenditures (*external same business group dummy*). We assume here that the dummy variable will capture whether being a MNE (in R&D and/or possibly production) matters or not for acquisition, so that the intensity variable reflects more clearly the effects of the type of knowledge input the firm uses. Finally, in column (iii) we replace the measures of total innovation expenditures with those on (the log of) external and internal R&D, whilst retaining the *external foreign R&D* variables.

Following evidence from Chen (2011) and others we also include in all regressions a set of other non-R&D variables including measures of firm size (employees), labour productivity (measured as sales over employees) and an indicator for whether the firm exports or not. In order to test for possible non-linearities in the effects of employment we create a set of size bands equal to one if the firm has employment of <50, 50-99, 100-199, 200-499 or 500+. We choose the size band 100-199 as the omitted category such that all marginal effects are calculated relative to that group. We also include a set of regional dummies.

From the non-R&D characteristics we find evidence of selection of the best firms for acquisition. From column (i) in Table 3, we find that even amongst the set of Spanish firms that conduct R&D the probability of acquisition by a foreign MNE is increasing in the labour productivity of the firm and is also positively correlated with the firms' export status. The effect of size on the probability of acquisition is non-linear. Compared to firms with average employment levels (employment between 100-199), those that are smaller are significantly less likely to be acquired. The estimates marginal effects reported in the table suggest that for the smallest firms (emp <50) this probability is 0.78% lower, while for firms with employment between 50 and 99 it is 0.26% lower. These effects are small because the probability of being acquired is low in the data, around 4%. For large firms we find no relationship with the probability of foreign acquisition however. Firms with more than 200 employees are not significantly more likely to be acquired than firms with between 100 and 199 employees.

In regression (i) we find that in addition to being more productive and larger, domestically owned firms are more likely to be acquired if they have greater innovation expenditures, although its innovation intensity has no effect. The marginal effects reported in the table suggest that the effect of total innovation spending is around half that estimated for labour productivity.

In column (ii) we find evidence that the relationship between total innovation spending and acquisition is explained by the multinational R&D status of the firm. This dummy variable, set equal to one if the firm has positive expenditures on innovation from other overseas affiliates (and is zero otherwise), is strongly significant in this regression, whereas the level of innovation expenditures ceases to be.[20] The marginal effects suggest that this variable has a sizeable effect on the probability of being

[20] The export status of the firm is similarly affected and no longer helps to predict the probability of acquisition.

acquired. Firms with R&D facilities abroad are 3.6% more likely to be acquired, close to the rate of acquisition we observe in the data. The measure of the intensity of these expenditures measured relative to total R&D is not statistically significant in contrast.[21] This result might indicate that foreign multinationals view the knowledge assets of Spanish owned MNEs to be superior to those of non-MNEs, or perhaps more likely given the insignificance of the R&D intensity variables, that foreign-MNEs view Spanish MNEs as more attractive targets for acquisition than non-MNEs.

In regression (ii) of Table 3 we also find no effect on the probability of acquisition from the ratio of external/internal R&D intensity, a result consistent with the summary statistics in Table 1. However, when we replace this intensity with variables the measure the (logged) level of internal and external R&D expenditures (columns iii and iv) we find a significant, and oppositely signed, effect on the probability of being acquired. The fact that firms that have greater expenditures on external knowledge are less likely to be acquired, whereas those with higher internal R&D expenditures are more likely, is consistent with the view that foreign MNEs value highly the internally generated aspects of new knowledge. [22]

In the remaining regressions in Table 3 we explore whether there are differences between acquisitions made by MNEs from Germany, Japan and the US and those made by MNEs from other countries. In these regressions we choose to drop the variable measuring external foreign R&D from within the same business group, using the results in regression (iv) as the relevant comparison for acquisitions from all countries pooled together. The results presented in column (v) refer to a regression where we drop from the regression acquisitions not made by MNEs from Germany, Japan and the US from the sample, and column (vi) we exclude acquisitions by MNEs from those three countries.

There are some noticeable differences between the results in these two columns. In column (v) of Table 3 we find that compared to non-acquired firms, the level of internal R&D no longer significantly affects the probability of acquisition, whereas in column (vi) it does. We also find that the estimated marginal effect on the dummy indicating expenditures on R&D from other subsidiaries abroad is larger in column (vi) compared to when we use acquisitions from Germany, Japan and the US only (column v). This would seem to suggest that it is those MNEs that are from less technologically intensive countries that value most the knowledge generated internally to the firm and this potential complementarity with the knowledge of the MNE might provide a motive for acquisition. However, when we test for differences between the firms that are acquired by MNEs from Germany, Japan and the US compared to MNEs from other countries in column (vii) we find that none of these differences are statistically significant at conventional levels.

[21] If we drop the dummy variable measuring the MNE status of a firms' R&D the intensity variable is statistically significant.

[22] A result not reported here is that we checked by further differentiating external R&D expenditures into subgroups. We found that this negative effect is attributable to external domestic R&D expenditures.

Thus far we have assumed that the complementary knowledge assets targeted by foreign MNEs is revealed by the flow of expenditures used in the creation of new knowledge. The knowledge production is also dependent on the stock of knowledge (Griliches, 1979) and it remains possible that it is this stock of existing knowledge that foreign MNEs target. The PITEC survey does not ask for complete information on the stock of assets held by the firm, but it does ask for the number of new patents granted over the previous three year period. We add this measure of the (log) number of new patents granted to the firm to the regression in Table 4. There is a small drop in the number of observations in the regressions as there are some firms that were not granted any patents.

In all of the specifications in Table 4 we find no role for the number of patents on the probability of being acquired by a foreign MNE. This might reflect the weakness of the measure used, that it measures only new patents over a 3-year window. It might alternatively reflect a view that not all Spanish R&D is at or close to the technological frontier and is therefore not a consistent factor used by foreign MNEs when choosing acquisition targets in Spain. Whichever view holds, the results for innovation expenditures we found in Table 3 are unaffected by the inclusion of the patent variable.

We conclude from this exercise that firms' acquired by foreign MNEs are significantly different from non-acquired firms in Spain, with strong evidence of cherry-picking. In addition to firm characteristics such as size and productivity this selection is also determined by differences in the knowledge production function, but not by any recent patents the firm has acquired. Complementarity appears to be in the location of R&D and the mix of inputs used. Foreign owned firms target firms that have greater internal R&D expenditures or are multinational in their R&D (and possibly other functions). While we find some suggestive evidence that there may also be difference in the type of firms acquired by MNEs from different origin countries, these differences are not statistically significant.

5. The Effects of Foreign Acquisitions on Different Measures of Innovation Expenditures

The fundamental evaluation problem in finding the effects of foreign acquisition on the innovative input structure of Spanish firms is that we would like to compare the after acquisition innovation expenditures of an acquired firm with the firm's expenditures had it been not acquired. Since no firm can be subject to acquisition and not at the same time, this direct comparison is not possible. To overcome this, we apply a calliper propensity score matching procedure as an evaluation method. The basic idea is to find in the group of non-treated those firms that are most similar to the treated in all relevant characteristics before acquisition. Given that finding a match for a treated unit is difficult when controlling for more than a few variables, Rosenbaum and Rubin (1983) suggest to control by a function of the vector X instead, which is the conditional probability of receiving treatment given the set of characteristics.[23] We calculate the propensity score on the basis of the probit model for the full sample, reported in column (iv) of Table 3. We pair each acquired firm with the closest non-acquired firm in the same industry and year by calliper matching with replacement.[24] The identifying assumption is therefore that conditional on observable firm, time and region effects that affect selection, acquisition is random. The results therefore describe the effects of acquisition FDI on the knowledge production function.

To validate the quality of the matching procedure, we test whether after matching pre-acquisition variables are balanced between acquired and non-acquired firms. The results of our balancing tests are displayed in Table 5 in part (a) and (b). After matching, our final sample consists of 295 firms with 154 acquisitions and 141 untreated firms. There are 55 acquisitions from frontier (Japan, USA and Germany, i.e., JUG countries) and 99 acquisitions from non-frontier countries (see Table 2, column ii).

Standardised biases are appropriate when looking at each ex ante covariate separately and overall.[25] From this table, we find that, for all of the firm characteristics individually, and together, there is a successful reduction in these biases after matching. For all covariates the t-tests indicate that after matching the equality of means cannot be rejected, i.e. no significant differences between the acquired and non-acquired can be found. For completeness we also report the median standardised bias and its reduction due to matching as well as the likelihood-ratio test of the joint insignificance of all regressors. The latter checks the overall covariate imbalance, as it is also the case for a comparison of the Pseudo-R^2 of the initial probit estimation with the Pseudo-R^2 of the identical estimation on the matched sample of treated and controls. We conclude that the treatment and the control group are balanced.

5.1. The Effect of Foreign Acquisition on the Different Measures of Innovation Expenditures

Having established the sample of matched acquired and non-acquired firms, we use the following model to estimate the effect of foreign acquisition on R&D inputs:

$$Y_{it} = \delta + \varphi Acquisition_{it} + \tilde{\varphi} Acquisition_{it-1} + Z_{it}^{'}\phi + \gamma_i + d_t + \vartheta_{it}, \qquad (2)$$

where Y_{it} are different measures of innovative expenditures. We include in the regression a set of firm-fixed effects, γ_i, such that Equation (2) can be interpreted as a difference-in-differences estimator, examining whether acquired firms deviate in their innovative behaviour compared to that in the pre-acquisition period and compared to the non-treated group. A positive sign on the coefficients φ and $\tilde{\varphi}$

[23] Rosenbaum and Rubin (1983) show that if conditioning on X makes the non-participation outcome independent of the treatment status it is also independent when conditioning on P(X).
[24] Our calliper is 0.001. A presentation of alternative matching possibilities is given in Caliendo and Kopeinig (2008) as well as in Sianesi (2004). Matching is carried out with STATA command PSMATCH2 by Leuven and Sianesi (2003).
[25] The criterion for judging the standardised bias as too large is varying with different studies. While Rosenbaum and Rubin (1985) and Bertrand (2009) report everything in excess to 20% as too large, Caliendo and Kopeinig (2008) demand 3-5% as maximum. For the definition of the standardised bias see Rosenbaum and Rubin (1985).

implies that in the year of the acquisition and one year after acquisition respectively, the plant is spending more than its pre-acquisition level as compared with the changes that occurred in the non-treated group. Owing to limits on the time series dimension of the panel available to us, we study post-acquisition effects for just two years. The vector Z_{it} is a set of control variables, d_t are time dummies, and ϑ_{it} is the error term. The regressions are estimated using robust variance-covariance matrix estimators clustering at the country level.

Our measures of firm level innovation are those previously described and reported in Table 1 and include *total innovation expenditures*, as well as expenditures on *internal* and *external R&D*. We also report results for various components of external R&D, where this includes those from other domestic firms (*external domestic R&D*) and imported knowledge (*external foreign R&D*). Finally we break down *external foreign R&D* further into knowledge imported from other affiliates within the same business group (labelled *R&D external foreign within the same business group*). For completeness we report results for the remaining sub-component of total R&D expenditure (*non-R&D expenditures*) and the remaining components of external foreign R&D (*external foreign non-private R&D*) and that from other private firms (*R&D external foreign from other private*) in Table A2 in the Appendix. As control variables we include firm size, measured by a set of non-overlapping dummies indicating the number of employees, and a dummy if the firm exports or not. In including these variables within the regression we attempt to control for other firm characteristics that may also change following acquisition by a foreign MNE and which may also affect the level of innovative expenditures.

In an extension to Equation (2) we allow the effects of acquisition to differ according to whether the acquiring firm is from a technologically intensive country or not. In comparing the effects of acquisition by MNEs from different countries we also consider the possibility that there may be other country differences that may determine the post-acquisition behaviour of the firm but which are not associated with international technology transfer. The most obvious example would be the possible transfer pricing by MNEs in order to move profits to low-tax jurisdictions, a factor that may be particularly relevant given the difficulty of pricing flows of intangible assets between countries (Devereux and Griffith, 2002). To control for this possibility we follow Branstetter et al. (2006) and include in the regressions a measure of *relative corporate taxes* between Spain and the country of origin of the acquiring MNE. We construct the ratio of corporate income taxes of a given country to the corporate income taxes of Spain. The data come from the “Tax database” from the OECD. If corporate taxes are higher in Spain than in the other country, MNEs might be expected to increase their innovation expenditures in Spain, thereby reducing taxable profits in the high-tax country. As corporate taxes in Spain increase with respect to the other country, the value of the *relative corporate taxes* ratio decreases. Therefore, if transfer pricing were a relevant source of differences in behaviour between MNEs from different countries we would expect a negative relationship between our measure of *relative corporate* *taxes* and innovative expenditures. Finally, we also include regional and year dummies to control for other relevant regional and year factors.

The effect of foreign acquisition on the different measures of innovation expenditures are presented in Tables 6 and 7. Table 6 shows the effect of acquisitions not distinguishing between the location of the headquarters of the acquiring MNEs. We use the results in this table largely to provide a comparison with evidence elsewhere in the literature. In Table 7 we separate acquisitions that occur from countries technologically leading countries (Germany, Japan and the US) and those from elsewhere. We test formally whether the effects of acquisition differ between JUG and non-JUG countries using a Wald test for the equality of the coefficients in the final row of the table.

In Tables 6 and 7, the additional variables that are included in the regression have relatively little explanatory power and generally display few consistent patterns. Of the firm level controls we find significance for the firm size dummies when employment is smaller than 100 for total innovation expenditures (columns i and ii). The export variable is significant on a few occasions, having a positive effect on external R&D and several of the sub-categories for this variable and a negative effect on internal R&D. We find no evidence of transfer pricing in our results however. On no occasion in Tables 6 and 7 do we find a significant effect associated with the relative corporate tax variable. This finding also holds where we to include a measure of the relative R&D tax incentives offered by countries.[26]

In Table 6 we find few significant changes to R&D expenditures associated with foreign acquisition. That total innovation expenditures are left unchanged relative to the control group of non-acquired firms means our evidence for Spain lies between the mix of positive and negative effects found elsewhere in the literature. We do however find some effect on the composition of expenditures. The evidence in the table shows a significant negative effect on external R&D (column ii) in the year following acquisition, where this is explained by a fall in domestic external R&D (column iv) and that from private firms abroad (see Table A3 in the Appendix). We also find initial evidence of international technology transfer in (column vi), where there is a significant contemporaneous increase in knowledge transfer from affiliates of the firm not located in Spain. Such evidence helps to explain why MNEs have been found to use more intensively external sources of knowledge in the cross-section evidence of Veugelers and Cassiman (2004), Criscuolo et al. (2010), and Wagner (2006). Our evidence suggests a causal relationship from multinational status and knowledge transfer from abroad. The effect of this increase in expenditures would appear to be large, in the period of acquisition transfers of technology from elsewhere in the business group rise by 0.411 log points. This equates to a rise of 50% on pre-acquisition levels, although as the summary statistics in Table 1 indicate this is from a relatively low level.

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[26] This measure of tax incentives for R&D is based on OECD's "B-indexes" following calculations by Warda (2001). These results are available from the authors on request.

Table 7 extends the results in Table 6 to allow for differences in the country of origin of the acquiring firm. Overall the results suggest that the effects of acquisition in Table 6 masked significant variation in innovation expenditures according to whether the MNE was from a technologically intensive country or not. From this table we conclude that the changes to the knowledge production function are more dramatic when FDI is from a more technologically advanced country. When FDI is from a non-JUG country, according to our results, there are no significant changes to the composition of R&D expenditure compared to the control group of non-acquired firms. When acquisition is from one of these countries, the MNE determines which domestic firms to acquire based on the knowledge inputs of the target, but does not re-organise these inputs or transfer R&D between affiliates compared to the pre-acquisition period. The evidence for this group of MNEs would appear to suggest that the R&D created knowledge of the target firm is an important motive for acquisition-FDI, but that the complementary knowledge asset of the acquirer is not R&D related. This might be because the target firm has product innovations that might be complemented by the brand or some other tangible or intangible asset of the acquiring MNE. Unfortunately, data limitations prevent us from exploring that possibility further.

For FDI from technologically intensive countries there is, in contrast, evidence of a significant fall in expenditures on internal R&D in the first two years following acquisition and a contemporaneous increase in expenditures on R&D effort outside of the firm. We observe a general shift from insourcing to outsourcing such that there is little impact on total R&D spending by the firm relative to the control group.[27] Moreover these changes are, at least in percentage terms, large. According to our estimates expenditures on internal R&D fall by 30% in each of the two periods following acquisition, whereas the value of R&D flows from elsewhere there is a one-off contemporaneous rise by 134% compared to their pre-acquisition levels.

The changes in the input-mix in the knowledge production function for MNEs from technologically intensive countries contrast with the evidence on the pre-acquisition characteristics of acquired firms in Table 3. There we found that the probability of acquisition was increasing in internal R&D expenditure and decreasing in expenditures on R&D efforts outside of the firm. This might occur because the MNE does not value all aspects of the internal R&D generated within its new affiliate, or because there is replication of R&D efforts already conducted with the business group. In support of this view Cassiman et al. (2005) report case study evidence that R&D expenditures decline when acquisition is by a firm in the same technological field (and rise when in complementary fields). Whichever effect dominates it would seem that the knowledge assets sought by the acquirer does not extend to all of the R&D conducted in the acquired firm prior to acquisition.

Disaggregating expenditures on outsourced R&D effort we find that the increase in external R&D expenditure is explained by an increase in knowledge transfers within the business group (column

[27] The net zero effect in the period contemporaneous with acquisition occurs despite the increase in external expenditure because of a decline in non-R&D innovation expenditure (see Table A4 in the Appendix).

vi). The effects on this category of expenditure are strong, rising by 0.660 log points in the year of acquisition and 0.582 log points in the year after that. These imply that the value of R&D flows from elsewhere in the business group rise by 93% and then 80% compared to their pre-acquisition levels. That we do not observe equivalent increases when FDI is from countries that are less technologically intensive confirms the empirical evidence in Branstetter et al. (2006) and points to a conclusion of complementarities between the technology in the non-frontier country and the MNEs own knowledge for this group. [28]

In the final rows on the table we examine whether the differences between acquisitions by JUG and non-JUG countries are statistically significant or not, which we test using a Wald test for the equality of the coefficients. The results indicate that in most cases the answer is no, they are not statistically different from each other. The exceptions to this are in column (vi) where we reject the hypothesis that technology transfers by JUG acquisitions are similar to those from non-JUG countries.

5.2. Alternative Definitions of Technological Frontier Countries

Within our analysis we consider Japan, USA and Germany (JUG) as countries that lie at the technological frontier. [29] While the empirical results we present in Table 7 suggest that this assumption is a reasonable partitioning of the acquisitions that take place in the data, in Table 8 we test the sensitivity of our results by choosing an increasingly larger set of countries that are described as on, or close to, the technological frontier. We consider three additional sets of classifications, which we describe in Table 2 columns (v) to (vii). The first alternative classification of country's technological intensity is based on the 10 countries with the highest ratio of Business Enterprise R&D expenditures (BERD) over GDP for the period 2004-2009. A second set of classifications is based on information generated by the European Commission and classifies technological leading countries according the European Innovation Scoreboard (EIS) 2009.[30] Finally, we choose the separate the 5 least technologically intensive countries for which we have acquisitions (Brazil, India, Mexico, Poland and Portugal) into a separate group.

Under the first three measures the greatest sensitivity surrounds the classification of Austria, Hong Kong and the UK. Of these the most relevant empirically is the UK; there are 7 acquisitions by UK MNEs in our sample compared to just one for Austria and Hong Kong. The UK is classified as a frontier country by the European Commission but is not amongst the 10 most R&D intensive countries according

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[28] This result strongly suggesting that MNEs transfer internal knowledge to newly acquired subsidiaries would appear to confirm the case study evidence presented in Bresman et al. (1999).

[29] Estimating the changes in R&D expenditures separately for acquisitions from Germany, Japan and the US separately suggests that the technology transfers within the firm in column (viii) are largely explained by the FDI from Germany and the US. We find weaker evidence of the same effect for Japan, although it should be noted that there are only 3 acquisitions from this country.

[30] Following this source, technologically leading countries include Germany, Denmark, Switzerland, Finland, Sweden and UK. We also add into this group the non-European countries: USA, Japan and Israel.

to the OECD's BERD measure. In contrast, Austria and Hong Kong are amongst the 10 most R&D intensive countries according to OECD data, but are not classified as technological leaders by the European Commission.

The regressions separating the top 10 countries as a single group are in Panel A of Table 8; results based on the European Commission classification are in Panel B and the results separating the 5 least technologically intensive countries into a separate group are in Panel C. Comparing the results across the panels with those in Table 7, we note that qualitatively they do not change until we get to panel C. We continue to find across panels A and B evidence of a decrease in internal R&D expenditure and, an increase in technology imported from other affiliates within the same business group, when the acquisition is by a technologically intensive country and no changes for firms acquired by MNEs from other countries. Quantitatively the effect of these two changes are smaller in panels A and B compared to Table 7 however. The contemporaneous increase in technology transfers in column (vi) are 0.66 log points in Table 7 and 0.58 and 0.52 log points in panels A and B of Table 8. These equate to a rise of 93%, 78% or 68% in expenditures on this category. Applying a Wald test for the equality of the coefficients we find that the differences between technologically advanced and non-advanced MNEs are now no longer statistically significant.[31] As might be expected, extending the definition of MNEs that are classified as being from countries that are more technologically intensive than Spain, the evidence of an effect from the internationalisation of R&D on the knowledge production function weakens.

In Panel C, where we use the broadest definition of FDI from technologically intensive countries and by definition the narrowest definition of what is not, we find little evidence of post-acquisition to the knowledge production when FDI is from technologically intensive countries. However, unexpectedly we do find that there are significant changes to the choice of knowledge inputs for acquisitions from the 5 least technologically intensive countries compared to the control group. For this group, and it should be remembered that these effects are identified from just 6 acquisitions, the results indicate that expenditures on internal R&D rise significantly and that on external R&D fall, where this is explained by the decline in domestically outsourced R&D effort. This is opposite to the results found in panels A and B. In column (ii) the estimated effect on internal R&D is 1.198 log points in the year following acquisition (a rise of 233%), while external R&D expenditures fall by an estimated 99% and 85% in the two years following acquisition. The net effect of this is for total R&D expenditures to rise, by on average 290% in year 1 and 108% in year 2, where again this contrasts with what was found from FDI from other countries.

Motivated by these results in Table 9 we separate acquisitions into one of three groups which we label as those from technologically intensive countries (Germany, Japan and the US), the 5 least technologically intensive countries (Brazil, India, Mexico, Poland, Portugal) and a final group of

[31] We do not report the Wald test within the table in order to conserve space.

countries which we now label as having a similar technologically intensity to Spain. The results in this table would appear to confirm different effects across these three groups. When FDI is from more technologically advanced countries we find there is a rebalancing of the knowledge production function away from internal R&D and towards a greater reliance on that from elsewhere within the MNE. For countries with a similar technological intensity as Spain we find no evidence of a change in the knowledge production function relative to the counterfactual. Finally, when acquisition occurs from a less technologically intensive country we find that there is again a significant change in the knowledge production function, but this time towards internal R&D and away from that on outsourced R&D in Spain. Only for this group is there evidence of an increase in total innovation expenditures following acquisition. This pattern of changes would appear consistent with an interpretation of technology sourcing by MNEs from less technologically intensive countries. For MNEs from technologically similar countries we find no clear evidence that the knowledge assets of both parties are a motive for the FDI that took place.

Finally and for completeness, in Table 10 we re-examine the types of firms that are acquired by MNEs from countries separated according to their technological intensity. In column (i) we compare the affiliates acquired by MNEs from the JUG countries and those countries with a technology level similar to Spain, in column (ii) we compare the JUG acquisitions with those by the 5 least technologically intensive, and in column (iii) those from the technologically similar and 5 least technologically intensive. Few of the coefficients are significant within the table, suggesting that the previous finding that the types of Spanish firms acquired by foreign MNEs are statistically similar to each other continue to hold. Of the two significance coefficients within Table 10 both relate to the comparison with the 5 least technologically intensive countries. In column (ii) we find evidence that those firms acquired by JUG countries have significantly lower external R&D expenditures compared to acquisitions from the least technologically intensive, while in column (iii) there is evidence that firms acquired by MNEs from countries with a similar technology level to Spain have significantly higher internal R&D.

6. Summary and Concluding Remarks

This paper exploits a unique dataset that provides detailed information on all components of innovation expenditures of Spanish firms, distinguishing knowledge inputs by provider and between national and international origins, in an annual panel setting. This allows us to study changes in the R&D structure of acquired firms following acquisition by foreign MNEs. In particular, we can observe the evolution of R&D imports coming from the business group after acquisition, which is our measure of international technology transfers. From this we infer whether complementarity of knowledge assets were a likely motive behind acquisition.

Our results suggest that foreign acquisitions are in part dependent upon the knowledge inputs used by a firm, which we interpret as evidence consistent with the view that the knowledge assets of the target firm may be a motive for acquisition FDI. We find that firms that spend more on internal R&D and less on external R&D are more likely to be acquired as are firms that already share knowledge between their R&D affiliates abroad. While this latter effect is consistent with the knowledge complementarities view, we note that this variable may capture other aspects of the firm. Given the country in which the acquisitions take place is not on the technological frontier we also examine differences between MNEs. While we find some suggestive evidence that MNEs from countries that are as, or less technologically intensive than Spain are more responsive the knowledge inputs used by the target firm, we find that any differences compared to the most technologically intensive countries (Germany, Japan and the US) are not statistically significant.

Between MNE differences appear to be instead more important to the post-acquisition changes in knowledge inputs. Relative to the control group of non-acquired firms we find that MNEs can be separated into three groups. When the acquisition FDI is from a more technologically intensive country there is a shift in the knowledge production function away from expenditures on internal-domestic R&D effort and towards R&D from elsewhere in the business group. We interpret this as direct evidence of technology transfer and argue that it may help to explain the post-acquisition improvement in productivity found in many studies. This also suggests that complementary knowledge assets were a motive for acquisition.

For acquisitions FDI from countries which are more technologically similar to the host country there are no significant changes to the knowledge production function compared to the control group. For these MNEs there is evidence of selection based on knowledge inputs but no post-acquisition changes. This result is interesting given MNEs from these countries represent the bulk of the FDI flows we observe in the data. Finally, for FDI from less technologically intensive countries there would appear to be a shift in the knowledge production function towards domestic-internal R&D, while external R&D falls by 100%. For MNEs that are from countries away from the technological frontier it is less clear that the knowledge assets held by the foreign MNE is a motive for FDI. This might instead be viewed as evidence of technology sourcing FDI, although that the firm does not attempt to 'tap-into' the R&D being undertaken in the rest of Spain suggests that the technology sourcing motive we observe in Spain is different from that for the US reported in Griffith et al. (2006).

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Table 1: Summary Statistics of Innovation Expenditures by Type of Firm

	All acquired firms			Acquired firms from JUG countries			Acquired firms from non-JUG countries			Never acquired
Year	*t-1*	*t*	*t+1*	*t-1*	*t*	*t+1*	*t-1*	*t*	*t+1*	
Total Innovation Expenditure (log)	*13.44*	*13.35*	*13.23*	*13.13*	*13.22*	*13.07*	*13.61*	*13.43*	*13.31*	*12.45*
	(1.56)	*(1.59)*	*(1.47)*	*(1.62)*	*(1.68)*	*(1.67)*	*(1.50)*	*(1.54)*	*(1.36)*	*(1.56)*
% of total innovation expenditure on...										
Internal R&D	73.78	68.60	71.36	77.74	68.40	63.40	71.61	68.71	75.47	73.45
	(32.72)	(34.77)	(36.15)	(31.97)	(36.42)	(40.02)	(33.06)	(33.98)	(33.47)	(31.02)
External R&D	12.89	14.62	14.38	10.06	13.49	12.82	14.45	15.23	15.19	11.43
	(23.61)	(25.37)	(28.46)	(22.89)	(25.79)	(28.40)	(23.95)	(25.22)	(28.61)	(20.83)
Non-R&D innovation	14.50	16.78	14.26	13.94	18.10	23.78	14.80	16.05	9.34	15.98
	(25.84)	(28.50)	(27.91)	(26.79)	(29.65)	(35.86)	(25.44)	(27.94)	(21.38)	(26.85)
Total External R&D Expenditure (log)	*5.36*	*5.71*	*4.93*	*4.28*	*5.48*	*4.66*	*5.96*	*5.84*	*5.08*	*4.89*
	(6.12)	*(6.13)*	*(6.02)*	*(5.89)*	*(6.11)*	*(5.93)*	*(6.18)*	*(6.16)*	*(6.09)*	*(5.62)*
% of external R&D on...										
External domestic	71.77	69.87	75.30	59.39	57.83	60.18	76.73	76.19	82.66	93.81
	(40.41)	(42.14)	(40.11)	(45.32)	(46.70)	(47.12)	(37.53)	(38.45)	(34.52)	(20.00)
External foreign	28.23	30.13	24.70	40.61	42.17	39.82	23.27	23.81	17.33	6.19
	(40.41)	(42.14)	(40.11)	(45.32)	(46.70)	(47.12)	(37.53)	(38.45)	(34.52)	(20.00)
Total External Foreign Expenditure (log)	*2.21*	*2.34*	*1.68*	*2.20*	*2.76*	*2.17*	*2.23*	*2.12*	*1.42*	*0.69*
	(4.82)	*(4.85)*	*(4.20)*	*(4.79)*	*(5.26)*	*(4.64)*	*(4.85)*	*(4.62)*	*(3.96)*	*(2.69)*
% of external foreign R&D on...										
External foreign same business group	58.62	69.59	72.27	54.17	76.84	80.01	61.05	64.64	65.94	5.41
	(48.39)	(44.87)	(43.88)	(49.81)	(40.43)	(39.99)	(48.61)	(47.94)	(47.76)	(21.38)
External foreign other private firms	35.50	27.71	12.73	29.17	16.49	8.88	38.95	35.36	15.87	74.19
	(46.92)	(43.55)	(31.39)	(45.02)	(34.70)	(26.65)	(48.61)	(47.94)	(35.77)	(41.90)
External foreign non-private firms	5.88	2.70	15.00	16.67	6.67	11.11	0.00	0.00	18.18	20.41
	(23.88)	(16.44)	(36.63)	(38.92)	(25.82)	(33.33)	(0.00)	(0.00)	(40.45)	(38.65)
Number of firms	189	189	144	67	67	48	122	122	96	4,106

Note: The symbol *t-1* denotes one year before acquisition by a foreign MNE; *t* denotes the year of the acquisition; and *t+1* means one year after acquisition. JUG countries are Japan, USA and Germany. Standard deviations are in parenthesis.

Table 2: Number of acquisitions distinguishing by headquarter of the MNE

	Number of acquisitions before matching (i)	Number of acquisitions after matching (ii)	BERD as % of GDP (average 2004-2009) (iii)	JUG countries (iv)	Top 10 BERD countries (v)	Technological leaders (vi)	Least Technologically Intensive (vii)
Israel	2	2	3.54		√	√	
Sweden	3	3	2.62		√	√	
Japan	3	3	2.58	√	√	√	
Finland	2	1	2.52		√	√	
Switzerland	8	8	2.17		√	√	
USA	33	26	1.87	√	√	√	
Denmark	2	2	1.80		√	√	
Germany	31	26	1.79	√	√	√	
Austria	1	1	1.76		√		
Hong-Kong	1	1	1.58		√		
Luxembourg	8	5	1.33				
France	25	21	1.32				
Belgium	8	8	1.29				
Canada	4	4	1.08				
United Kingdom	12	7	1.08			√	
Netherlands	16	12	0.96				
Slovenia	1	1	0.97				
Czech Republic	1	0	0.90				
Norway	3	2	0.85				
Spain			0.66				
Italy	17	15	0.58				
Portugal	3	3	0.52				√
Brazil	1	1	0.49[(a)]				√
Mexico	1	1	0.18				√
Poland	2	1	0.17				√
India	1	0	n/a				√
Total	189	154					

Notes: Period 2004-2009. (a) Data of Brazil are for the year 2006. BERD as % of GDP data come from OECD database. Columns (iv) to (vii) refer to different classifications of technologically leading countries and technologically non-leading countries. Source for column (vi) European Innovation Scoreboard (2009).

Table 3: Determinants of Acquisitions by a Foreign MNE: Base regressions

Sample Regression No.	Full sample (i)	Full sample (ii)	Full sample (iii)	Full sample (iv)	JUG vs. non-acquired (v)	Non-JUG vs. non-acquired (vi)	JUG vs. non-JUG (vii)
Log(Total innovation expenditure)	0.0011***	0.0006					
	(0.000)	(0.000)					
Log(Total innovation /turnover)	-0.0046	-0.0035					
	(0.005)	(0.005)					
External R&D/internal R&D		-0.0000					
		(0.000)					
Log(internal R&D)			0.0012***	0.0011***	0.0003	0.0008***	0.0005
			(0.000)	(0.000)	(0.000)	(0.000)	(0.010)
Log(external R&D)			-0.0004***	-0.0004***	-0.0002***	-0.0002***	-0.0031
			(0.000)	(0.000)	(0.000)	(0.000)	(0.003)
External R&D same business group/external R&D		0.0000	0.0001				
		(0.000)	(0.000)				
External R&D same business group dummy		0.0368**	0.0465**	0.0672***	0.0206*	0.0552***	-0.0428
		(0.018)	(0.021)	(0.018)	(0.011)	(0.018)	(0.033)
Labour productivity	0.0025***	0.0026***	0.0030***	0.0030***	0.0013***	0.0017***	0.0136
	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)	(0.000)	(0.014)
Size <50 employees	-0.0078***	-0.0077***	-0.0073***	-0.0073***	-0.0020**	-0.0052***	0.0395
	(0.002)	(0.002)	(0.002)	(0.002)	(0.001)	(0.001)	(0.053)
Size: 50-99 employees	-0.0026**	-0.0025**	-0.0024**	-0.0023**	0.0001	-0.0022***	0.0610
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.055)
Size: 200-499 employees	0.0006	0.0005	0.0008	0.0008	0.0016	-0.0004	0.0861
	(0.002)	(0.002)	(0.002)	(0.002)	(0.001)	(0.001)	(0.055)
Size: >=500 employees	0.0006	0.0005	0.0007	0.0009	0.0005	0.0005	-0.0043
	(0.002)	(0.002)	(0.002)	(0.002)	(0.001)	(0.001)	(0.047)
Export dummy	0.0018*	0.0009	0.0008	0.0008	0.0001	0.0006	-0.0295
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.041)
Observations	17,581	16,394	16,394	16,394	16,068	16,216	504

Note: In columns (i) to (vi), the dependent variable is a dummy variable that takes the value one if the firm is acquired in year t, and zero otherwise. In column (vii), the dependent variable is a dummy variable that takes the value one if the firm is acquired by a MNE from either Germany, Japan or the US (JUG) in year t, and zero if the acquisition is by a MNE from a non-JUG country. All estimations use a probit model. The coefficients refer to marginal effects calculated at sample means. Estimated standard errors are clustered at the firm level and shown in parenthesis. All independent variables are lagged one period and are in logarithms except dummy variables. All regressions include region and year dummies. * Significant at 10%. ** significant at 5%. *** significant at 1%.

Table 4: Determinants of Acquisitions by a Foreign MNE: Adding Patents

Sample Regression No.	Full sample (i)	Full sample (ii)	Full sample (iii)	Full sample (iv)	JUG vs. non-acquired (v)	Non-JUG vs. non-acquired (vi)	JUG vs. non-JUG (vii)
Log(Number of patents)	-0.0001	-0.0002	-0.0002	-0.0002	-0.0000	-0.0002	0.0019
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.002)
Log(Total innovation expenditure)	0.0015***	0.0008					
	(0.000)	(0.001)					
Log(Total innovation /turnover)	-0.0061	-0.0036					
	(0.006)	(0.005)					
External R&D/internal R&D		-0.0000					
		(0.000)					
Log(internal R&D)			0.0013***	0.0013***	0.0003	0.0009***	-0.0060
			(0.000)	(0.000)	(0.000)	(0.000)	(0.013)
Log(external R&D)			-0.0004***	-0.0004***	-0.0002***	-0.0002**	-0.0012
			(0.000)	(0.000)	(0.000)	(0.000)	(0.003)
External same business group/external R&D		0.0001	0.0001				
		(0.000)	(0.000)				
External same business group dummy		0.0387**	0.0479**	0.0731***	0.0234*	0.0574***	-0.0618
		(0.019)	(0.022)	(0.021)	(0.013)	(0.020)	(0.039)
Labour productivity	0.0025***	0.0027***	0.0031***	0.0031***	0.0014***	0.0017***	0.0152
	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)	(0.000)	(0.018)
Size <50 employees	-0.0067***	-0.0077***	-0.0074***	-0.0074***	-0.0017	-0.0054***	0.0924
	(0.002)	(0.002)	(0.002)	(0.002)	(0.001)	(0.002)	(0.075)
Size: 50-99 employees	-0.0029**	-0.0033***	-0.0031***	-0.0031***	-0.0001	-0.0026***	0.0811
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.071)
Size: 200-499 employees	-0.0004	-0.0012	-0.0009	-0.0008	0.0014	-0.0013*	0.1128
	(0.002)	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)	(0.072)
Size: >=500 employees	-0.0004	-0.0006	-0.0003	-0.0001	0.0014	-0.0007	0.0329
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.001)	(0.072)
Export dummy	0.0023*	0.0017	0.0016	0.0016	0.0003	0.0012	-0.0261
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.050)
Observations	14,523	13,527	13,527	13,527	13,295	13,397	362

Note: In columns (i) to (vi), the dependent variable is a dummy variable that takes the value one if the firm is acquired in year t, and zero otherwise. In column (vii), the dependent variable is a dummy variable that takes the value one if the firm is acquired by a MNE from either Germany, Japan or the US (JUG) in year t, and zero if the acquisition is by a MNE from a non-JUG country. All estimations use a probit model. The coefficients refer to marginal effects calculated at sample means. Estimated standard errors are clustered at the firm level and shown in parenthesis. All independent variables are lagged one period and are in logarithms except dummy variables. All regressions include region and year dummies. * Significant at 10%. ** significant at 5%. *** significant at 1%.

Table 5: Balancing tests

a) For each ex ante covariate

Variable	Mean		%bias	% |Bias|	t-test	
	Treated	Control		Reduction	t	p-value
Log(internal R&D)	11.91	12.52	-17.0	13.4	-1.50	0.134
Log(external R&D)	4.81	4.93	-2.1	75.4	-0.18	0.859
External same business group dummy	0.08	0.05	14.6	74.8	1.39	0.166
Labour productivity	12.32	12.29	3.7	94.7	0.36	0.722
Size <50 employees	0.19	0.19	0.0	100	0.00	1.000
Size 50-99 employees	0.18	0.21	-8.7	-463.7	-0.72	0.471
Size 200-499 employees	0.22	0.21	1.7	95.4	0.14	0.891
Size >500 employees	0.18	0.12	17.6	55.3	1.43	0.155
Export dummy	0.79	0.86	-14.5	60.5	-1.50	0.135

b) Overall measures of covariate balancing

	Mean abs. std. bias	% mean bias reduction	Median ads. std. bias	% median bias reduction	Pseudo R^2	LR test	
						X^2	p> X^2*
Before matching	39.53		37.68		0.145	279.08	0.000
After matching	8.88	77.53%	8.74	76.80%	0.020	8.49	0.486

Notes: *Likelihood-ratio test of the joint insignificance of all regressors.

Table 6: The Effect of Foreign Acquisition on Innovation Expenditures

Innovation Expenditure Regression No.	Total (i)	Internal R&D (ii)	External R&D (iii)	External Domestic (iv)	External Foreign (v)	External Foreign Same Bus. Group (vi)
Year of acquisition	0.043	-0.178	0.351	0.222	0.315	0.411***
	(0.063)	(0.145)	(0.383)	(0.412)	(0.241)	(0.145)
One year after acquisition	-0.016	-0.133	-0.460*	-0.607*	-0.029	0.136
	(0.061)	(0.169)	(0.241)	(0.295)	(0.356)	(0.269)
Relative corporate tax	-0.033	-0.482	0.777	0.551	0.026	0.431
	(0.180)	(0.772)	(0.823)	(0.923)	(1.345)	(1.115)
Size <50 employees	-0.526***	-0.761***	-0.127	0.783	-0.803	-0.600
	(0.151)	(0.130)	(1.618)	(1.475)	(0.698)	(0.429)
Size: 50-99 employees	-0.507***	-0.630***	0.279	1.111	-0.079	-0.311
	(0.117)	(0.115)	(1.168)	(0.842)	(0.382)	(0.330)
Size: 200-499 employees	-0.035	-0.124	0.599	0.183	0.464	-0.016
	(0.199)	(0.114)	(0.554)	(0.635)	(0.448)	(0.384)
Size: >=500 employees	0.030	0.127	0.291	-0.436	0.860*	0.565
	(0.174)	(0.311)	(0.509)	(0.896)	(0.461)	(0.519)
Export dummy	-0.066	-0.248*	0.514**	0.368*	0.347*	0.447***
	(0.093)	(0.121)	(0.232)	(0.211)	(0.183)	(0.125)
Observations	1,490	1,490	1,490	1,490	1,490	1,490
R-squared	0.089	0.415	0.011	0.013	0.017	0.024
Number of firms	295	295	295	295	295	295

Note: OLS estimates. Estimated standard errors are clustered at the country level and shown in parenthesis. All regressions include firm-fixed effects, sector, region, and year dummies. Variables are all in logs (except dummy variables). * Significant at 10%;** Significant at 5%; *** significant at 1%.

Table 7: The Effect of Foreign Acquisition on Innovation Expenditures: Differences between JUG and non-JUG acquisitions

Innovation Expenditure	**Total**	**Internal R&D**	**External R&D**	**External Domestic**	**External Foreign**	**External Foreign Same Bus. Group**
Regression No.	**(i)**	**(ii)**	**(iii)**	**(iv)**	**(v)**	**(vi)**
JUG countries						
Year of acquisition	0.018	-0.355***	0.851***	0.525***	0.561	0.660***
	(0.049)	(0.018)	(0.083)	(0.134)	(0.343)	(0.144)
One year after acquisition	-0.144***	-0.392***	-0.505	-1.136***	0.260	0.582***
	(0.044)	(0.100)	(0.450)	(0.272)	(0.623)	(0.139)
Non-JUG countries						
Year of acquisition	0.059	-0.066	0.037	0.033	0.160	0.253
	(0.098)	(0.233)	(0.635)	(0.681)	(0.287)	(0.162)
One year after acquisition	0.058	0.019	-0.446	-0.313	-0.201	-0.125
	(0.079)	(0.244)	(0.281)	(0.289)	(0.394)	(0.325)
Relative corporate tax	-0.033	-0.495	0.828	0.591	0.045	0.449
	(0.197)	(0.713)	(0.862)	(0.947)	(1.364)	(1.126)
Size <50 employees	-0.533***	-0.770***	-0.147	0.741	-0.793	-0.582
	(0.151)	(0.127)	(1.630)	(1.500)	(0.693)	(0.416)
Size: 50-99 employees	-0.510***	-0.634***	0.268	1.091	-0.075	-0.303
	(0.116)	(0.114)	(1.177)	(0.856)	(0.382)	(0.334)
Size: 200-499 employees	-0.038	-0.130	0.604	0.179	0.472	-0.007
	(0.200)	(0.113)	(0.555)	(0.634)	(0.450)	(0.379)
Size: >=500 employees	0.033	0.143	0.259	-0.448	0.839*	0.541
	(0.178)	(0.320)	(0.496)	(0.893)	(0.455)	(0.525)
Export dummy	-0.065	-0.247*	0.517**	0.373*	0.347*	0.446***
	(0.092)	(0.120)	(0.240)	(0.215)	(0.179)	(0.117)
Wald test of equality of coefficients (p-value): JUG vs. non-JUG						
Acquisition year	0.711	0.225	0.225	0.487	0.367	0.066
Year after acquisition	0.029	0.117	0.913	0.040	0.541	0.054
Observations	1,490	1,490	1,490	1,490	1,490	1,490
R-squared	0.090	0.416	0.012	0.014	0.018	0.027
Number of firms	295	295	295	295	295	295

Note: OLS estimates. Estimated standard errors are clustered at the country level and shown in parenthesis. All regressions include firm-fixed effects, sector, region, and year dummies. Variables are all in logs (except dummy variables). * Significant at 10%;** Significant at 5%; *** significant at 1%.

Table 8: The Effect of Foreign Acquisition on Innovation Expenditures: Alternative Definitions of Technologically Intensive Countries

Innovation Expenditure Regression No.	Total (i)	Internal R&D (ii)	External R&D (iii)	External Domestic (iv)	External Foreign (v)	External Foreign Same Bus. Group (vi)
Panel A: Top 10 and non-top 10 in terms of BERD as percentage of GDP[b)]						
Top 10						
Year of acquisition	-0.002	-0.404***	0.634**	0.348	0.397	0.583***
	(0.048)	(0.084)	(0.233)	(0.207)	(0.323)	(0.148)
One year after	-0.151***	-0.464***	-0.648	-1.145***	0.118	0.477***
acquisition	(0.042)	(0.144)	(0.430)	(0.328)	(0.512)	(0.148)
Not Top 10						
Year of acquisition	0.083	0.021	0.106	0.117	0.243	0.259
	(0.113)	(0.240)	(0.715)	(0.769)	(0.325)	(0.183)
One year after	0.098	0.150	-0.312	-0.163	-0.154	-0.154
acquisition	(0.090)	(0.250)	(0.244)	(0.256)	(0.469)	(0.373)
Panel B: Technological leaders and non-leaders (Source European Commission)[c)]						
Technological Leader						
Year of acquisition	-0.003	-0.353***	0.574**	0.333*	0.350	0.519***
	(0.045)	(0.086)	(0.227)	(0.192)	(0.304)	(0.165)
One year after	-0.093	-0.365**	-0.677*	-1.106***	0.096	0.417**
acquisition	(0.061)	(0.149)	(0.381)	(0.339)	(0.468)	(0.163)
Not Techno. Leader						
Year of acquisition	0.091	0.008	0.118	0.109	0.278	0.295
	(0.124)	(0.261)	(0.779)	(0.842)	(0.357)	(0.196)
One year after	0.061	0.101	-0.257	-0.125	-0.153	-0.143
acquisition	(0.092)	(0.267)	(0.284)	(0.293)	(0.503)	(0.405)
Panel C: 5 least technologically intensive countries						
More Techno. Intensive						
Year of acquisition	-0.012	-0.246	0.537	0.409	0.360	0.418**
	(0.054)	(0.143)	(0.362)	(0.398)	(0.243)	(0.148)
One year after	-0.059	-0.211	-0.384	-0.529	-0.114	0.135
acquisition	(0.053)	(0.179)	(0.253)	(0.312)	(0.370)	(0.286)
Least Techno Intensive						
Year of acquisition	1.360***	1.413	-4.208**	-4.357**	-0.957	0.238
	(0.160)	(1.591)	(1.701)	(1.846)	(0.733)	(0.364)
One year after	0.733**	1.198***	-1.874***	-2.062***	1.317**	0.148
acquisition	(0.321)	(0.343)	(0.646)	(0.666)	(0.522)	(0.128)

Note: OLS estimates. Estimated standard errors are clustered at the country level and shown in parenthesis. All regressions include firm-fixed effects, sector, region, and year dummies. For classification of countries a), b) and c) see Table 2. Variables are all in logs (except dummy variables). * Significant at 10%;** Significant at 5%; *** significant at 1%.

Table 9: The Effect of Foreign Acquisition on Innovation Expenditures: Separating JUG, Technologically Similar and Least Technologically Intensive Countries

Innovation Expenditure	Total	Internal R&D	External R&D	External Domestic	External Foreign	External Foreign Same Bus. Group
Regression No.	(i)	(ii)	(iii)	(iv)	(v)	(vi)
JUG countries						
Year of acquisition	0.019	-0.354***	0.846***	0.520***	0.559	0.660***
	(0.054)	(0.020)	(0.097)	(0.117)	(0.344)	(0.144)
One year after	-0.144***	-0.393***	-0.509	-1.139***	0.254	0.581***
Year of acquisition	(0.041)	(0.103)	(0.460)	(0.266)	(0.623)	(0.138)
Technologically Similar						
Year of acquisition	-0.032	-0.173	0.331	0.339	0.226	0.253
	(0.077)	(0.233)	(0.614)	(0.669)	(0.296)	(0.171)
One year after	-0.006	-0.094	-0.313	-0.149	-0.349	-0.152
Year of acquisition	(0.072)	(0.267)	(0.277)	(0.273)	(0.397)	(0.355)
Least Techno. intensive						
Year of acquisition	1.359***	1.414	-4.215**	-4.362**	-0.958	0.236
	(0.160)	(1.593)	(1.709)	(1.854)	(0.732)	(0.361)
One year after	0.733**	1.198***	-1.871***	-2.058***	1.317**	0.148
Year of acquisition	(0.321)	(0.343)	(0.647)	(0.664)	(0.521)	(0.125)
Observations	1,490	1,490	1,490	1,490	1,490	1,490
R-squared	0.104	0.419	0.016	0.019	0.020	0.027
Number of firms	295	295	295	295	295	295

Note: OLS estimates. Estimated standard errors are clustered at the country level and shown in parenthesis. All regressions include firm-fixed effects, sector, region, and year dummies. For classification of countries a), b), c) and d) see Table 2. Variables are all in logs (except dummy variables). Remaining controls are the same as in Table 6. * Significant at 10%;** Significant at 5%; *** significant at 1%.

Table 10: Determinants of Acquisitions by a Foreign MNE: Comparing Country Samples

Sample	JUG vs. Techno. Similar	JUG vs.5 Least Techno Intensive	Techno similar vs. 5 Least Techno Intensive
Regression No.	(i)	(ii)	(iii)
Log(internal R&D)	-0.0016	0.0440	0.0414*
	(0.010)	(0.029)	(0.023)
Log(external R&D)	-0.0028	-0.0124*	-0.0025
	(0.003)	(0.007)	(0.006)
External same business group dummy	-0.0458	-0.1241	0.0471
	(0.034)	(0.117)	(0.103)
Labour productivity	0.0148	-0.0067	0.0372
	(0.015)	(0.044)	(0.028)
Size <50 employees	0.0307	0.1573	0.0469
	(0.054)	(0.151)	(0.091)
Size: 50-99 employees	0.0628	0.1083	0.0225
	(0.057)	(0.136)	(0.098)
Size: 200-499 employees	0.0787	0.2004	0.0697
	(0.056)	(0.141)	(0.083)
Size: >=500 employees	-0.0051	-0.0899	-0.0488
	(0.049)	(0.130)	(0.092)
Export dummy	-0.0367	-0.0565	-0.0503
	(0.044)	(0.106)	(0.083)
Observations	480	202	326

Note: In columns (i) the dependent variable is a dummy variable that takes the value one if the firm is acquired by a MNE from either Germany, Japan or the US (JUG) in year t, and zero if acquired from a Technologically Similar Country. In columns (ii) the dependent variable equals one if the firm is acquired by a MNE from either Germany, Japan or the US (JUG) in year t, and zero if acquired from one of the 5 Least Technologically Intensive Countries. In columns (iii) the dependent variable equals one if the firm is acquired by a MNE from A Technologically Similar Country in year t, and zero if acquired from one of the 5 Least Technologically Intensive Countries. All estimations use a probit model. The coefficients refer to marginal effects calculated at sample means. Estimated standard errors are clustered at the firm level and shown in parenthesis. All independent variables are lagged one period and are in logarithms except dummy variables. All regressions include region and year dummies. * Significant at 10%. ** significant at 5%. *** significant at 1%.

APPENDIX A: Additional tables

Table A1: Classification of total innovation expenditures

Subcategories of *Total innovation expenditures*	[1-3]	Definition
R&D internal	[1]	In-house or intramural R&D: Creative work undertaken within an enterprise on an occasional or regular basis in order to increase the stock of knowledge and its use to devise new and improved goods, services and processes.
R&D external	[2]	Acquisition of R&D or extramural R&D: Firm purchases of creative work on an occasional or regular basis in order to increase the stock of knowledge and its use to devise new and improved goods, services and processes form other companies (including other enterprises within the group) or public and private research organizations
R&D external-domestic	[2.1]	Acquisition of R&D in Spain.
R&D external-foreign	[2.2]	Acquisition of R&D abroad.
R&D external-foreign same business group	[2.2.1]	R&D acquisitions abroad from companies that belong to the same business group
R&D external-foreign other private	[2.2.2]	R&D acquisitions abroad from companies that are legally independent and do not belong to the same business group
R&D external-foreign non-private	[2.2.3]	R&D acquisitions abroad from public administrations, universities, non-profi organizations and other international organizations
Innovation expenditures other than R&D	[3]	*Acquisition of machinery, equipment and software*: Acquisition of advanced machinery, equipment and computer hardware or software to produce new or significantly improved goods, services, production processes, or delivery methods. *Acquisition of external knowledge*: Purchase or licensing of patents and non-patented inventions, know-how, and other types of knowledge from other enterprises or organizations. *Expenditures on design functions* for the development or implementation of new or improved goods, services and processes. Expenditure on design in the R&D phase of product development should be excluded. *Internal or external training for personnel* specifically for the development and/or introduction of innovations. Expenditures on all activities concerning *market preparation* and introduction of new or significantly improved goods and services, including market research and launch advertising.

Note: The numbers correspond to the classification of innovation expenditures, which we use in tables 3 and 6 to 9. Data are in Euros. We take the logarithms of these variables to construct the variables that we use in the empirical analysis (Source PITEC database).

Table A2: Summary Statistics of Innovation Expenditures by Type of Firm

	All acquired firms			Acquired firms from JUG countries			Acquired firms from non-JUG countries			Never acquired
Year	*t-1*	*t*	*t+1*	*t-1*	*t*	*t+1*	*t-1*	*t*	*t+1*	
Non-R&D Expenditures (log)	6.09	6.06	5.40	5.67	5.95	6.90	6.32	6.12	4.63	5.84
	(6.10)	(6.05)	(5.95)	(6.12)	(6.14)	(6.02)	(6.10)	(6.02)	(5.80)	(5.58)
External foreign same business group (log)	1.47	1.82	1.36	1.31	2.36	1.93	1.56	1.52	1.07	0.05
	(4.13)	(4.44)	(3.87)	(3.91)	(4.93)	(4.42)	(4.26)	(4.13)	(3.55)	(0.84)
External foreign other private firms (log)	0.79	0.70	0.25	0.75	0.63	0.25	0.82	0.74	0.25	0.53
	(2.97)	(2.81)	(1.74)	(3.02)	(2.99)	(1.76)	(2.96)	(2.71)	(1.73)	(2.38)
External foreign non-private firms(log)	0.10	0.05	0.21	0.29	0.14	0.21	0.00	0.00	0.21	0.17
	(1.02)	(0.72)	(1.44)	(1.71)	(1.21)	(1.45)	(0.00)	(0.00)	(1.44)	(1.37)
Number of firms	189	189	144	67	67	48	122	122	96	4,106

Note: The symbol *t-1* denotes one year before acquisition by a foreign MNE; *t* denotes the year of the acquisition; and *t+1* means one year after acquisition. JUG countries are Japan, USA and Germany. Standard deviations are in parenthesis.

Table A3: The Effect of Foreign Acquisition on Innovation Expenditures

Innovation Expenditure **Regression No.**	**Non-R&D** **(i)**	**External Foreign Other Private** **(ii)**	**External Foreign Non-private** **(iii)**
Year of acquisition	-0.135	0.222	0.315
	(0.343)	(0.412)	(0.241)
One year after acquisition	-0.802	-0.607*	-0.029
	(0.721)	(0.295)	(0.356)
Relative corporate tax	-0.029	0.551	0.026
	(1.817)	(0.923)	(1.345)
Size <50 employees	-0.947	0.783	-0.803
	(0.965)	(1.475)	(0.698)
Size: 50-99 employees	-1.793**	1.111	-0.079
	(0.723)	(0.842)	(0.382)
Size: 200-499 employees	0.074	0.183	0.464
	(0.777)	(0.635)	(0.448)
Size: >=500 employees	0.079	-0.436	0.860*
	(0.941)	(0.896)	(0.461)
Export dummy	0.416	0.368*	0.347*
	(0.655)	(0.211)	(0.183)
Observations	1,288	1,490	1,490
R-squared	0.061	0.013	0.017
Number of firms	288	295	295

Note: OLS estimates. Estimated standard errors are clustered at the country level and shown in parenthesis. All regressions include firm-fixed effects, sector, region, and year dummies. Variables are all in logs (except dummy variables). * Significant at 10%;** Significant at 5%; *** significant at 1%.

Table A4: The Effect of Foreign Acquisition on Innovation Expenditures: Differences between JUG and non-JUG acquisitions

Innovation Expenditure Regression No.	Non-R&D (i)	External Foreign Other Private (ii)	External Foreign Non-private (iii)
JUG countries			
Year of acquisition	-0.833***	0.020	0.025
	(0.113)	(0.345)	(0.050)
One year after acquisition	0.240	-0.464	0.097
	(0.451)	(0.497)	(0.140)
Non-JUG countries			
Year of acquisition	0.304	-0.068	-0.004
	(0.493)	(0.174)	(0.054)
One year after acquisition	-1.389	-0.496	0.256
	(0.937)	(0.318)	(0.253)
Relative corporate tax	-0.104	-1.090	0.308
	(1.778)	(0.739)	(0.401)
Size <50 employees	-0.826	-0.126	0.258***
	(0.972)	(0.345)	(0.069)
Size: 50-99 employees	-1.725**	0.317	0.245***
	(0.703)	(0.238)	(0.073)
Size: 200-499 employees	0.095	0.083	0.184
	(0.792)	(0.201)	(0.209)
Size: >=500 employees	0.126	-0.162	0.166
	(0.952)	(0.220)	(0.217)
Export dummy	0.402	-0.068	0.054
	(0.657)	(0.123)	(0.164)
Wald test of equality of coefficients (p-value): JUG vs. non-JUG			
Acquisition year	0.031	0.823	0.682
Year after acquisition	0.120	0.957	0.585
Observations	1,288	1,490	1,490
R-squared	0.064	0.023	0.035
Number of firms	288	295	295

Note: OLS estimates. Estimated standard errors are clustered at the country level and shown in parenthesis. All regressions include firm-fixed effects, sector, region, and year dummies. Variables are all in logs (except dummy variables). * Significant at 10%;** Significant at 5%; *** significant at 1%.

Table A5: The Effect of Foreign Acquisition on Innovation Expenditures: Alternative Definitions of Technologically Intensive Countries

Innovation Expenditure Regression No.	Non-R&D (i)	External Foreign Other Private (ii)	External Foreign Non-private (iii)
Panel A: Top 10 and non-top 10 in terms of BERD as percentage of GDP[b)]			
Top 10			
Year of acquisition	-0.566*	-0.093	0.023
	(0.274)	(0.306)	(0.042)
One year after	-0.363	-0.469	0.067
acquisition	(0.693)	(0.403)	(0.115)
Not Top 10	0.241	0.017	-0.006
Year of acquisition	(0.512)	(0.192)	(0.061)
	-1.157	-0.494	0.308
One year after	(1.038)	(0.374)	(0.296)
acquisition	-0.566*	-0.093	0.023
Panel B: Technological leaders and non-leaders (Source European Commission)[c)]			
Technological Leader			
Year of acquisition	-0.572**	-0.087	0.023
	(0.254)	(0.277)	(0.040)
One year after	0.132	-0.421	0.066
acquisition	(0.586)	(0.372)	(0.109)
Not Techno. Leader	0.323	0.022	-0.009
Year of acquisition	(0.569)	(0.210)	(0.066)
	-1.711*	-0.542	0.327
One year after	(0.975)	(0.398)	(0.319)
acquisition	-0.572**	-0.087	0.023
Panel C: 5 least technologically intensive countries			
More Techno. Intensive			
Year of acquisition	-0.332	0.011	0.000
	(0.293)	(0.174)	(0.039)
One year after	-1.041	-0.453	0.078
acquisition	(0.741)	(0.287)	(0.136)
Least Techno Intensive	4.736**	-1.115*	-0.008
Year of acquisition	(1.741)	(0.577)	(0.101)
	4.247	-1.020*	2.175**
One year after	(2.907)	(0.546)	(0.959)
acquisition	-0.332	0.011	0.000

Note: OLS estimates. Estimated standard errors are clustered at the country level and shown in parenthesis. All regressions include firm-fixed effects, sector, region, and year dummies. For classification of countries a), b) and c) see Table 2. Variables are all in logs (except dummy variables). * Significant at 10%;** Significant at 5%; *** significant at 1%.

Table A6: The Effect of Foreign Acquisition on Innovation Expenditures: Separating JUG, Technologically Similar and Least Technologically Intensive Countries.

Innovation Expenditure Regression No.	Non-R&D (i)	External Foreign Other Private (ii)	External Foreign Non-private (iii)
JUG countries			
Year of acquisition	-0.835***	0.019	0.024
	(0.127)	(0.350)	(0.047)
One year after	0.235	-0.464	0.092
Year of acquisition	(0.459)	(0.500)	(0.137)
Technologically Similar			
Year of acquisition	-0.001	0.006	-0.016
	(0.425)	(0.167)	(0.058)
One year after	-1.828*	-0.446	0.069
Year of acquisition	(0.913)	(0.340)	(0.203)
Least Techno. intensive			
Year of acquisition	4.766**	-1.115*	-0.008
	(1.749)	(0.577)	(0.101)
One year after	4.225	-1.020*	2.176**
Year of acquisition	(2.922)	(0.546)	(0.960)
Observations	1,288	1,490	1,490
R-squared	0.070	0.024	0.046
Number of firms	288	295	295

Note: OLS estimates. Estimated standard errors are clustered at the country level and shown in parenthesis. All regressions include firm-fixed effects, sector, region, and year dummies. For classification of countries a), b), c) and d) see Table 2. Variables are all in logs (except dummy variables). Remaining controls are the same as in Table 6. * Significant at 10%;** Significant at 5%; *** significant at 1%.