Do Foreign-Owned Firms Have a Lower Innovation Intensity Than Domestic Firms?

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Abstract:

This paper addresses the question of whether foreign ownership matters regarding innovation intensity. It is well documented that foreign firms display lower innovation and R&D intensity than local firms do. However, (foreign) investors bear not only innovation performances in mind when making up their investment decisions. Unless factors such as firm size, labour productivity, skill and export intensity, sectoral affiliation and geographical area of operation are not properly controlled for, one is running the risk of comparing apples and oranges. To account for the selectivity bias we employ matching estimators when comparing the innovation intensity between domestic and foreign-owned firms. The observed gaps in innovation intensities do not only survive this matching test, but turn out higher as compared to the results that would have been derived from conventional regression analyses.

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1. Introduction[1]

In their attempts to increase innovative capacity and national R&D expenditures several below-average R&D performing countries place great emphasis in the attraction of foreign-owned (multinational) firms. Large amounts of public funds are spent to incentivize such firms to settle down, especially in R&D- and skill-intensive domestic industries. Do such FDI-insourcing strategies pay with respect to the advancement of the Barcelona goals to increase investment in research to 3%?

At first sight the answer is in the affirmative. The share of foreign affiliates in total industrial R&D is very high in some smaller and medium-sized OECD countries. In Austria, Hungary, Ireland, Spain, Sweden, Canada, the Netherlands, and Portugal the respective shares range between 30 to 72 per cent, which is clearly above the OECD average of 12 per cent (OECD, 2003). A second look at the statistics put these numbers into perspectives and scales down the expectations raised from such (catching-up) strategies. In most OECD countries, foreign-owned firms are characterized by lower R&D intensities as compared to the domestically owned ones (OECD, 1998, 2003, 2005). This reflects the fact that multinational firms still tend to undertake most of their R&D activities within their headquarter countries, or home country, respectively, while their abroad innovation activities rather take the form of development and market related activities (OECD, 2003, 2005). Hence, the contribution of foreign-owned firms to the host country's R&D-intensity seems to result rather from sheer quantities than from the "quality" of these firms. To asses their potential for rising national R&D intensities, firm level studies are indispensable.

So far, few studies rely on firm-level data when investigating the extent to which foreign firms undertake R&D activities within a host country. Using firm level data for the UK, Griffith et al. (2004) find that establishments that are part of British-owned multinationals account for a larger share of R&D activity as compared to foreign-owned multinationals. Using CIS III data for Nordic countries, Ebersberger and Lööf (2004, 2005) find mixed results regarding R&D intensity measured as R&D expenditures per employee. In Sweden, the R&D intensity of domestic

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multinationals is significantly larger compared to all other types of ownership. In Norway and Finland, the R&D-intensity of domestic multinationals is higher than other domestic and foreign firms are, except for Anglo-Saxon firms. Other studies focus on the propensity to innovation rather than the level of innovation expenditures. For instance, Balcet and Evangelista (2005) find that foreign affiliates have a relatively high propensity to innovate. However, much of the effect is explained by the fact that foreign affiliates are overrepresented in science-based industries, and by their size – pointing to the weakness of the aforementioned studies.

Admittedly, foreign-owned firms differ from domestic firms in more than just their R&D or innovation intensity, respectively, and one may question the validity of comparing apples and oranges. For instance, Griffith et al. (2004) point out that foreign-owned firms tend to be larger in terms of employment. Since innovation intensity decreases significantly with firm size significant differences in firm size may in turn account for observed gaps in innovation intensities.[2] In the same line of argument we note that foreign affiliates are not only concentrated in science-based industries, but also in scale-intensive industries such as wholesale trade, where innovation activities are not particularly strong in general. Arguably, a large part of the differences in innovation intensity between foreign affiliates and domestic firms might be attributable to such compositional effects and the observed gaps in innovation intensity would vanish once we compared like with like.

This paper uses matching techniques to explore if and to what extent foreign multinationals actually carry out R&D activity more intensively than domestic-owned firms do. The matching approach boils down to a conventional comparison group analysis – i.e. compare foreign-owned and domestic firm with respect to their innovation intensity - with the crucial difference that the descriptive analysis draws on a “matched” sample. Ideally, matched firms are identical except for their ownership status.

Egger and Pfaffermayr (2004) use Kernel and matching estimators to compare multinationals (including both domestic multinationals and foreign affiliates) to a selected group of non-multinationals with similar characteristics. The authors find that multinationals have a significantly higher investment in intangible assets (i.e. R&D and marketing expenditures) than

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[2] CIS results – available on request.

non-multinationals, implying greater R&D intensities. We challenge their findings by directly addressing R&D intensities. To the best of our knowledge, the present paper is the first one to apply the propensity score matching estimator to potential gaps in innovation intensities between foreign-owned and domestic firms.

For second, this paper contributes to the ongoing discussion on the gaps in innovation intensities between foreign-owned and domestic firms by broadening the definition of innovation activities beyond R&D. Apparently, R&D activities constitute only one of many inputs to innovation activities and non-R&D innovation expenditures account for a significant share of the total innovation outlay. This observation applies in particular to non-R&D intensive manufacturing industries and to services (see European Commission and Eurostat 2004) where the cost of innovation come in the form of product design, trial production, training and tooling-up, or innovation expenditures rather relate to the acquisition of products and licences than to the original generation thereof.

As a case study we use Austria, a country being characterized by only medium F&E-intensities, but ambitious internationalization strategies. The goal of becoming an attractive headquarter location is ranking high in Austrian innovation policies (BMBWK 2006 and FFG 2005). Designed to foster the sustainable development of new R&D competences in Austria, a "Headquarter Strategy" programme has been launched to incentivize multimationals to set up their central R&D units in Austria. The federal R&D promotion fund (FFG) spends some 11.5 million Euro on attracting foreign R&D firms (and giving them financial incentives to stay). The most recent national R&D survey in 2002 shows that such policies are effective in as far as 30 percent of total business R&D are financed by foreign-owned firms. Evidence based on CIS III data suggests that parent companies of the foreign affiliates are mainly located in Germany (41 per cent of innovative firms), US (15 per cent), and UK (6.5 per cent).

The empirical analysis presented in this study is based on data from the third CIS,[3] which provides a wide range of information on the specific innovation strategies and respective activities of firms, and on their ownership structure. The structure of this paper is as follows: Section 2 presents the empirical model and hypotheses. Section 3 presents the data used, while

[3] The third wave of the Community Innovation Survey (CIS) has been carried out in 2001 and covers the period 1998-2000.

the empirical results are discussed in section 4. Some concluding remarks are provided in section 5.

2. Empirical model

The question of ownership is not exogenous to the firm. The interests of both foreign and domestic investors in a particular firm hinges on a number of firm characteristics, some of which are observable, others are not. As has been argued in the previous section, the selection bias is essential to our research question. Therefore, one needs to control for the sample selectivity when exploring whether foreign ownership matters regarding innovation intensity. One way of doing so is to make use of matching techniques (see Heckman, Ichimura, and Todd, 1997, 1998),[4] i.e. to compare any performance measure of a distinct sub-group of firm to the counterfactual performance these firms would realize if they were not part of the relevant sub-group. The firms in question are denoted as the "treatment group"; they are "treated" if they fall into the distinct subgroup (foreign ownership) and they are "not treated" (domestic ownership) if they do not fall into that sub-group. With cross section data at hand the propensity score matching estimator applies[5] which features some rather convenient properties: the outcome equation (in our case: R&D intensity) requires neither a particular functional form, nor are their any restrictions as to the distributional assumptions. Furthermore, the impact of variables may vary across foreign-owned and domestic firms.

2.1 The propensity score matching setup[6]

Following Heckman, Ichimura, and Todd (1997, 1998), denote Y^T as the outcome variable of the treated firm and Y^C as the outcome variable of the control group, i.e. Y^C denotes the outcome that would have been realised if the treatment group had not been treated. The treatment in our

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[4] Alternatively, the analysis could be framed within a sample selection model, or instrumental variable estimators could be applied. The major difficulty with these approaches is to find valid instruments that have an influence on the ownership variable, but do not at the same time effect the relevant outcome, i.e. innovation intensities.

[5] See Almus and Czarnitzki (2003) and Czarnitzki, Ebersberger and Fier (2006) for recent applications of the matching estimator to firm level data. For panel data the appropriate estimator would be the difference in difference estimator.

[6] This section draws heavily on Almus and Czarnitzki (2003).

case is whether or not a firm is foreign-owned, $D = 1$, whereas the indicator switches to zero, $D = 0$, for domestic firms. The average impact of the treatment on the treated is defined as:

(1) $$E(\alpha_{TT}) = E\left(Y^T \middle| D = 1\right) - E\left(Y^C \middle| D = 1\right).$$

As a matter of fact, however, the counterfactual outcome of the treated group, $E\left(Y^C \middle| D = 1\right)$ is unobservable. Replacing $E\left(Y^C \middle| D = 1\right)$ by $E\left(Y^C \middle| D = 0\right)$ is not feasible because the treatment is selective, i.e. foreign investors care for distinctive firm characteristics. As a way out the counterfactual situation can be estimated from a selected control group of non-treated firms if a conditional independence assumption (CIA) is imposed (see Rubin, 1977). Under the CIA assumption, the average treatment effect on the treated (ATT) can be rewritten as:

(2) $$E(\alpha_{TT}) = E\left(Y^T \middle| D = 1, X\right) - E\left(Y^C \middle| D = 0, X\right),$$

where X is a vector of the control variables.

In order to obtain an unbiased estimate of the ATT, the non-treated firms (i.e. domestic firms) should have similar “control” characteristics as compared to the treated (foreign-owned) firms.

Out of a number of methods that have been proposed to estimate the counterfactual group, we use the Nearest Neighbour matching approach: for each treated firm, we search for the most similar firms in terms of the characteristic X in the potential control group. In a second approach we make use of kernel matching methods.

Since the number of variables X can be quite large, Rosenbaum and Robin (1983) suggest to use the conditional propensity score P(X) as a single index, where $\mathrm{P(X) = Pr(D = 1 | X)}$ gives the probability of being a foreign-owned firm. Substituting X for $P(X)$, the average treatment effect on the treated can be rewritten as:

(3) $$\mathrm{E}(\alpha_{\mathrm{TT}}) = \mathrm{E}\left(\mathrm{Y^T} \middle| \mathrm{D = 1, P(X)}\right) - \mathrm{E}\left(\mathrm{Y^C} \middle| \mathrm{D = 0, P(X)}\right).$$

The propensity score matching approach constructs a statistical comparison group by matching foreign-owned firms with domestic firms that have similar values in their propensity score. As a first step, we model the probability of being treated (simple probit model) and calculate the propensity scores for each firm i as $\mathrm{x_i'}\hat{\beta}$ (i.e. the ‘fit’). Each foreign-owned firm is then matched with the domestic firm with the closet propensity score.

The probit model is specified as follows (subscript i is suppressed for convenience):

(4) $$\Pr(D = 1 \mid X) = \Phi(\beta_0 + \beta_1 \ln YL + \beta_2 SKILL + \beta_3 XY + \beta_4 NEW + Z\chi^{'})\ ,$$

where D is the dummy variable indicating whether or not a firm is foreign-owned. YL denotes labour productivity measured as total sales per employee in 2000; $SKILL$ gives the fraction of workers with a university degree; NEW is a dummy variable for newly founded firms (i.e. within the last three years before the survey year); XY is the export intensity, being measured by the ratio of exports to turnover. Finally, Z contains a set of dummy variables indicating whether or not the firm operates on the regional, national, or international markets. Z also contains controls for firm size and sector affiliation. (We also experimented with the investment ratio but the t-test on mean differences revealed that there are no differences in innovation intensities between foreign-owned and domestic firms.)

After estimating the propensity scores $x_i^{'}\hat{\beta}$, a matching algorithm is required to estimate the missing counterfactual for each treated observation i. Several algorithms have been suggested in the literature. For each algorithm, there are a number of choices to be made. Since in small samples the matching results could be sensitive to the choice of the matching approach (Heckman, Ichimura, and Todd, 1997), it seems advisable to try a number of approaches and test the sensitivity of the results with respect to the different methods. The simplest algorithm is the (single) nearest-neighbour matching, whereby each treated observation is paired with the control observation whose propensity score is closest in absolute value. This algorithm works with and without the replacement, where the former means that the picked non-treated firms may be used more than once. Furthermore, we have to decide on the number of non-treated individuals to be matched with a single treated individual. Using the same non-treated firm more than once (with replacement), potentially improves the matching quality, but also increases the variance. Conversely, the variance of the estimates is decreasing with a growing number of neighbours (Smith and Todd 2005). In order to check if and to what degree the estimates differ when more neighbours are included, we implement an oversampling with 2, 5, and 10 nearest neighbours.

Besides the nearest neighbour method, we also make use of Kernel matching techniques (KM). With Kernel matching all treated firms are matched with a weighted average of all control firms with weights that are inversely proportional to the distance between propensity scores of treated and control firms (Caliendo and Kopenig, 2005). Kernel estimators increase efficiency, but also introduce more bias than the nearest neighbour matching would. With respect to the kernel function to be chosen, we opt for the algorithms provided by Leuven and Sianesi (2003).

3. Data and descriptive statistics

The data used to apply propensity score matching estimators should satisfy the following conditions:

1) The data should contain a rich set of (firm) characteristics which allows to estimate the probability of being treated,
2) The setup of the questionnaire should be as similar as possible for the treated and the non-treated control group,
3) Treated and non-treated observations should face the same environment. In our case this boils down to the claim that firms should be in the same market (see Heckman et al., 1997; Smith and Todd, 2005).

The Community Innovation Survey meets these requirements and hence our analysis is based on data from the CIS-3 conducted by Statistics Austria in 2001. The sample includes both manufacturing and service firms – 1,300 observations in total - , and contains relevant information for the time period 1998-2000. The sample is restricted to the set of (517) innovative firms only – firms which have neither introduced product nor process innovations in the past or firms that had no ongoing innovation activities at the time of the survey do not report on innovation expenditures. Since the outcome variable denotes a share, i.e. the ratio of innovation expenditures to sales - ranging from values that are close to zero up to one, we use the logarithm as well as logistically transformed shares. The logistic transformation may also account for the fact that the distribution of the ratio of innovation expenditures to sales is skewed towards firms with low innovation intensity. Furthermore, some extreme values such as very high levels of innovation intensity of 50 per cent or more might affect the mean of the distribution. Both, the logarithmic and logistic transformation, scale down the large values and reduce the problem with the skewed distribution.

In the general part of the survey, firms are asked whether they are part of an enterprise group, and if so, to subsequently indicate the nationality of the parent company. Evidence based on the sample of innovative firms suggests that 103 (out of 517) such firms are in foreign ownership and that parent companies of these foreign affiliates are mainly located in Germany (41 per cent of the foreign-owned firms), US (15 per cent), and UK (6.5 per cent).

Table 1 shows the differences in observable characteristics for the two sub-samples of foreign and domestic firms. The right column of the table presents the results from a t-test on the null of equal means across the two sub-samples.

Table 1: Descriptive statistics: foreign versus domestic firms

		foreign-owned firms N_1=103	domestic firms N_2=413	test on equal means	
		Mean	Mean	t-value	p-value
	outcome variables				
	log innovation intensity	-4.4642	-4.2438	-1.28	0.201
	logistically transformed innovation intensity	-4.3846	-4.1923	-1.04	0.297
	right hand side variables:				
YL	log labour productivity	8.097	7.769	4.08	0.000
SKILL	share of university graduates	0.074	0.054	1.95	0.051
INV	Investment ratio	0.081	0.080	0.09	0.926
XY	export ratio	0.441	0.257	4.81	0.000
NEW	newly founded firm	0.087	0.041	1.90	0.059
Z_1	main geographical area of operations: regional	0.019	0.065	-1.83	0.068
Z_2	main geographical area of operations: national >50km	0.327	0.278	0.97	0.330
Z_3	main geographical area of operations: international >50km	0.596	0.407	3.51	0.000
Z_4	employment 20-49 (reference 10-19)	0.125	0.237	-2.50	0.013
Z_5	employment 50-249	0.269	0.274	-0.09	0.929
Z_6	employment > 249	0.452	0.274	3.55	0.000
Z_7	nace 20-22 (reference 15-19)	0.058	0.058	-0.02	0.987
Z_8	nace 23-26 (chemicals, rubber, plastics, minerals)	0.096	0.075	0.71	0.478
Z_9	nace 27-28 (basic metals)	0.029	0.039	-0.48	0.632
Z_{10}	nace 29 (machinery)	0.087	0.116	-0.86	0.389
Z_{11}	nace 30-35 (electrical and transport equipment)	0.212	0.053	5.30	0.000
Z_{12}	nace 36-40 (other manuf., energy)	0.019	0.051	-1.40	0.163
Z_{13}	nace 50-64 (trade and transport)	0.308	0.220	1.87	0.062
Z_{14}	nace 65-67 (financial sector)	0.087	0.223	-3.16	0.002
Z_{15}	nace 70-74 (business services)	0.048	0.061	-0.48	0.628

Source: CIS-3 Austria, own calculations.

Foreign-owned firms are significantly different from the domestic-owned ones in many respects. For instance, the former display significantly higher measures of labour productivity, being defined as turnover per employee. We also find our initial conjecture to be confirmed in as far as foreign-owned firms are significantly larger as compared to the domestic ones. As has been argued before, the lower innovation intensity of foreign affiliates can be due to size effects, since innovation intensity is inversely related to firm size. Foreign-owned firms export a much higher proportion of their output and are more likely to operate on international markets, as one would certainly expect. Similarly, we observe clear differences in the main geographical areas of operation, where firms in domestic ownership operate more on a regional scale, while foreign-owned firms operate more on an international scale. Furthermore, at the time of the survey, foreign-owned firms have a significantly higher probability to have been founded within the last three years. They also rely more on high-skilled labour. Last, there are clear differences in the extent of multinational activity across sectors. For instance, foreign-owned firms are overrepresented in electrical and transport equipment as well as in wholesale and retail trade. About 50 per cent of all foreign-owned firms in our estimation sample are affiliated to these two industry branches. The corresponding share for domestic firms is 27 per cent. Finally, it comes a bit by surprise that there are no differences in the investment ratio between foreign and domestic firms.

To summarize the findings from Table 1 we may definitely conclude that the ownership issue is highly biased with respect to various firm characteristics.

4. Results

4.1 Results of the probit model

Table 2 shows the estimation results for the probit model on the factors that influence the probability of being a firm in foreign ownership. The marginal effects are calculated at the sample means. As already indicated in the descriptive section, foreign ownership is positively affected by a firm's labour productivity and export ratio, and by the geographical area of operation, the sectoral affiliation and size class. The estimate on the educational level of the work force displays a positive sign, too, but the associated marginal effect does not turn out statistically significant at conventional levels.

Table 2: Probit estimation on the probability to be foreign-owned

		coeff		t-value	marg effect
YL:	log labour productivity	0.31	***	3.11	0.074
SKILL:	share of university graduates	0.84		1.01	0.204
XY:	export sales ratio	0.60	*	1.83	0.146
NEW:	newly founded firm	0.31		1.13	0.085
Z_1:	main geographical area of operations: regional	-0.33		-0.80	-0.069
Z_2:	main geographical area of operations: national >50km	0.42		1.63	0.110
Z_3	main geographical area of operations: international >50km	0.08		0.27	0.020
Z_4:	employment 20-49 (reference 10-19)	0.05		0.24	0.013
Z_5:	employment 50-249	0.36	*	1.65	0.094
Z_6:	employment > 249	0.55	***	2.56	0.147
Z_7:	nace 20-22 (reference 15-19)	0.26		0.70	0.070
Z_8:	nace 23-26	0.50		1.49	0.147
Z_9:	nace 27-28	-0.12		-0.26	-0.027
Z_{10}:	nace 29	0.09		0.26	0.021
Z_{11}:	nace 30-35	0.95	***	2.88	0.306
Z_{12}:	nace 36-40	-0.19		-0.41	-0.042
Z_{13}:	nace 50-64	0.66	**	2.22	0.186
Z_{14}:	nace 65-67	0.06		0.18	0.015
Z_{15}:	nace 70-74	0.16		0.40	0.042
	Constant	-4.39	***	-5.66	
	F-test: geographical area	chi2(3) =6.74; p-value = 0.08			

Source: CIS-3 Austria, own calculations.

Notes: ***(**,*) indicate a 1 (5, 10) percent, level. The number of observations is 517.

The greatest effects (in descending order) are attributable to

- Sectoral affiliation: When a firm shifts its activity from the (reference) low-tech manufacturing industries to the science-based industries in NACE 30-35, it increases its probability of being a foreign-owned firm by 30.6 percentage points. A shift towards wholesale trade would increase the respective probability by 18.6 percentage points.
- Firm size: Being a firm with at least 250 employees increases the probability of foreign ownership by 14.7 percentage points.

- Export intensity: Export share has a significant positive effect indicating that the likelihood of being foreign-owned is higher for internationally oriented production units than for domestically oriented ones.
- An F-test indicates that the three indicators of geographical area are jointly significant at the 8 per cent level, implying that foreign-owned firms are more likely to operate on international markets.

4.2 Propensity score matching results

Before discussing the results in terms of differences in R&D intensities between foreign-owned and domestic firms, it seems advisable to first have a brief look at the quality of matching. Table 2 report the mean values of the relevant variables after NNM matching techniques have been applied.[7] Columns (3) list associated p-values for the null that the means for these selected control groups do not differ from those of the foreign-owned firms. No test on mean equality is rejected at conventional levels of significance. This indicates that other variables which impact on R&D-intensities are well levelled across the treatment and control groups and hence reported differences in the R&D-intensities (see Table 3) are solely attributable to the type of ownership.

Table 4 displays the causal treatment effect of foreign ownership on the innovation intensity as measured by the (log and logistic transformed) ratio of innovation expenditures to total sales.[8] The t-values are associated with the null hypothesis that the means are equal; they are based on bootstrapped standard errors (with 100 replications). The last column provides an estimate of the bias.

[7] The p-values associated with Kernel matching are almost identical and are available on request.

[8] Matching estimations are performed in Stata 9.2 using the psmatch2 command developed by Leuven and Sianesi (2003).

Table 3: Matching quality

:		Nearest Neighbour Matching (NNM) foreign-owned firms N_1=101 (mean)	selected control group, domestic firms (mean)	test on mean equality (p-value)
YL:	log sales per employee	8.090	8.031	0.60
SKILL:	share of university graduates	0.074	0.082	0.63
XY:	export ratio	0.430	0.483	0.34
NEW:	newly founded firm	0.078	0.108	0.50
Z_1:	main geographical area of operations: regional	0.020	0.020	1.00
Z_2:	main geographical area of operations: national >50km	0.333	0.235	0.15
Z_3	main geographical area of operations: international >50km	0.588	0.706	0.10
Z_4:	employment 20-49 (reference 10-19)	0.127	0.147	0.71
Z_5:	employment 50-249	0.275	0.294	0.77
Z_6:	employment > 249	0.441	0.461	0.79
Z_7:	nace 20-22 (reference 15-19)	0.059	0.020	0.18
Z_8:	nace 23-26	0.098	0.108	0.83
Z_9:	nace 27-28	0.029	0.059	0.34
Z_{10}:	nace 29	0.088	0.078	0.81
Z_{11}:	nace 30-35	0.196	0.186	0.87
Z_{12}:	nace 36-40	0.020	0.020	1.00
Z_{13}:	nace 50-64	0.314	0.314	1.00
Z_{14}:	nace 65-67	0.088	0.078	0.81
Z_{15}:	nace 70-74	0.049	0.059	0.77

Source: CIS-3 Austria, own calculations.

As regards the matching algorithms, we tried a number of different specifications. Nearest neighbour matching is implemented with and without replacement. For the kernel matching estimators, we use the biweight, Epanechnikov kernel, and default Gaussian bandwidth of 0.06. As recommend in Smith and Todd (2005), all matching algorithms are implemented only for those firms with common support. This is performed by omitting the observations that have propensity scores above the maximum propensity scores or less than the minimum scores of the controls. Imposing this so-called "common support" restriction leads to a loss of two observations. For the remaining observations in the group of treated firms, we find appropriate twins.

Table 4: Matching results

		ATT-coeff. (in %)	t-value	bias
	outcome variable: log (innovation expenditures/sales)			
	number of nearest neighbours			
NNM	1 without replacement	-0.36	-1.66	0.04
NNM	1 (with replacement)	-0.51	-1.76	0.24
NNM	2 (with replacement)	-0.40	-1.49	0.10
NNM	5 (with replacement)	-0.36	-1.53	0.05
NNM	10 (with replacement)	-0.33	-1.74	0.05
	outcome variable: log(innovation expenditures/sales)			
	types of Kernel			
Kernel	Biweight	-0.41	-2.19	0.15
Kernel	Gaussian	-0.32	-1.97	0.04
Kernel	Epan	-0.40	-2.48	0.11
	outcome variable: logistic transformation of (innovation expenditures/sales)			
Kernel	Biweight	-0.38	-1.94	0.14
Kernel	Gaussian	-0.30	-2.01	-0.01
Kernel	Epanechnikov	-0.38	-1.79	0.10

Source: CIS-3 Austria, own calculations. Matching estimations are performed in Stata 9.1 using the psmatch2 command developed by Leuven and Sianesi (2003).

The point estimates of the average treatment effect on the treated (ATT) generated by the different matching algorithms is negative in all cases. Based on a two-tailed (one-tailed) t-test we find that the ATT estimates are significant at the 10 per cent (five percent) level with only two exceptions.[9] Taken together these findings imply that the mean innovation intensity of foreign-owned firms is considerably – and statistically significantly - lower as compared to the performance of domestically owned firms with otherwise similar characteristics. For the nearest neighbour matching with replacement, the point estimates differ somewhat, especially when we increase the number of neighbours, with ATT-coefficients ranging between 33 and 51 per cent.[10]

[9] The two exceptions refer to NNM with replacement and 2 or 5 nearest neighbours

[10] Since the underlying regression equation is semilogarithmic, estimates turn out biased. To convert them into unbiased effect, the following formula applies: exp(ATTcoeff.)-1 (see Halvorsen and Palmquist (1980) on the correct interpretation of dummy variables in semilogarithmic equations).

By contrast, the three specifications of the Kernel matching produce rather similar estimates and also the standard errors turn out more alike and lower. This is not surprising since Kernel estimates use more control cases and hence tend to be more efficient. Based on two-tailed t-test all estimates are significant at the five percent level. The bias is the lowest when a Gaussian type of Kernel function is used. An ATT-coefficient of -0.32 indicates that – on average - foreign-owned firms are characterised by 27 per cent (exp(-0.32)-1=-0.27) lower innovation sales ratios as compared to the selected control group of domestic firms.

Last, we applied Kernel matching on the logistically transformed innovation intensities to account for their left-skewed distribution. The results are in fact a bit sensitive to the transformation method as can be seen from the lower section of Table 4.

4.3 Benchmarking

The present study is the first one to discuss the presumed effects of foreign ownership on firms' innovation intensities in a matching framework. It remains to validate our findings against results derived from conventional regression techniques. We ran OLS and Box-Cox regressions for logarithmic/logistically transformed/and plain innovation intensities (see Table 5). The set of right-hand side variables is the same as before, except, of course, that an additional foreign-ownership dummy enters the model.

This dummy proves to be significant and negative in all specifications, as one would expect. A comparison between conventional regression and matching results shows that the gap in innovation intensity is not declining once we control for differences in firm characteristics introduced by the selectivity bias. Far from it, the matching approach proves to increase observed innovation intensities of domestic as opposed to foreign-owned firms.

Table 5: Determinants of innovation intensity (OLS and Box-Cox regression model)

	(i)		(ii)		(iii)	
	log (innovation expenditures/sales)		(innovation expenditures/sales), logistically transformed		(innovation/sales)	
	OLS		OLS		Box-Cox	
	coeff.	t-value	coeff.	t-value	coeff.	LR-test: chi-square, p-value
foreign-owned firm	-0.31	-1.97	-0.29	-1.71	-0.24	0.036
YL:	-0.67	-7.59	-0.72	-7.69	-0.52	0.000
SKILL:	3.17	4.52	4.17	4.02	2.66	0.000
XY:	0.33	1.17	0.43	1.38	0.27	0.226
NEW:	-0.08	-0.25	-0.08	-0.24	-0.03	0.875
Z_1:	0.31	0.99	0.35	1.05	0.24	0.253
Z_2:	0.29	1.35	0.24	1.04	0.20	0.158
Z_3	0.66	2.51	0.62	2.22	0.49	0.007
Z_4:	-0.05	-0.28	-0.04	-0.18	-0.03	0.831
Z_5:	-0.34	-1.71	-0.33	-1.61	-0.25	0.070
Z_6:	-0.48	-2.45	-0.47	-2.22	-0.37	0.011
Z_7:	0.45	1.22	0.51	1.30	0.37	0.105
Z_8:	0.70	2.64	0.71	2.52	0.53	0.012
Z_9:	0.25	0.86	0.22	0.72	0.16	0.552
Z_{10}:	0.59	2.12	0.59	2.03	0.46	0.019
Z_{11}:	0.96	3.32	0.94	3.06	0.74	0.001
Z_{12}:	0.09	0.26	0.09	0.28	0.06	0.800
Z_{13}:	-0.18	-0.63	-0.16	-0.53	-0.12	0.517
Z_{14}:	-0.18	-0.64	-0.19	-0.66	-0.15	0.453
Z_{15}:	0.66	1.85	0.71	1.84	0.51	0.052
constant	0.39	0.57	0.81	1.12	-0.09	
R^2	0.33		0.35			
Number of firms	517		517		517	

Notes: Column (i) and column (ii) show OLS results with t-values based on heteroskedasticity consistent standard errors. Column (iii) displays the results of the Box-Cox regression model where only the left hand variable is transformed.

5. Conclusions

This paper addresses the question of whether foreign ownership matters regarding innovation intensity. It is well documented that foreign firms display lower innovation and R&D intensity than local firms do. However, (foreign) investors bear not only innovation performances in mind when making up their investment decisions. Unless factors such as firm size, export and skill intensity, labour productivity, sectoral affiliation and geographical area of operation are not properly controlled for, one is running the risk of comparing apples and oranges. To account for the selectivity bias we employ matching estimators when comparing the innovation intensity between domestic and foreign-owned firms. The observed gaps in innovation intensities do not only survive this matching test, but turn out higher as compared to the results that would have been derived from conventional regression analyses.

This finding casts serious doubts on FDI-insourcing strategies – at least the costs of such policies should be carefully traded off against the costs incurred thereby. Since it is the type of firm, and not the type of firm-owner, that is relevant for promoting national innovation performance measures, the question of ownership should enter neither policy rationales, nor funding practices.

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