Foreign acquisitions, domestic multinationals, and R&D

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Abstract
The aim of this paper is to evaluate the causal effect of foreign acquisition on R&D intensity in targeted domestic firms. We are able to distinguish domestic multinationals and non-multinationals, which allows us to investigate the fear that the change in ownership of domestic to foreign multinationals leads to a reduction in R&D activity in the country. We use unique and rich firm level data for the Swedish manufacturing sector and micro-econometric estimation strategies in order to control for the potential endogeneity of the acquisition decision. Overall, our results give no support to the fears that foreign acquisition of domestic firms lead to a relocation of R&D activity in Swedish MNEs. Rather, this paper finds robust evidence that foreign acquisitions lead to increasing R&D intensity in acquired domestic MNEs and non-MNEs.

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1. Introduction

The debate about the home country effects of multinational activity is still lively. While the popular media and the general public tend to associate outward investment by multinationals necessarily with economic losses (in employment, wages, etc.), much economic research has found that this is not the case. Indeed, studies find that multinational firms have an advantage over others in terms of efficiency and productivity, which can be further exploited abroad. Even if they relocate activity abroad, they tend to concentrate on high value / high skill headquarter activities at home, and overall there is little evidence that they substitute host country for home country employment (e.g., Blomström, Fors and Lipsey, 1997; Barba Navaretti et al., 2009; Hijzen et al., 2011).

The recent wave of cross-border mergers and acquisitions has added a new dimension to this debate. The question that is discussed now is: What will happen to the domestic multinationals, and in particular their R&D and other headquarter activities, once they are acquired by a foreign owner? In Sweden, the country to which our empirical analysis pertains, this has been an important issue. During the 1990's a wave of foreign acquisitions of Swedish multinational firms took place and many headquarters were relocated abroad. Former flagship Swedish multinationals such as Volvo, Saab, Asea and Astra were acquired by foreign owners. This raised national concerns against foreign firms exploiting the knowledge capital in Swedish firms or outsourcing domestic production to other countries.[1]

What happens to R&D activity once the multinational gets taken over by a foreign multinational? Will the R&D of the firm be cut, depleting the home country of its high skill activity? Or will the R&D location be maintained and perhaps even extended as a result of the foreign takeover? And, how do these effects compare to the R&D effects of acquisitions of domestic non-multinationals – is there a special "multinationality effect"? This is an important issue that is not only of academic interest, but also has strong policy implications. R&D is an activity that is likely to generate positive externalities, hence, relocation of the R&D activity abroad may lead to potential welfare losses (Krugman, 1991).

[1] Braunerhjelm (2001) argues that the possible relocation of Swedish multinationals headquarter activities abroad may cause a "brain-drain" in the Swedish business sector.

The fear that R&D activity gets relocated may be explained in a simple theoretical set-up. Consider a firm that operates in a global technology market where R&D assets are important. The firm may wish to advance its market position through an international merger or acquisition (M&A). If the R&D performed in the acquired and acquiring firms is similar (i.e., substitutable) there is a risk that R&D in the acquired firm may be divested for cost minimization purposes (e.g., Veugelers, 2006). This may be especially important if the acquirer is more efficient at R&D. If there are economies of scale in R&D the acquirer may find it profitable to concentrate R&D activities even if R&D performed in the acquired and acquiring firms are complementing each other. In both cases the acquirer has incentives to locate R&D close to the headquarters in the acquirer's home country. This allows it to maintain better control over the long term direction of the R&D activity, and also limits communication costs between R&D activities and other headquarter services (Caves, 1996).[2]

Recent theoretical models suggest a more benevolent effect of foreign acquisitions, however. In the model by Ekholm and Hakkala (2007), firms locate production in large markets in order to access consumers, while R&D activities are attracted to countries which already have high R&D activities in order to benefit from externalities. Such countries may be economies with small markets (where high skilled labour is relatively cheap, due to the absence of large production activities) which, through spillovers, generate an agglomeration of R&D activity. They argue that Sweden fits this pattern– a country with a relatively small market potential but high agglomeration of R&D activity. While the model is strictly speaking about Greenfield investment and not acquisitions, one may develop the intuition that, if these agglomeration forces are indeed strong, one may expect that ownership changes may not lead to any changes in the pattern of location of R&D.

Bertrand et al. (2012), develop a model which considers the relationship between the mode of foreign entry and R&D activity in the foreign affiliate. In their oligopolistic model, a multinational may acquire a foreign affiliate if the complementarity between the R&D assets of the parent and the foreign affiliate is sufficiently high.[3] This has two implications. Firstly, the foreign acquirer has an incentive to increase R&D in the foreign affiliate post-acquisition in order to prevent the expansion of domestic rivals. Secondly, the foreign acquirer tends to "cherry pick" those affiliates with an

[2] For empirical evidence that firms locate R&D close to the headquarter at home, see UNCTAD (2005).
[3] In a review of the empirical literature, Veugelers (2006) concludes that the probability of acquisitions increases with the R&D assets within target firms. This is especially important if there are complementarities in the acquired and acquiring firms R&D assets.

initially high quality of the R&D asset, as this increases the profitability of the foreign multinational vis-a-vis its domestic competitors. This model, hence, has clear empirically testable predictions: foreign acquisitions will tend to increase R&D activity in the acquisition target post-acquisition, and foreign acquirers tend to "cherry pick" R&D active targets.

We look at the effects of foreign acquisitions on R&D in the target firm empirically and use this theoretical discussion as a motivation for our empirical analysis. There are a number of earlier empirical studies which our paper relates to.[4] Some papers look at the relationship between M&As in general, and foreign acquisitions in particular, on R&D in the host country (e.g., Cassiman et al, 2005; Bertrand and Zuniga, 2006). This literature, however, does generally not look at the effect on the target firm, but rather overall R&D, and also does not specifically look at the experience of domestic multinationals. Bertrand (2009) investigates empirically post acquisition R&D performance in target firms using French data.[5] He finds that R&D activity increases post acquisition. However, he does not distinguish targets into multinationals and non-multinationals. Most closely related to our paper, Bertrand et al. (2012) provide some empirical evidence from Swedish firm level data that acquisitions are associated with higher R&D intensity than greenfield investments. While this is consistent with their theoretical model, they are unable to investigate the relevance of "cherry picking" vis-à-vis post acquisition increases in R&D. Our data allows us to do exactly that and we specifically look at the post-acquisition R&D performance in the target firm, controlling for possible "cherry picking" pre-acquisition.

We study in detail the acquisitions of domestic firms by foreign owners, and examine in particular the implications for R&D activity in the target. In the empirical analysis, we take particular account of the potential endogeneity of the acquisition decision by combining difference-in-differences with propensity score matching techniques.[6]

[4] Previous empirical literature using industry level data or a small number of firms found ambiguous effects on R&D activity in merged entities. Some explanations put forward for negative effects on R&D due to M&As were lower incentives due to larger market concentration caused by the M&A, and debt constrains due to costly M&As (Hitt et al. (1991); Baysinger & Hoskisson, 1989). On the other hand, a large group of merged firms should more easily be able to raise finance for risky R&D investments internally but also on the capital market due to more bargaining power, Hall (2002). For a detailed review of this literature, see Bertrand (2009).

[5] There are also studies with firm level data analysing the effects of foreign acquisitions on productivity, employment, wages or exit (e.g., Harris and Robinson, 2002; Girma and Görg, 2007; Huttunen, 2007; Bandick and Görg, 2010).

[6] The probability for a firm to be acquired is likely to be determined by information about the acquisition target, such as available R&D assets, human and real capital etc. These factors may be unobservable to the researcher but not to the managers in the acquired and acquiring entities and may affect both R&D expenditures and the probability of acquisition. The decision to acquire a firm is thus endogenous. For example, Table 5 provides some evidence of

The analysis is based on unique detailed firm level data for Sweden which allow us to investigate the extent of R&D undertaken in the Swedish firms before and after acquisition. We look at the timing of these effects, considering changes in R&D activity one, two and three years after the acquisition took place. We also contrast the effect of acquisition on R&D for domestic multinationals and domestic non-multinationals.

From recent theoretical models of heterogeneous firms we know that multinationals have "better" production technology than purely domestic firms (e.g., Helpman et al., 2004). While theory assumes the productivity draws to be exogenous, in the real world investment activities such as R&D clearly act to improve technology. Hence, R&D activities in multinationals generate firm-specific assets that are exploited when serving foreign markets (Markusen, 2002). R&D activities in purely domestic firms may be of a different nature, as evidently these activities do not allow the firm to generate the firm specific asset that would allow it to become multinational.[7] Hence, the R&D activity in a multinational may be more complementary to the foreign acquirer, hence increasing the probability that the foreign acquirer will invest heavily in R&D post acquisition. Moreover, from a policy point of view, given the fact that domestic multinationals tend to have higher R&D activities than purely domestic firms, there may be particular concern about the acquisition of such targets, as a relocation of R&D and other headquarter activities that generate externalities may lead to substantial welfare losses. To the best of our knowledge, we are the first paper to explore such potentially differential effects for domestic multinationals and non-multinationals in any detail.

To preview our results, we find robust evidence that there is on average no negative effect from acquisitions on R&D performance in Swedish firms. Rather, the evidence suggests that there are strong positive effects. These effects are stronger for the acquisition of domestic non-multinationals than for Swedish multinationals. However, it is important to stress that we do not find any evidence

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persistent differences in R&D, capital and skill intensity between acquired and non-acquired firms. We control for these aspects in our econometric approach, assuming that the measured variables (including R&D, skill and capital intensity as well as other firm level characteristics) are correlated with both the quantity and quality of R&D assets, human and real capital. Unfortunately, we are not able to measure these indicators directly in our data.

[7] This conjecture is in line with evidence on R&D activities in Ireland reported by Forfás (2011). It shows that domestic firms spend a large share (49%) of their R&D expenditure on licences and externally produced software. By contrast, multinationals spend 81 percent on instruments and equipment for own R&D activities. These latter activities are arguably more likely to generate firm specific assets.

that foreign acquisitions of domestic multinationals lead to reductions of R&D in Sweden. Furthermore, our results suggest that there is "cherry picking", in that the R&D activity in the target firm pre-acquisition is strongly positively correlated with the probability of being acquired. These results are consistent with the theoretical model by Bertrand et al. (2012).

The rest of the paper is structured as follows. Section 2 describes the dataset and presents some preliminary empirics on the link between foreign acquisition and R&D. Section 3 describes the empirical methodology. Section 4 discusses first results from OLS and fixed effects estimations in order to provide initial correlations. Section 5 focuses on difference-in-differences propensity score matching. Section 6 concludes.

2. Data and description

The data are from Statistics Sweden (SCB) and the Swedish Agency for Growth Policy Analysis (formerly Swedish Institute for Growth Policy Studies, ITPS). The dataset covers all manufacturing firms operating in Sweden with at least 50 employees for the period 1993-2002. The register information used in this analysis was obtained from several sources and was merged using unique identification numbers. The Structural Business Statistics (SBS) gives us information by firm on sales, investments, R&D,[8] various inputs, and whether it is foreign or domestic owned. Foreign owned firms (foreign MNEs) are firms where foreigners possess more than 50% of the voting rights. The data from the Agency from Growth Policy Analysis provides information on all Swedish controlled enterprise groups with subsidiaries abroad. With this data we are able to separate all domestically owned firms into Swedish MNEs and Swedish non-MNE. A Swedish MNE is then a

[8] We do, unfortunately, not know whether R&D is internal or external R&D. In the SBS database firms provide information on the actual level of R&D spending. If the level is less than 10 million SEK, the information is provided in specific intervals of SEK; 1-249 000, 250 000-999 000, 1-4.9 million, 5-9.9 million. If the yearly R&D expenditures exceed 10 million SEK, the firms specify the exact amount. The R&D information covers firms that have a minimum of one employee who is active in any R&D activity at 50% of a full time employment. Moreover, the SBS R&D statistics are retrieved annually and it is compulsory for firms to reply. For firms that provide information in intervals, we use the midpoint value in the analysis. Only 12 percent of all firms with R&D data provide the information in intervals, hence, we would not expect any severe bias in our estimation. To check the robustness, we also carry out a check where we estimate equation (2) discussed below, using interval regression. The results, which are available upon request, are similar to those reported in Section 4.

domestically owned firm that is part of an enterprise with affiliates abroad.[9] Non-MNEs are firms that are neither Swedish MNEs nor foreign MNEs.

By using the information on ownership status we can define foreign acquisition of a domestic MNE as a change in ownership indicator from a domestic MNE to foreign and foreign acquisition of a domestic non-MNE as a change in ownership indicator from a domestic non-MNE to foreign.[10] Hence, an acquisition implies that at least 50 percent of the voting rights are acquired by a foreign owner.[11]

Since R&D data are only available for firms with at least 50 employees we have to restrict the analysis to firms above this threshold.[12] However, the firms included in our sample cover more than three fourth of total value added and employment in the manufacturing sector (Karpaty, 2006). Moreover, two-thirds of all private R&D is concentrated in the top ten R&D firms, see Karpaty and Tingvall (2011). This should motivate an analysis based on larger firms only. Still, of course, our conclusions are conditional on large firms; we do not claim to be able to make general statements about the behaviour of small manufacturing firms from this sample.

From *Table 1* we see that the number of foreign MNEs and the employment shares in these firms have increased during the whole period in manufacturing industries. This seems to have been at the expense of Swedish MNEs. This pattern can be partly explained by the fact that several large Swedish MNEs have become foreign-owned due to acquisitions by foreign MNEs, e.g. Pharmacia and Upjohn 1995, Saab Automobile and General Motors 1998, Astra and Zeneca 1999 and Volvo Car Corporation and Ford 1999. The relative importance of Swedish non-MNEs remained fairly constant over the period, however.

[9] The first year in which we can distinguish Swedish MNEs from non-MNEs is 1993. This explains why our analysis begins in 1993.

[10] Firms that switch between domestic and foreign ownership more than once over the period are not included in the sample. Also, firms that disappear from the sample one year and reappear in later years are excluded.

[11] One may argue that this includes takeovers by foreign financial investors. Unfortunately we are not able to distinguish such cases from the genuine acquisition by a foreign company (with production facilities in other countries). However, our definition implies that foreign owners have at least 50 percent of the voting rights, not just 50 percent of the shares.

[12] Since R&D is only collected for firms with more than 50 employees, the analysis is restricted to firms that pass the threshold of 50 employees or more during the period. The observations in which the firms are not passing this threshold are excluded from the sample. This accounts for about 2 percent of the total observation per year. As a test of robustness we also excluded firms that have less than 50 employees once or more. These results were similar to the ones presented in Table 6- Table 10 and are thus not reported separately.

Table 1 here

Table 2 provides the distribution of the number of firms across 22 industries at the two digit level in 1993 and 2002.[13] The distribution of foreign and domestic MNEs is characterized by large heterogeneity between different industries and over time. It appears that the presence of foreign firms decreased between 1993 and 2002 in only five out of 22 industries (in two other industries there was no foreign presence at all). A different pattern is apparent for domestic MNEs whose share of firms fell in eleven out of 22 industries during the same period. This again reflects partly the extent of foreign acquisitions of domestic MNEs.

Table 2 here

Table 3 shows differences in means for some firm characteristics between domestic and foreign–owned firms in 2002. We compare unweighted averages and use t-statistics for any possible difference between foreign and domestic firms for each variable. What seems to matter in general is not whether the firm is foreign or domestically owned but whether the firm is multinational or not (see also Criscuolo and Martin, 2010). There is a statistically significant difference in all variables when we compare Swedish MNEs and non-MNEs. Hence, foreign and Swedish MNEs are more R&D intensive, larger, use more skilled labor, are more productive and pay higher wages than their non-multinational counterparts. This is in line with the idea that Swedish multinationals have more extensive headquarter activities in Sweden than purely domestic firms. Comparing Swedish and foreign MNEs we find that there is no statistically significant difference in terms of employment, sales, labor productivity, capital and skill intensity. However, it appears that foreign owned firms invest more in R&D and pay higher wages than domestic multinationals.

Table 3 here

We investigate in what follows whether this higher R&D intensity, defined as the ratio of expenditures by a firm on research and development to the firm's sales, in foreign MNEs is due to post-acquisition increases, or whether it may be explained by foreign firms targeting high R&D

[13] The industry classification is based on SNI92, which is the Swedish standard for industrial classification (Svensk Näringsgrensgrensindelning). It corresponds to the two digit European NACE Rev 1. classification system in 1993 and 2002.

intensive domestic firms when choosing takeover targets. To see how important foreign acquisitions were in the Swedish manufacturing sector, *Table 4* reports the number of foreign acquisitions in the sample used in the analysis for the period 1993-2002.[14]

Table 4 here

In *Table 5* we test the hypothesis that target and non-target Swedish firms have different characteristics before and after acquisitions using the sample of acquired and non acquired firms (i.e., disregarding firms that are always foreign-owned). It appears that acquired firms invest more in R&D one year prior to an acquisition. There are also other important differences pre- and post acquisitions. Target firms are in general larger in terms of employment and sales, have higher capital and skill intensities, and are more productive than non-target firms. Most of these differences are maintained or even strengthened under the new ownership post acquisition. Skill intensity does, however, decline in foreign acquired firms post acquisition. Overall this suggests that foreign ownership does matter. In the next section we will go beyond these mean values and analyze the effects of foreign acquisition on R&D intensity post acquisition more thoroughly.

Table 5 here

3. Methodology

The aim of this paper is to evaluate the causal effect of foreign acquisition on R&D activity in a targeted domestic firm. Following Heckman et.al. (1997), we define the average effect of acquisition on the acquired firms as:

$$E\left\{y^1_{it+s} - y^0_{it+s} \middle| AF_{it} = 1\right\} = E\left\{y^1_{it+s} \middle| AF_{it} = 1\right\} - E\left\{y^0_{it+s} \middle| AF_{it} = 1\right\} \qquad (1)$$

[14] Recall that these are acquisitions rather than mergers. If the merger means that a new firm is created it will not appear as an acquisition and will not be included in our analysis. If however a foreign and a Swedish owned firm are merged and the merged entity retains the same identifier as the Swedish firm it will appear as a foreign acquisition. The main mode of market entry during the period 1993-2002 has been acquisitions of Swedish firms (see e.g. ITPS 2002). Mergers constitutes between 2 and 4 per cent of the foreign owned firms in Sweden. Our definition of an acquisition is that at least 50 percent of the voting rights are acquired by a foreign owner.

where, $AF_{it} \in \{0,1\}$ is an indicator of whether domestic firm *i* is acquired by a foreign firm in time period *t*. y^1_{it+s} denotes R&D activity *s* years after the acquisition year *t* given that the firm was acquired. Correspondingly, y^0_{it+s} denotes R&D activity in the firm in the absence of the treatment (acquisition). The problem is that y^0_{it+s} is by definition unobservable, as we cannot observe the counterfactual R&D activity for a treated firm in the absence of treatment. Hence, the counterfactual for the last term in equation (1) is estimated using the R&D activity of the domestic firms that were not acquired, $E\{y^0_{it+s} | AF_{it} = 0\}$.

In the empirical analysis, we first consider $s = 1$. Then, our first baseline estimation strategy is to regress the outcome variable on the acquisition dummy and a full set of time dummies,

$$y_{it+1} = \alpha_{it} + \beta AF_{it} + d_t + \varepsilon_{it} \qquad (2)$$

where AF_{it} is a dummy variable equal to 1 in the period when the firm is acquired, and 0 before that.[15] It is also equal to zero throughout for non-acquired firms. d_t is a vector of time dummies. We only include domestic firms in the control group. Firms that are foreign-owned at the beginning of the period under investigation are dropped from sample. We start by estimating this model using simple OLS and, alternatively an estimator with firm fixed effects. The coefficient β provides an unbiased estimate of the causal effect of *AF* on *y* under the assumption of no correlation between AF_{it} and ε_{it}.

However, this assumption is unlikely to hold. Time varying differences in characteristics and performance between acquired and non-acquired firms in the years before acquisition may be correlated with foreign acquisition and may also impact on post-acquisition performance. One example may be "cherry picking". If such "cherries" are firms that constantly outperform others, then this would be captured by the firm fixed effect in equation (2). However, if there are temporary firm specific shocks to firm performance (e.g., through changing management), then firms that receive a positive shock would turn into "cherries", become likely targets for acquisitions

[15] Observations for post acquisition periods where s>1 are dropped. We also experimented defining the dummy = 1 in the period when the firm is acquired and in all post-acquisition periods. This produces similar results. These estimations are not reported here to save space but can be obtained from the authors upon request.

and would be likely to perform better after acquisition. Another example would be if firms receive early signs of being targets for acquisitions and as a result of that change their R&D activity. Both incidences would bias the estimates from equation (2).

To limit the influence of such effects we use a second strategy, namely a differences-in-differences propensity score matching estimation DID-PSM (see Blundell and Costa Dias, 2000). The idea of the propensity score matching approach is to find for every foreign acquired firm, a similar firm that has remained in domestic hands and from which we can approximate the non-observed counterfactual event. Thus, the matching technique allows us to construct a sample of acquired and non-acquired firms with similar pre-acquisition characteristics.[16,17] This enables us to impose "common support", i.e., we compare firms that are similar in terms of pre-treatment characteristics. DID eliminates the influence of unobserved firm specific effects.

However, even this combined estimation approach leaves us with one potential problem concerning unobserved effects. Firms may be acquired based on their future potential. Our approach assumes that this potential is captured by our observed pre-acquisition characteristics that are included in the propensity score estimation. Still, there may be time varying unobserved (to the econometrician) effects that determine a firm's future potential. If this is the case for both acquired and non-acquired firms (conditional on the estimated propensity score) then this should not cause a problem for our analysis. If, however, firms with an unobserved good potential are more likely to be acquired, then our approach may overstate the positive effect of foreign acquisition. Unfortunately, we cannot completely rule out this possibility. Instead, we argue that our propensity score estimation, which includes pre-acquisition R&D and other firm variables, is rich enough so that it is unlikely that there are other time-varying unobservables that may be correlated with foreign acquisition and R&D.

The DID-PSM proceeds in the following steps. Conditional on a set of firm characteristics we estimate the propensity score of being acquired by a foreign firm using a probit model

[16] Since the purpose of this paper is to compare foreign acquired with domestic firms any firm that remains in domestic hands is a valid control. This could also include domestic establishments that were taken over by other domestic owners, or that are likely to be targets for domestic takeovers. In our data we are not able to adequately observe domestic acquisitions.

[17] Temporary shocks to firm performance would not invalidate this approach to the extent that these are correlated with the variables included in the propensity score estimation (observable pre-treatment characteristics) and uncorrelated with the treatment variable.

$$P(AF_{it} = 1) = F(X_{it-1}, I_j, T_t) \quad (3)$$

where X_{it-1} is a vector of relevant firm specific characteristics in year *t-1* which may affect the firms' probability of being acquired in year *t*. *I* and *T* control for fixed industry and time effects.

Once the propensity scores are calculated, we can select the control firm which is closest in terms of its propensity score as a match for an acquired firm.[18] Moreover, we check whether the balancing condition is verified, that is whether each independent variable does not differ significantly between acquired and non-acquired firms. Another condition that must be fulfilled in the matching procedure is the so-called common support condition[19], i.e. firms with the same X values have a positive probability of being both target and control.[20]

The difference-in-differences matching estimator, described by Blundell and Costa Dias (2000) and recently employed by, for example, Arnold and Javorcik (2009) and Girma and Görg (2007), can then be expressed as:

$$\beta = \sum_{i \in A} \left(\Delta y_i - \sum_{j \in C} g(p_i, p_j) \Delta y_j \right) w_i \,. \quad (4)$$

where p_i denotes the predicted probability of being acquired (generated using equation (3)) for firm *i* in the group of acquired firms (A) and p_j is the predicted probability of being acquired for firm *j* in the control group (C). Δy is the log difference between the average R&D activity before and after the change of ownership. The function g(.) assigns the weights to be placed on the comparison firm *j* while constructing the counterfactual for acquired firm *i*. In the case of nearest neighbor matching as employed in this paper, g(.) = 1 for the pair with the minimum difference between p_i

[18] This is done using nearest neighbour matching method, i.e., a one-to-one matching. We match acquired and non-acquired firms using the PSMATCH2 routine in Stata version 10 (Leuven and Sianesi, 2003).

[19] In determining the common support region we use two methods where the first is to compare the minima and maxima of the propensity score in both target and control group and the second is to estimate the density distribution in both groups. For a detailed review of these two methods, see Caliendo and Kopeinig (2008)

[20] Eventually, we end up with a sample, henceforth denoted the matched sample which consists of 227 acquired firms and 2,842 non-acquired firms. Note that the difference can pertain to different calendar years for different firms. The propensity score estimation includes year dummies to take this into account.

and p_j, and 0 for all other pairs. w_i is the weight used in the construction of the outcome distribution for the treated sample (1/N in the case of nearest neighbour matching).

4. Initial estimations

We now turn to some first estimations providing initial correlations on the link between foreign acquisition and R&D. We estimate equation (2) measuring R&D activity as the log-level of R&D spending.[21] First, we present the results from a specification without firm specific fixed effects in order to establish a benchmark. We then estimate the same equation using a fixed effects (FE) technique. Results are shown in *Table 6*, columns (1) and (2). These baseline results indicate that foreign acquired firms had higher R&D spending in the year following takeover as compared to non-acquired firms.

In columns (3) and (4) we estimate a similar model, but the dependent variable is now the log difference of R&D expenditures between t-1 and t+1, i.e., ($\log R\&D_{t+1} - \log R\&D_{t-1}$). Compared to the baseline model the dependent variable in differences allows for unobserved time invariant firm effects that are conditionally correlated with the acquisition decision and the growth of R&D activity (not levels as in the previous model). This estimation also shows positive effects of the acquisition on the growth of total R&D spending.

Columns (5) and (6) then reports estimations which have as dependent variable the log difference of R&D intensity (i.e., R&D spending over total sales). This also takes into account differences in R&D spending depending on the size of the firm. These results again underline the positive acquisition effect. From columns (3) to (6) we can see that foreign acquisitions increase the growth of R&D activity by between 4 to 5 percent in the post-acquisition year.

Table 6 here

These results provide initial evidence that fears about foreign acquisitions leading to less R&D activity in the target firms appear to be misplaced. The focus of the further analysis is to establish the robustness of a causal relationship between foreign acquisitions and R&D using a propensity

[21] We use log-transformed variables in all regressions.

score matching approach, and to investigate whether there are differences in effects depending on whether the target firm is itself a multinational or not.

5. Difference-in-differences propensity score matching

Before turning to the estimation results, we look first at the propensity score. *Table 7* presents the results of estimating the probit model in equation (3). The choice of variables included in the vector X is influenced by the empirical literature on foreign acquisitions (e.g. Conyon et al, 2002, Girma and Görg, 2007, Harris and Robinson, 2002, Lipsey and Sjöholm, 2002). Such studies usually argue that establishment size and age are important determinants for acquisitions and hence we include those in the probit. Also, high productivity, capital- or skill-intensive firms are commonly found to be more likely to be taken over, indicating that foreign firms may be "cherry picking" the best performing establishments. To control for sectoral effects we include a full set of industry dummies and a measure of foreign presence in an industry, defined as the share of employment in foreign firms relative to total industry employment. Importantly, since we are interested in identifying an effect of foreign acquisition on R&D post-acquisition, we include pre-acquisition (t-1) R&D intensity in the propensity score estimation. This also allows us to consider the particular cherry picking hypothesis in Bertrand et al. (2012), where targets are picked depending on their quality of the R&D asset.

The results in *Table 7* indicate that firms are more likely to be acquired by foreign owners the more R&D active they are, which is in line with Bertrand et al. (2012).[22] Also, the acquisition probability of firms is higher the more productive, and skill intensive they are pre-acquisition. Moreover, firms in industries with a large foreign presence are more likely to be taken over.

We also present the estimation of a slightly different model in the table, column 2. We use this model as a robustness check for the validity of our propensity score matching. Dehejia (2005) suggests that one should check the sensitivity of the matching estimates to minor changes in the propensity score model. If the results are not sensitive to such minor changes, the propensity score

[22] We use R&D expenditures at t-1 as one of the conditioning variables in an effort to even out all unobservables. Ideally one would use a measure of R&D assets or human capital and shocks to these. As a test of robustness we replaced R&D expenditures at t-1 with the growth in R&D expenditures between t-2 and t-1. However, this did not significantly affect the results.

specification can be deemed robust and reliable. In line with Girma and Görg (2007), who also estimated propensity scores for the probability of foreign acquisitions, we add a squared term of the size variable to the specification. While all our matching estimates reported below are based on the first propensity score estimation in column (1), the model in column (2) produces very similar results, which we take as indication that the matching procedure is reliable. These results are available upon request.

Table 7 here

The propensity score matching method will provide a reliable and robust method for estimating the foreign acquisition effect if, conditional on the propensity score, the potential outcomes for acquired and non-acquired firms are independent of the incidence of acquisition. Under this assumption of independence conditional on observables, the pre-acquisition variables should be balanced between the acquired and non-acquired groups. We therefore perform a number of balancing tests suggested in the recent literature (e.g., Smith and Todd, 2005).

The first balancing test examines the standardized difference (or bias) for all variables in the vector X. For example, the standardized bias for the *skill intensity* variable is defined as the difference in means between the foreign acquired sample of firms (group *A*) and the appropriately matched comparison group of firms (group *C*) scaled by the average variances of the *skill intensity* variable in groups A and C. Note that the lower the standardized difference, the more balanced or similar the treatment and comparison groups will be in terms of the variable under consideration. Although there is no formal criterion as to how large a standardised bias should be for it to be considered serious, a value of 20 is generally considered large. Furthermore, for each variable entering the propensity score model we perform a formal paired t-test between acquired and matched comparison to satisfy ourselves that no significant differences exist.

Whereas the above balancing test calculates the cross-sample difference of each variable entering the probit model separately, there also exists a test that considers whether those differences can be taken as *jointly* insignificant. This test is known as the Hotelling's T-squared test and it has the flexibility of being based either on all observations or for separate segments of the sample defined

by the propensity score estimates. In this study we divide the sample by propensity score quintile and conduct the Hotelling's T-squared test for each sub-sample.

The balancing tests are reported in the appendix *Tables A1* to *A3* for both propensity score models. The standardized differences between acquired and comparison sample are all less than 10% in the matched sample. There is also a substantial bias reduction as a result of adopting the matching method. Furthermore, the results from the Hotelling test indicate that the balancing conditions are satisfied within each propensity score quintile.

Having established that our propensity score matching procedure appears reliable, we can now turn to the results of the difference-in-differences propensity score matching approach. These are reported in *Table 8*. We look at both log R&D levels and log R&D intensity in the table. The first line, where s = 1 present results that are comparable to the baseline estimates reported in the previous section. In this case, the outcome variable is calculated as $(y_{t+1} - y_{t-1})$. We find significant positive post-acquisition effects for both R&D levels and intensity. The estimated coefficients suggest slightly larger effects than in Table 6. The incidence of foreign acquisition increases the growth of R&D activity by 6 to 10 percent in the post-acquisition year.

We then expand on the earlier analysis and consider longer time intervals in which the post acquisition effect can take place. In the case of s = 2 the difference is calculated as $(y_{t+2} - y_{t-1})$, i.e., we look at the change in R&D activity two years after acquisition took place. Notice that we find for both s = 2 and 3 still positive and statistically significant post-acquisition effects on R&D activity.[23]

Overall, these results suggest that foreign acquisitions in general have positive effects on R&D activity in the target firm, in line with the theoretical predictions by Bertrand et al. (2012). We looked at robustness of the results by using different matching estimators. Using Kernel or Radius

[23] Of course, it may be the case that effects take more than three years to manifest themselves. If this is the case, our analysis would underestimate the true acqusition effects. We do not expand our analysis further in time since, the further we move away from the incidence of acquisition, the more difficult it becomes to establish causal links (i.e., maintain the conditional independence assumption). Also, the ability to make long-term data analysis is heavily constrained by data availability, as we would need to be able to follow individual firms for more than three years.

matching does not change our results, hence, we report in what follows the results of nearest-neighbour matching.[24]

The analysis thus far is based on pooled data for the whole manufacturing sector. This hides potential industry heterogeneity. While being crucial for some industries, for other industries R&D assets may be of minor importance. In order to look at this issue, we divide our sample into high- and low-tech sectors. This classification is based on R&D intensity in the sectors.[25] We find positive post-acquisition effects on R&D for both sectors in *Table 9*. However, judging by the magnitude of the coefficients it appears that these effects are stronger in low-tech sectors. For example, the impacts of foreign acquisition on the growth of R&D intensity in low-tech sectors for s = 2 and 3 are around 15 and 11 percent while the corresponding figures for high-tech sectors are around 11 and 8 percent.[26]

In the policy debate, particular attention is paid to what happens to headquarters, and in particular R&D activity of domestic multinationals if they are taken over by a foreign firm. As pointed out in the introduction, this may be an important issue given that MNEs may be expected to have more extensive R&D activities in Sweden. We now dig deeper into our data to investigate this. Specifically, to allow for different impacts of foreign acquisitions on R&D intensity depending on whether a Swedish MNE or Swedish non-MNE is acquired, we split the sample accordingly. *Table 10* shows the results of our estimations. These indicate that as compared to non-acquired firms, both targeted Swedish MNEs and non-MNEs have higher growth in R&D intensity one, two and three years after the takeover. However, these effects appear to be slightly stronger for non-MNEs than for Swedish multinationals.

While our overall findings that there are positive post-acquisition effects on R&D are in line with Bertrand et al. (2012), the results for the split samples are more difficult to interpret. While the

[24] These results are available upon request. Another potential concern is that the analysis is based on continuing firms and, hence, does not capture the possibility that acquiring firms may close down the takeover target post acquisition. Bandick and Görg (2010) focus on this question using a similar data set. They show that the probability of surviving in plants within acquired firms is higher than in plants within non-acquired firms in the Swedish manufacturing sectors. Hence, there is no evidence to expect that the probability of exit increases post-acquisition. Yet another potential concern is that the sample composition in Table 7 is not exactly the same for all possible outcomes (s=1-3). We have however estimated our regressions with a balanced sample (not reported in the paper to save place) and the results do not differ from those reported in Table 7.

[25] Following Hatzichronoglou (1997), sectors with R&D intensity lower than 5 percent are defined as low-tech sectors. This resulted in 10 low tech sectors (sni92: 15 to 21, 23, 27 and 28 from *Table 2*) and 12 high tech sectors.

[26] These differences, not reported here but can be obtained upon request, are significant at the 1 percent level.

model is not explicit on this, one may argue that firms in high-tech sectors, and those that are themselves multinationals, posses R&D assets that are of higher quality, and that may also be more complementary to those assets of the foreign acquirer. If this were the case, one may expect that these firms should experience larger post-acquisition R&D increases. This is, however, not what we find.

An alternative explanation for positive post-acquisition effects on R&D is that the foreign acquirer transfers technology to its foreign affiliate. This would enable the foreign affiliate to increase its own R&D activity as a result. However, the scope for technology transfer may be higher the lower is the quality of the target's own R&D activity. This is consistent with our summary statistics where we found that Swedish MNEs are similar to foreign MNEs, but both of these are different compared to Swedish non-MNEs. Hence, one would expect stronger post acquisition effects for firms in low-tech sectors or firms that are non-multinationals.

6. Conclusion

Overall it would appear that the increased foreign presence in terms of foreign acquisitions of Swedish firms has had positive effects on the R&D activity in these firms. This is in line with the empirical study by Bertrand et al. (2012) who also use Swedish data and find a positive correlation between M&A and R&D. Compared to that paper, however, our methodology allows us to be more confident about causal effects, as we can distinguish pre-acquisition "cherry picking" and post-acquisition R&D performance. We use different estimation strategies based on combinations of propensity score matching and difference-in-differences (PSM-DID) estimations to control for selection bias in the evaluation of causal effects.

The point estimates from our DID propensity score matching estimator suggest increases in R&D intensity by between 5 to 10 percent after a foreign acquisition. These effects are somewhat similar to those found for French firm level data by Bertrand (2009). Our analysis, however, exploits a further dimension in the data and shows that post-acquisition effects are stronger for the acquisition of domestic non-multinationals than for Swedish multinationals. However, it is important to stress that even for the acquisition of Swedish multinationals, the effect on R&D is generally positive, never negative. Hence, our results suggest that fears that the acquisition of large Swedish

multinationals by foreign owners may lead to a relocation of R&D activities abroad appear unfounded.

Our findings are also policy relevant. The implication of our analysis is that foreign acquisitions can have beneficial effects for domestic R&D activity. Hence, there is no need for fears and therefore no need for policy makers to start thinking about limiting international merger and acquisition activity. Quite the contrary: foreign acquisitions may be an important way to generate new knowledge and contribute to boosting the level of technology in the domestic economy. This result is based on data for Sweden, a country that is highly conducive to R&D given its highly educated labour force and small size (Ekholm and Hakkala, 2007). Whether our results can be generalized to other country settings remains an important question for future research.

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Table 1 Number of firms and employment shares in Swedish manufacturing, 1993-2002.

	Foreign MNEs			Swedish MNEs			Swedish non-MNEs		
Year	Firms		Employment	Firms		Employment	Firms		Employment
	(Percent)		Percent	(Percent)		Percent	(Percent)		Percent
1993	255	(20.5)	21.0	421	(33.8)	54.0	568	(45.7)	25.0
1994	275	(21.5)	22.0	436	(34.1)	56.6	567	(44.4)	21.4
1995	297	(22.2)	22.8	427	(31.8)	55.0	617	(46.0)	22.2
1996	342	(24.9)	26.7	402	(29.2)	51.1	631	(45.9)	22.2
1997	365	(26.2)	28.4	400	(28.7)	51.7	629	(45.1)	20.0
1998	396	(26.8)	29.8	396	(26.8)	49.2	683	(46.3)	20.9
1999	400	(27.6)	35.9	406	(28.1)	41.0	641	(44.3)	23.1
2000	426	(28.6)	41.1	415	(27.8)	36.6	651	(43.6)	22.3
2001	454	(30.5)	46.4	396	(26.6)	32.4	640	(43.0)	21.2
2002	464	(31.8)	47.3	396	(27.1)	33.6	601	(41.1)	19.0

Notes: The sample is truncated at 50 employees. Source: Statistics Sweden. Foreign MNEs are firms where foreigners possess more than 50% of the voting rights and a Swedish MNE is a domestically owned firm that is part of an enterprise with affiliates abroad. Non-MNE firms are firms that are neither Swedish MNEs nor foreign MNEs.

Table 2 Development of MNEs and non-MNEs in Sweden by industry in percent. 1993, 2002

		1993			2002		
Industry	sni92 Codes	Foreign MNEs	Swedish MNEs	Swedish non-MNEs	Foreign MNEs	Swedish MNEs	Swedish non-MNEs
Food & beverages	15	26,79	13,39	59,82	28,87	9,28	61,86
Tobacco products	16	0,00	100,00	0,00	0,00	100,00	0,00
Textiles	17	25,00	21,43	53,57	28,57	25,00	46,43
Apparel	18	11,11	44,44	44,44	0,00	100,00	0,00
Leather, footwear	19	0,00	100,00	0,00	0,00	0,00	100,00
Wood	20	3,64	27,27	69,09	17,50	13,33	69,17
Paper & pulp	21	18,75	47,92	33,33	42,86	34,92	22,22
Publishing, printing	22	9,62	17,31	73,08	13,19	21,53	65,28
Coke & petroleum	23	0,00	100,00	0,00	100,00	0,00	0,00
Chemicals	24	44,78	35,82	19,40	66,67	17,33	16,00
Rubber & plastic	25	25,93	46,30	27,78	34,21	46,05	19,74
Non-metallic mineral	26	19,30	52,63	28,07	55,81	13,95	30,23
Basic metals	27	24,44	46,67	28,89	53,06	22,45	24,49
Fabricated metal	28	11,67	34,17	54,17	17,87	29,47	52,66
Machinery, equipm.	29	23,12	46,24	30,64	32,38	36,67	30,95
Electrical & optical	30	62,50	12,50	25,00	9,09	27,27	63,64
Electrical machinery	31	45,10	15,69	39,22	42,86	28,57	28,57
Radio TV	32	29,17	37,50	33,33	27,59	41,38	31,03
Medical instruments	33	25,71	57,14	17,14	53,33	31,11	15,56
Motor vehicles	34	18,00	40,00	42,00	32,94	40,00	27,06
Other transport eq.	35	34,62	34,62	30,77	29,03	25,81	45,16
Other manufacturing	36	10,77	33,85	55,38	21,79	34,62	43,59

Notes: The sample is truncated at 50 employees. Source: Statistics Sweden.

Table 3 Characteristics of MNEs (foreign and Swedish) and non-MNEs in Swedish manufacturing 2002.

	2002				
Variables	Foreign MNEs	Swedish MNEs	Non-MNEs	Difference foreign MNEs and Swedish MNEs (t-ratio)	Difference Swedish MNEs and non-MNEs (t-ratio)
R&D intensity	28.5	23.4	8.8	5.1 (2.19)	14.6 (8.41)
Employment	408	334	125	74 (1.05)	209 (6.31)
Sales	711	536	151	175 (1.12)	385 (5.23)
Labor productivity	452	438	364	14 (0.68)	74 (5.45)
Capital-labor ratio	220	143	51	77 (1.43)	92 (3.51)
Skill intensity	20.1	18.7	14.2	1.4 (1.44)	4.5 (5.29)
Average wage	204	197	179	7 (2.73)	18 (7.33)

Notes: The sample is truncated at 50 employees. Source: Statistics Sweden. R&D intensity is defined as the ratio of R&D expenditure over firm sales. Labor productivity is measured as value added, deflated by the industry producer price index, per employee. Physical capital is here measured by the book value of machinery and buildings, per employee and human capital intensity is measured by the proportion of employees with more than upper secondary education

Table 4 Frequency of foreign acquisitions by year 1993-2002

	1994	1995	1996	1997	1998	1999	2000	2001	2002	94-02
Acquired Swedish MNE	1	5	26	3	5	10	6	3	9	68
Acquired Swedish Non-MNE	18	16	20	11	11	14	14	39	16	159
Total	19	21	46	14	16	24	20	42	25	227

Notes: The sample is truncated at 50 employees. Source: Statistics Sweden. We report a shift in ownership when a foreign firm acquirer more than 50% of the votes in a Swedish firm.

Table 5 Pre- and post acquisition differences in means between acquired and non-acquired firms.

Variable	T-1	T+1	T+2	T+3
	Difference	Difference	Difference	Difference
	(t-ratio)	(t-ratio)	(t-ratio)	(t-ratio)
R&D intensity	0.9	0.9	1.3	1.3
	(3.37)***	(2.73)***	(3.76)***	(3.45)***
Employment	314	401	416	422
	(2.94)***	(3.61)***	(3.69)***	(3.68)***
Sales	832	1086	743	713
	(3.12)***	(2.92)***	(1.75)*	(1.44)
Labor productivity	66	48	67	63
	(3.30)***	(2.26)**	(3.03)***	(2.49)**
Capital-labor ratio	268	369	357	373
	(5.27)***	(6.00)***	(5.31)***	(5.10)***
Skill intensity	3.5	2.8	2.7	2.4
	(3.09)***	(2.40)**	(2.23)**	(1.89)*
Observations of acquired firms	89	89	89	89
Observations of non- acquired firms	4,095	4,095	4,095	4,095

Notes: The sample is truncated at 50 employees. Source: Statistics Sweden. Shipment is in million SEK. Capital-labor ratios and labor productivity, value added per employee, are in thousand SEK. R&D intensity, R&D expenditure over firm sales, and Skill intensity, share of employees with a post-secondary education, are in percent.

Table 6 Post-acquisition effect on R&D OLS and Fixed effect model.

	$R\&D_{t+1}$		**$\Delta R\&D_{t+1}$**		**$\Delta R\&D\ intensity_{t+1}$**	
	OLS	FE	OLS	FE	OLS	FE
	(i)	(ii)	(iii)	(iv)	(v)	(vi)
Foreign acquired	1.063	0.776	0.040	0.043	0.052	0.057
	(0.271)***	(0.122)***	(0.020)**	(0.020)**	(0.012)***	(0.012)***
Observations	8,982	8,982	8,982	8,982	8,994	8,994
R^2	0.241	0.017	0.024	0.006	0.026	0.018

Notes: The sample is truncated at 50 employees. Source: Statistics Sweden. Regressions include full sets of year and industry dummies. R&D activity is measured as the level of log R&D spending in column (1) and (2), in column (3) and (4) as log difference of R&D expenditures between t-1 and t+1 and in column (5) and (6) as growth of log R&D intensity (i.e., R&D spending over total sales). Industries are defined at the SNI92 3-digit level (99 industries). Standard errors in parentheses. ***, **, * indicate significance at 1, 5 and 10 percent levels, respectively.

Table 7 The Probit model. Probability of foreign acquisition, 1993-2002.

Variables	Model (1)	Model (2)
R&D intensity	0.912	0.920
	(0.413)**	(0.414)**
Labor productivity	0.137	0.135
	(0.042)***	(0.042)***
Size	-0.003	-0.007
	(0.002)	(0.004)**
Skill intensity	0.887	0.900
	(0.137)***	(0.138)***
Age	-0.041	-0.041
	(0.009)***	(0.009)***
Age squared	0.001	0.001
	(0.000)***	(0.000)***
Capital intensity	0.121	0.124
	(0.012)***	(0.012)***
Size squared		0.001
		(0.001)
Foreign presence	0.133	0.130
	(0.017)***	(0.017)***
Industry dummies	Yes	Yes
Year dummies	Yes	Yes
Pseudo R^2	0.043	0.043
LR chi2	380.01	380.34
Observations	9,612	9,612

Notes: The sample is truncated at 50 employees. Source: Statistics Sweden. AF_{it} is an indicator of whether domestic firm i is acquired by a foreign firm at time t. Standard errors within parentheses. The explanatory variables are, apart from age age^2, firm specific characteristics in year $t-1$. Firm size is firm employment relative to mean firm employment at the industry level. Labor productivity is value added per employee and skill intensity is the share of employees with post-secondary education at the firm level. R&D intensity is defines as R&D spending over total sales. The share of foreign employment at industry level (SNI92 2-digit level) is used as a proxy for foreign presence. ***, **, * indicate significance at 1, 5 and 10 percent levels, respectively.

Table 8 Post-acquisition effect on R&D activity, DID Matching estimator

$y_{t+s} - y_{t-1}$		Foreign acquired				
		DID	Std.Err.	Observations		
				Treated	Untreated	
					On support	Off support
ΔR&D intensity	$s = 1$	0.064	(0.016)***	227	227	8,388
	$s = 2$	0.122	(0.024)***	227	227	7,013
	$s = 3$	0.063	(0.024)***	227	227	5,672
ΔR&D	$s = 1$	0.099	(0.021)***	227	227	80,15
	$s = 2$	0113	(0.031)***	227	227	6,706
	$s = 3$	0.098	(0.032)***	227	227	5,431

Notes: The sample is truncated at 50 employees. Source: Statistics Sweden. The outcome variable in the first three rows is log R&D intensity before and after acquisition and in the next three rows log R&D expenditures before and after acquisition.

Table 9 Post-acquisition effect on R&D in low and high tech industries, DID Matching estimator

$y_{t+s} - y_{t-1}$		Low tech					High tech				
		DID	Std.Err.	Observations			DID	Std.Err.	Observations		
				Treated	Untreated				Treated	Untreated	
					On support	Off support				On support	Off support
ΔR&D intensity	$s = 1$	0.061	(0.030)***	75	75	3,409	0.057	(0.022)***	152	152	4,979
	$s = 2$	0.155	(0.037)***	75	75	2,855	0.107	(0.027)***	152	152	4,158
	$s = 3$	0.111	(0.041)***	75	75	2,345	0.080	(0.029)***	152	152	3,327
ΔR&D	$s = 1$	0.106	(0.034)***	75	75	3,257	0.107	(0.025)***	152	152	4,758
	$s = 2$	0.114	(0.054)***	75	75	2,732	0.083	(0.042)*	152	152	3,974
	$s = 3$	0.084	(0.018)***	75	75	2,240	0.079	(0.043)*	152	152	3,191

Notes: See *Table 8*. Following Hatzichronoglou (1997), sectors with R&D intensity lower than 5 percent are defined as low-tech sectors. This resulted in 10 low tech sectors (sni92: 15 to 21, 23, 27 and 28 from *Table 2*) and 12 high tech sectors.

Table 10 Post-acquisition effect on R&D intensity in different targets, DID Matching estimator

$y_{t+s} - y_{t-1}$		Acquired Swedish MNE					Acquired Swedish non-MNE				
		DID	Std.Err.	Observations			DID	Std.Err.	Observations		
				Treated	Untreated				Treated	Untreated	
					On support	Off support				On support	Off support
ΔR&D intensity	$s = 1$	0.032	(0.015)**	68	68	6,841	0.094	(0.018)***	159	159	8,011
	$s = 2$	0.094	(0.037)***	68	68	5,355	0.098	(0.025)***	159	159	6,075
	$s = 3$	0.093	(0.031)***	68	68	4,341	0.136	(0.033)***	159	159	4,926
ΔR&D	$s = 1$	0.040	(0.018)**	68	68	6,565	0.115	(0.029)***	159	159	8,010
	$s = 2$	0.098	(0.052)*	68	68	5,152	0.107	(0.038)***	159	159	6,074
	$s = 3$	0.034	(0.051)	68	68	4,182	0.125	(0.043)***	159	159	4,924

Notes: See *Table 8.*

Appendix A: Details on the propensity score matching

Table A1 Balancing test for the matching sample, Model (1)

Variable	Sample	Mean		Standardized bias	Bias reduction	*t*-test	
		Treated	Control			*t*	p>|*t*|
R&D intensity	Unmatched	0.017	0.009	20.0		3.33	0.001
	Matched	0.017	0.023	-7.2	14.3	1.28	0.200
Labor productivity	Unmatched	5.980	5.884	21.3		3.32	0.001
	Matched	5.980	5.995	-3.4	84.0	0.35	0.727
Size	Unmatched	5.774	5.504	3.1		0.46	0.643
	Matched	5.774	5.385	4.4	-44.1	0.50	0.617
Skill intensity	Unmatched	0.177	0.138	29.9		5.11	0.000
	Matched	0.177	0.181	-3.2	89.3	0.30	0.768
Age	Unmatched	13.035	15.838	-31.7		4.92	0.000
	Matched	13.035	14.044	-9.4	64.0	1.14	0.255
Age squared	Unmatched	254.7	322.27	-24.8		3.66	0.000
	Matched	254.7	289.38	-8.7	48.7	1.29	0.198
Foreign presence	Unmatched	8.783	8.613	19.8		2.81	0.005
	Matched	8.783	8.795	-1.4	93.0	0.15	0.881
Capital intensity	Unmatched	10.175	9.888	17.4		2.76	0.006
	Matched	10.175	10.197	-1.4	92.0	0.14	0.890

Notes: The sample is truncated at 50 employees. Source: Statistics Sweden. Size is firm employment relative to mean firm employment at the industry level. Labor productivity is value added per employee and skill intensity is the share of employees with post-secondary education at the firm level. R&D intensity is defines as R&D spending over total sales. The share of foreign employment at industry the level (SNI92 2-digit level) is used as a proxy for foreign presence.

Table A2 Balancing test for the matching sample, Model (2)

Variable	Sample	Mean		Standardized bias	Bias reduction	*t*-test	
		Treated	Control			*t*	p>|*t*|
R&D intensity	Unmatched	0.017	0.009	20.0		3.33	0.001
	Matched	0.017	0.021	-8.9	45.8	0.86	0.200
Labor productivity	Unmatched	5.980	5.884	21.3		3.32	0.001
	Matched	5.980	5.971	1.9	91.2	0.18	0.727
Size	Unmatched	5.774	5.504	3.1		0.46	0.643
	Matched	5.774	6.183	-4.7	-51.8	0.48	0.617
Size squared	Unmatched	112.02	104.91	1.1		0.16	0.870
	Matched	112.02	122.12	-1.6	-42.1	0.18	0.854
Skill intensity	Unmatched	0.177	0.138	29.9		5.11	0.000
	Matched	0.177	0.183	-4.6	84.5	0.44	0.660
Age	Unmatched	13.035	15.838	-31.7		4.92	0.000
	Matched	13.035	133.097	-0.7	97.8	0.07	0.944
Age squared	Unmatched	254.7	322.27	-24.8		3.66	0.000
	Matched	254.7	262.25	-2.8	88.8	0.28	0.778
Foreign presence	Unmatched	8.783	8.613	19.8		2.81	0.005
	Matched	8.783	8.799	-1.9	90.3	0.21	0.836
Capital intensity	Unmatched	10.175	9.888	17.4		2.76	0.006
	Matched	10.175	10.093	4.9	71.7	0.50	0.616

Notes: See *Table A1*.

Table A3 Hotelling´s T-squared test for equality of means in different quintiles, Model 1 and 2

Model 1	Quintile 1		Quintile 2		Quintile 3		Quintile 4	
Variable	Treated	Untreated	Treated	Untreated	Treated	Untreated	Treated	Untreated
R&D intensity	0.002	0.002	0.002	0.007	0.012	0.009	0.022	0.020
Labor productivity	5.844	5.832	5.729	5.810	5.952	5.884	6.046	6.012
Size	5.854	5.342	4.587	5.414	5.001	5.851	6.152	5.400
Skill intensity	0.128	0.110	0.120	0.130	0.165	0.140	0.196	0.174
Age	21.52	19.00	15.04	16.88	16.46	15.01	10.180	12.36
Age squared	498.19	405.15	272.61	343.50	383.45	298.93	182.86	239.16
Foreign presence	8.588	8.329	8.816	8.577	8.740	8.727	8.817	8.822
Capital intensity	9.507	9.668	9.480	9.650	10.414	9.946	10.319	10.293
F-statistic	1.071		0.788		1.241		0.883	
P-value	0.381		0.613		0.271		0.506	

Model 2	Quintile 1		Quintile 2		Quintile 3		Quintile 4	
Variable	Treated	Untreated	Treated	Untreated	Treated	Untreated	Treated	Untreated
R&D intensity	0.002	0.002	0.002	0.007	0.012	0.009	0.022	0.020
Labor productivity	5.844	5.832	5.729	5.810	5.952	5.884	6.046	6.012
Size	5.854	5.342	4.587	5.414	5.001	5.851	6.152	5.400
Size squared	68.49	67.20	50.24	84.41	42.00	148.61	146.47	118.55
Skill intensity	0.128	0.110	0.120	0.130	0.165	0.140	0.196	0.174
Age	21.52	19.00	15.04	16.88	16.46	15.01	10.180	12.36
Age squared	498.19	405.15	272.61	343.50	383.45	298.93	182.86	239.16
Foreign presence	8.588	8.329	8.816	8.577	8.740	8.727	8.817	8.822
Capital intensity	9.507	9.668	9.480	9.650	10.414	9.946	10.319	10.293
F-statistic	1.133		0.707		1.103		0.826	
P-value	0.336		0.704		0.357		0.566	

Notes: See *Table A1*.