WORKING PAPER SERIES

WORKING PAPER NO 6, 2004

ESI

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http://www.oru.se/esi/wps

SE-701 82 Örebro
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ISSN 1403-0586

Are foreign owned-firms more productive?

Evidence from Swedish firm data

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August 30, 2004

Abstract

This paper analyzes the difference between foreign and domestic ownership of firms with respect to productivity. The analysis is performed using a panel of firm data from Statistics Sweden, covering the entire manufacturing sector in the 1990's. First we show that, other things equal, foreign-owned firms have higher labor productivity as well as total factor productivity than domestic firms. We also find that Swedish multinational firms are as productive as foreign-owned firms. Then we show that the rate of growth in productivity is higher in foreign-owned firms. We find no evidence for reverse causality.

JEL Classification: F23

Keywords: Foreign ownership, productivity

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1 Introduction

The flow of inward Foreign Direct Investments (FDI) to Sweden has increased dramatically during the 1990s, mainly in terms of foreign acquisitions of domestic firms and to a less extent greenfield operations. Before 1991, the situation was the reverse, inward FDI was sparse and much smaller than the FDI outflows (see Figure 1). The number of foreign-owned firms in Swedish manufacturing with at least 50 employees increased from 346 in 1990, to 528 in 2000 (see Table 1 or Tables 11 and 12 for regional and sectoral distribution). An overwhelming majority of these firms became foreign-owned through acquisition of a domestic firm.[1] The decline in the total number of firms with at least 50 employees was the result of the deep recession during the 1990s.

The effects of FDI are important from a policy perspective. Can Sweden benefit from an increasing inflow of investments, or are the effects on the economy negative? In the popular debate concerning foreign acquisition of domestic firms (as opposed to greenfield investments) the negative aspects have often been emphasized.[2] Foreign acquisition (or mergers) may imply loss of national control and sometimes outsourcing of the domestic production to other countries. On the other hand, foreign acquisition may also contribute to a higher productivity in the acquired firm (see Norbäck & Persson (2001))[3] and to knowledge spillovers to domestic firms.[4]

The questions we seek answers to in this paper are: Are foreign-owned firms in Sweden on average more productive than purely domestic Swedish firms? If foreign-owned firms also differ in other respects from domestic firms, can this explain the difference? Is productivity growth, other things given, higher in foreign-owned firms? Does superiority of foreign-owned firms hold even after controlling for selection bias?

A number of studies on the plant and firm level indicate that there are differences between multinational and purely local firms. For the US, Doms & Jensen (1998) found that workers at

[1] Firms firms with less than 50 employees were sampled before 1996. The number of accumulated firms in Table 1 is thus likely to underestimate the true numbers.

[2] The consequences of increased inward FDI were intensively debated in the middle of the 1990s. The main concerns emanated from Swedish business leaders who feared that the developments would increase market concentration and that outsourcing of domestic production to other countries would increase dramatically. In reports from the ITPS (2004) and ISA (2003), it was shown that during the recession in the 1990s high-skilled production was not outsourced from Sweden to other countries and that differences in behaviour between foreign and Swedish companies during the recession in the 1990s was small.

[3] Norbäck & Persson (2002) show that a liberal policy against cross-border M&As is optimal when domestic assets are sufficiently scarce. The domestic assets are expected to be more efficiently used when they are transferred from domestic to foreign ownership.

[4] Increased productivity, as measured, could be due to a more efficient use of available input in foreign-owned firms than in domestically-owned firms. However the "increase" in productivity could also be due to higher product prices if the foreign firms use their superiority to increase their price cost margin (PCM) on a specific product. This effect may not be fully neutralized by deflating output by the producer price index (PPI) since PPI is seldom available at the product level, but rather at the industry level.

Figure 1: The inward and outward flow of FDI in Sweden 1986-2002

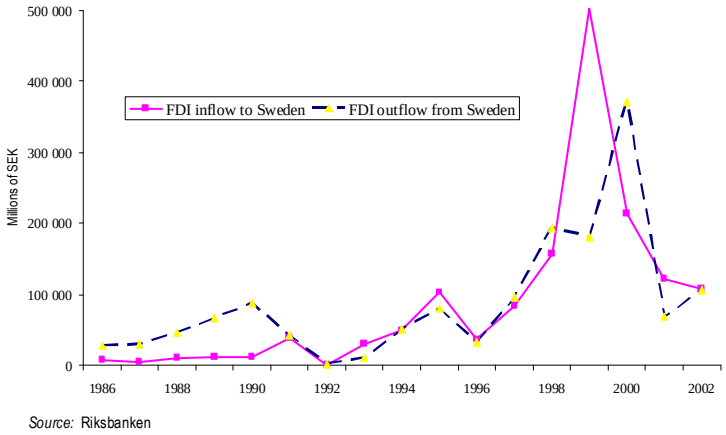

Table 1: The number and share of foreign-owned firms in the sample

Year	Foreign owned	All firms	Ratio percent	Foreign greenfields
1990	346	2020	17.1%	74
1992	339	1761	20.6%	83
1994	363	1656	20.5%	70
1996	416	1804	23.1%	79
1998	486	1928	25.2%	105
2000	528	1938	27.2%	116

Source: Statistics Sweden and authors' calculation. The sample consists of firms with at least 50 employees in the manufacturing sector. Foreign greenfields is a subsample of foreign-owned firms.

foreign-owned manufacturing plants (MNF:s) generate about 50 percent more value added and receive 20 percent higher wages than employees at the average domestically-owned plant.[5] Aitken et al. (1996) found similar results for a number of developing countries. Modén (1998) found that foreign-owned firms in Sweden are more productive and use more capital intensive technologies than do domestic firms. For the UK, Griffith and Simpson (2001) found that the level of labor productivity as well as the rate of growth of labor productivity was higher in foreign-owned firms as compared to domestic firms in manufacturing.[6] Also for the UK, Criscuolo and Martin (2003)

[5] Doms and Jensen (1998) made a distinction between US local firms and US MNFs. They found that US MNFs were more productive than foreign MNFs and that US local firms were least productive.

[6] Griffith and Simpson (2001) found that only establishments that were always foreign-owned had significantly higher labor productivity. Furthermore, the difference in productivity was explained by differences in levels of investments per employee.

found that UK MNFs are less productive than US-owned plants, but as productive as non-US foreign-owned plants.

We believe that many of the owner-specific advantages proposed by John Dunning's Ownership, Location, Internalization (OLI) framework, such as higher quality, more efficient production, better marketing or stronger brand name in MNFs, will be reflected in the key variables we study, namely labor productivity (Lpr), measured as value added, deflated by the industry producer price index (PPI), per employee, or alternatively total factor productivity (TFP), computed as the ratio of deflated sales value to an index of input volumes. For instance, higher quality or a fashionable brand name should be reflected in higher prices relative to the industry average (i.e. the PPI) and thus higher productivity as measured. However, a positive relationship between foreign ownership and productivity may also exist because of reverse causality, i.e., if foreign investors select high performance firms as acquisition targets. To control for this selection bias we consider the firms' productivity before acquisition and by using the instrumental variables approach. Another method used to control for the selection bias, which we use in this paper, is to control for not only the productivity level but also the productivity growth.[7]

The rest of the paper is organized as follows. In section 2 we present the theoretical considerations. First, we discuss the international trade theory on the motives behind FDIs. We then continue with a theory behind acquisitions in general, advanced by Lichtenberg & Siegel (1987), according to which a low level of productivity will induce a change in ownership. This theory contradicts the reverse causality hypothesis. In the next section, section 3 we present the characteristics of our longitudinal firm level data and econometric issues. The methods used and empirical findings are outlined in section 4, while section 5 summarizes.

2 Theoretical framework

2.1 Motives for FDI

Caves (1974) argued that FDI should influence the host country conditions in at least two ways: by technology transfers, and by increased competition. That transfer of knowledge to affiliates should occur is of course also a central tenet in the traditional OLI paradigm, according to which, in order to overcome the obvious handicap of having less information about how to operate in

[7] Alternatively one may use propensity score matching and difference in difference approaches. See e.g. Görg & Girma (2003). This methodology will be used in a companion paper on Swedish firm level data in progress.

a foreign country, the Multinational Firm (MNF) has to be in possession of some owner-specific advantage such as a better product, more efficient production and/or marketing skills, or an established brand name (Dunning (1977), Markusen & Venables (1998)). If an MNF transfers such knowledge to its affiliate, e.g. management or technological skills, this should enhance the productivity in the firm.

These effects are sometimes referred to as the direct effects of increased inward FDI, whereas the indirect effects are externalities such as spillovers from the foreign affiliates to domestic firms (see e.g. Görg and Greenaway (2001) for a survey of the spillover literature). A basic question, central for the relevance of spillovers, however, is whether it can be shown that the foreign-owned firms really are superior in some respect to the purely domestic firms, since otherwise there would not seem to be much scope for spillovers whatsoever.

To further elaborate on the motive behind FDI:s the Dunning's (1993) taxonomy of broad motives is often used. They include the resource-seeking (when a natural resource is scarce in the home country), market-seeking (e.g. when the home market is to small), efficiency-seeking (when some products can be more efficiently produced abroad) and strategic asset-seeking motives. The strategic asset motive would be particularly important in oligopolistic markets with rival firms preempting competitors gaining any advantage. The reduction of institutional barriers, such as trade and FDI restrictions over the past two decades has simplified cross border investments dramatically. Foreign acquisitions constitute more than 80% of all foreign-owned firms in Sweden during the 1990s (Table 1). This development can be explained by both the motives of efficiency-seeking and the market-seeking motives.

While the theories of multinational firms suggest that foreign-owned firms should be more productive per se, there are theories explaining why ownership changes in general (not necessarily foreign takeovers) should increase the efficiency in the acquired firms. Lichtenberg and Siegel (1987) actually contradict the popular view of reverse causality of the acquirers' superiority. They extend the job matching theory of Jovanovic (1987) and test the validity of their theory on US plant level data. The matching theory focuses on the quality of the match between the owner and the plant/firm. The theoretical implications of the matching theory of firm turnover are that firms with a low level of productivity are more likely to be acquired than firms with a high productivity and that the new owner will either raise the productivity or, if it is a poor match, divest the acquired firm. This theory thus contradicts the reverse causality explanation

of foreign-owned firms' superiority, i.e. that MNFs tend to acquire domestic firms with initially high productivity.

2.2 Definition and measurement of productivity

When comparing productivity in foreign and domestic firms we use both labor productivity and total factor productivity. Labor productivity is only a partial measure of the firm performance and is used as a complement to our other measure of efficiency, total factor productivity. This will make it possible to compare our results with the results of studies that use labor productivity. Moreover, the use of both labor productivity and total factor productivity will enable us to check the robustness of our results.[8]

Assume that the production function of the firm is a generalized Cobb-Douglas where output is a function of the inputs skilled labor, unskilled labor and capital:[9]

$$Q_{it} = A_{it} U_{it}^{\alpha_U} S_{it}^{\alpha_S} K_{it}^{\alpha_K} \qquad \mu = \alpha_{_U} + \alpha_{_S} + \alpha_{_K} - 1 \tag{1}$$

where $Q_{it}, A_{it}, U_{it}, S_{it}, K_{it}$ is output (value added), total factor productivity, inputs of unskilled labor, skilled labor and capital, in the i:th firm in period t, and μ *is* an indicator of returns to scale, where $\mu > 0$ indicates increasing returns to scale. The parameters are the same for all firms. Dividing both sides of Equation 1 by total employment $L_{it} = U_{it} + S_{it}$ (i.e. multiplying with $L^{-1} = L^{\mu-\alpha_U-\alpha_S-\alpha_K}$) we may write labor productivity $q_{_{it}} = \frac{Q_{it}}{L_{it}}$ as

$$q_{it} = A_{it} u_{it}^{\alpha_U} s_{it}^{\alpha_S} k_{it}^{\alpha_K} L_{it}^{\mu} \tag{2}$$

where s_{it}, k_{it},are skill- and capital intensity and L is supposed to capture scale effects. The total factor productivity, or efficiency, of the of the i:th firm in period t (A_{it}) is assumed to be proportional to the stock of firm-specific knowledge. Such knowledge may come from different sources internal or external to the firm, such as R&D expenditure of the firm itself, learning by doing or knowledge spillovers from various sources, domestic or international, where the latter may follow input-output or trade links. One particular link for international spillovers may go

[8] The optimal combination of capital and labor differs among firms and industries, see e.g. Coelli et al. (1998, pp. 87). Therefore TFP is the theoretically most relevant concept. However, McGuckin and Nguyen (1993) argue in favor of labor productivity. The reason is that inputs such as capital and energy often suffer from measurement errors as opposed to data on output and labor.

[9] For simplicity we assume Cobb Douglas production technology in the derivations. The calculation of the TFP measure in the Appendix, and the empirical analysis where we use the TFP measure, is based on a translog production function technology, which by definition equals the Cobb Douglas only if a number of conditions are fulfilled.

from a foreign MNF to its affiliates in the host country. Let us write productivity as a function of the different components of the knowledge capital stock:

$$A_{it} = F(\kappa_{it}^{L}, \kappa_{it}^{R\&D}, \kappa_{it}^{S}, \kappa_{it}^{FDI}) \tag{3}$$

On the sources of knowledge coming from learning (κ_{it}^{L}) and spillovers in general, domestic and international (κ_{it}^{S}), we have no information, and thus we have to assume that these components of knowledge are the same for all firms.[10] We do have information on R&D expenditures and whether the firm is foreign-owned ($\kappa_{it}^{R\&D}, \kappa_{it}^{FDI}$). In the next section we consider how this information can be linked to productivity.

2.3 Determinants of labor productivity

Since $s_{it} + u_{it} = 1$ (share of skilled- and unskilled employees) in equation 2 we only include one of these shares. We add industry, λ_j, and time, λ_t, dummy variables and specify:

$$\ln q_{it} = A_{it} + \beta_1 \ln k_{it} + \beta_2 \ln s_{it} + \beta_3 \ln L_{it} + \lambda_j + \lambda_t + \varepsilon_{it} \tag{4}$$

Firm size, L_{it} is measured as employment of the i :th firm. [11]

By substituting R&D expenditures and foreign ownership for A_{it} in equation 4 we estimate,

$$\begin{aligned} \ln q_{it} \quad = \quad & \underbrace{(\beta_4 R_{it-\tau} + \beta_5 F_{it} + \beta_6 F_{it} R_{it-\tau})}_{A_{it}} + \beta_1 \ln k_{it} + \beta_2 \ln s_{it} + \\ & \beta_3 \ln L_{it} + \lambda_j + \lambda_t + \varepsilon_{it} \end{aligned} \tag{5}$$

where $R_{it-\tau}$ is firm $i's$ R&D expenditures in period $t-\tau$ and F_{it} is a dummy variable for foreign ownership ($F_{it} = 1$ for foreign-owned firms). The interaction term is added to allow for the fact that the productivity effect of the (local) R&D expenditure of a foreign-owned firm could be different from that of the R&D of a domestic firm. [12]

[10] For a formal discussion of how R&D and TFP can be related see Griffith et al. (2000). Griliches and Lichtenberg (1984) and Aghion & Howitt (1992) use endogenous growth models to formulate the connection between R&D and economic growth.

[11] The effect captured by the F dummy should reflect superior technology but could also be due to foreigners having better better access to foreign markets, etc. resulting in higher productivity (with constant technology).

[12] Fors (1998) finds that overseas R&D is mainly conducted to adapt technology and processes to local market conditions. He also finds that in industries that are relatively more specialized, the overseas R&D can serve as a channel for the firm to gain access to knowledge in "centers of excellence".

2.4 Determinants of total factor productivity

We calculate the TFP of the ith firm in year t as the difference between the output and a weighted index of the inputs, according to:

$$\begin{aligned} \ln A_{it} &= \ln Y_{it} - \omega_{S_t} \ln S_{it} - \omega_{U_t} \ln U_{it} - \omega_{M_t} \ln M_{it} \\ &\quad -\omega_{B_t} \ln B_{it} - \omega_{I_t} \ln I_{it} \end{aligned} \tag{6}$$

where $Y_{it}, S_{it}, U_{it}, M_{it}, B_{it}, I_{it}$ are deflated sales, employment of skilled and unskilled workers, the deflated capital stock separated into machinery and buildings, and inputs of raw materials, energy and semi-processed goods, and the ω's are the Törnqvist weights calculated by relative cost shares (details on the TFP calculations are provided in the Appendix).

As discussed above, total factor productivity A_{it} may be expected to depend on the stock of firm-specific knowledge. To estimate the importance of foreign ownership on total factor productivity, we run regressions on an indicator of foreign ownership and a set of control variables. Since the capital stock and the skill intensity are reflected in the calculated TFP these variables are not included in the right hand of the regressions. Thus we estimate

$$\ln A_{it} = \beta_0 + \beta_1 R_{_{it-T}} + \beta_2 F_{it} + \beta_3 \ln L_{it} + \beta_4 F_{it} R_{it-\tau} + \lambda_j + \lambda_t + \nu_{it} \tag{7}$$

2.5 On the measurement of firm-specific knowledge stocks

One possible approach would be to calculate knowledge stocks by cumulating R&D expenditure over time, with deduction for depreciation, i.e., knowledge becoming obsolete (see Hall & Mairesse (1995)), but the available time series are too short for that. Thus we have to use the flow of R&D, i.e., R&D expenditure as a proxy for the stock of firm-specific knowledge. The lag reflects the fact that making new knowledge operative may take time; we experiment with different values of τ. Whether it would be better to use R&D intensities instead of absolute expenditures is open to discussion. Our approach is to use R&D expenditure. This corresponds to the theoretical case where each firm, whatever its size, produces one single product, and a given amount of R&D expenditure results in a given improvement of the quality of the product or the efficiency with which it is produced, irrespective of the size of the firm (Hansson & Lundberg (1995)).

3 Data and econometric issues

3.1 Data

Our analysis of differences in productivity is based on a sample from the FIEF longitudinal firm level data base. The sample consists of Swedish manufacturing firms during the period 1990-2000. The Statistics Sweden industry codes (SNI) were changed in 1992 (SNI92), which made it difficult to use data for the period before 1990 (SNI69). For the years 1990-1992 the industry classification codes for each firm were reported in both SNI69 and SNI92. Each firm reports information on nationality of ownership and has a unique identification number. The data, supplied by Statistics Sweden, include all manufacturing firms in Sweden with at least 50 employees because variables such as energy costs are not available for smaller firms. In Table 2 we show that the firms in the sample account for 77.5 percent of employment and 82 percent of total value added in the manufacturing industry in 1997. Two different data bases have been matched, the financial statistics with information by firm on sales and various inputs in the production and the regional labor market statistics (RAMS) containing detailed information on the educational level of workers by firm. Each firm has also been assigned a four-digit industry code (according to SNI92).

Foreign ownership is defined in the statistics as the case where a foreign firm has a controlling position in a Swedish firm, which in turn is defined as possessing 50% or more of the votes (not necessarily equal to 50% of the shares, since Swedish firms may - and do - issue shares with widely different voting power).[13] Obviously the issue of foreign control is not so simple that it can be completely described by a binary variable switching from 0 to 1 at a certain level of voting power, here 50%, since - depending on the ownership structure - a share of the votes much lower than that may be sufficient to give a high degree of control.

It should be noted that almost two out of three firms in our sample report zero R&D expenditure, which means that taking logarithms of the R&D variable - whether as intensity or in absolute terms - drastically reduces the sample size. In the estimations presented below the R&D variable is included without taking logarithms, in order to preserve the sample size. As a check of robustness we also use the log of R&D. We use disaggregated producer price indices (PPI) to deflate value added and sales. The producer price index used for the manufacturing sector

[13] The advantages of using this definition is further discussed in e.g. the concept paper on the definition of investment: WTO (2002). Other studies use different definitions of ownership. Griffith and Simpson (2001) define a holding of at least 20% of the votes as an effective voice in the the foreign enterprise.

Table 2: Employment and value added for the sample and for total manufacturing sector 1997

Item	Sample	Total population	Percent covered
Employment	531,241	685,382	77.5%
Firms	1979	51427	4%
Value added (billions of SEK)	289.27	353.51	82%
Value added per plant (billions of SEK)	0.16	0.01	...
Employment per plant	290.1	13.3	...

Notes: The population sample values are derived from the FIEF database and the totals from NV19 SM 0201 (SCB). The manufacturing sector covers SNI92 industries 15-36. The sample is truncated at 50 employees.

is at the 4-digit level. The service sector was excluded since we lack appropriate price indices. The R&D expenditures is deflated by an aggregated PPI index. Intermediate goods, buildings, machinery and energy are deflated by their appropriate and specific disaggregated producer price indices.

3.2 Econometric issues

In the process of estimating the role of foreign ownership for productivity, a number of econometric problems have to be addressed. We expect that the presence of unobserved influences (e.g. firm-specific fixed effects) may affect the results. Another important aspect is the possible endogeneity of the ownership dummy (selection bias) and the R&D variable, foreign investors may select firms with an above average productivity and R&D stock. There is also scope for heteroskedasticity as well as serial correlation. For the OLS estimates the heteroskedasticity-robust t statistics or alternatively time differenced variables with the Prais Winsten estimator may be used. Both the within-firm (within group) estimator and first differencing eliminate unobserved time invariant effects. The within-firm estimator is more efficient if serial correlation is not present.[14] We follow Griffith and Simpson (2001) using a two-step procedure (see Hsiao, 1986) to analyze potential productivity differences between foreign and domestic firms when the nationality is constant. We highlight the potential problem with endogeneity by using a Durbin-Wu-Hausman test (Davidson and MacKinnon (1993)).

[14] Traditionally time invariant omitted variables are solved for by using the within firm (group) estimator directly or by first differencing; but the RHS varible is a dummy (F), so within firm; $(y_{it} - \bar{y}_i) = (F_{it} - \bar{F}_i)\beta + (\varepsilon_{it} - \bar{\varepsilon}_{it}) = f_{it}\beta + v_{it}$; where $0 \leq F_i \leq 1$ is higher the longer the firm is foreign-owned. For all firms that do not change ownership, all $f_{it} = 0$; for firms shifting to foreign-owned, f_{it} shifts from a negative to a positive value, at the time of shift; f_{it} is then constant, but its level depends on the time of the shift. For first differencing; $\triangle\, y_{it} = \triangle\, F_{it} + \triangle\, \varepsilon_{it}$. In this case $\triangle\, F_{it} = 0$ except for the shift year ($\triangle\, F_{it} = 1$).

In this paper, instead of differencing the equations 5 and 7 w.r.t time, we set up a slightly different equation, addressing a different question: Do foreign firms show a higher rate of productivity growth, controlling for R&D expenditures, size of the firms, industry and common time trends. [15]

$$\Delta \ln A_{it} = \beta_0 \ln A_{it-1} + \beta_1 \frac{R_{it}}{Y_{it}} + \beta_2 F_{it} + \beta_3 \Delta \ln L_{it} + \beta_4 \Delta F_{it} \frac{R_{it}}{Y_{it}} + \varepsilon_{it} \tag{8}$$

where $\Delta \ln A_{it} = \ln A_{it} - \ln A_{it-1}, \Delta R_{it} \approx \frac{R_{it}}{Y_{it}}, \Delta \ln L_{it} = \ln L_{it} - \ln L_{it-1}$. Across manufacturing sectors or regions, productivity levels in domestic firms may exhibit "conditional β-convergence". Firms with low initial productivity levels will then exhibit the fastest rates of growth in productivity. A firm behind the industry frontier is expected to either exit or increase its productivity due to increased competition from all other firms, whether foreign or domestic. Firms lagging behind can also be expected to benefit from knowledge spillovers in general and thus increase their productivity, see Barro and Sala-i-Martin (1995). We control for possible productivity convergence effects by means of lagged total factor productivity.

4 Results

4.1 Mean values

We start by answering the question whether foreign-owned firms, on average, are more productive than domestic firms. Table 3 shows differences in mean values between domestic and foreign-owned firms across all manufacturing firms during the whole period. By subtracting unweighted averages for the foreign firms from the corresponding variables of the domestic firms for each variable it seems clear that foreign-owned firms have on average higher labor productivity - measured as value added, deflated by the industry producer price index, per employee - than domestic firms. At the same time, foreign firms are also more human capital intensive - measured by the proportion of employees with more than secondary education - as well as more physical capital intensive (defined as the stock of capital, measured by book value machinery and buildings, per employee). Foreign firms are larger, in terms of number of employees, older and pay higher wages to both low-skilled (not in table) and high-skilled employees. Foreign firms also

[15] Griliches and Licthenberg (1984) suggest that the R&D intensity (instead of expenditures) reflect the changes in the stock of R&D capital. For the US they find a positive relationship between an industry's productivity growth and its R&D intensity.

Table 3: Similarity of mean values 1990-2000

	Mean values			
Variables	Domestic	Foreign	Mean difference	t-statistic
lnLpr	5.79	5.91	-2.14%	-16.20
$\ln\left[\frac{K}{L}\right]$	4.97	5.17	-3.82%	-11.00
$\ln\left[\frac{S}{L}\right]$	0.13	0.17	-25.64%	-22.00
R&D intensities	0.017	0.018	-4.78%	-0.09
ln(employment)	4.86	5.22	-7.34%	-22.60
age	11.10	12.81	-15.00%	12.14
ln(wageHigh)	7.91	8.67	-10.00%	-31.40
Export intensity	0.08	0.17	-113.00%	-28.97
Market share	0.04	0.07	-55.80%	-13.05

Note: The unweighted averages of each variable for the foreign-owned firms are subtracted from that of the domestic firms. The t-statistics for these mean differences are also reported where the hypothesis is Ho: mean(0) - mean(1) = diff = 0 and the alternative Ha: diff $\neq$ 0.

have much larger export (measured by export intensity) and market shares than their domestic counterparts. Turning to R&D intensity, the difference between domestic and foreign firms is not significant.[16]

4.2 The role of foreign ownership for productivity

We now turn to the next question: are the foreign-owned firms more productive, even after controlling for factors that may influence the results. Table 4 shows the regression parameters, estimated by OLS, of Equation 5 explaining the variation across firms and over time in the logarithm of labor productivity, $\ln q_{it}$. Since test indicates heteroskedasticity, the heteroskedasticity-robust t statistics are reported.

In column (2) we have included a dummy for domestically-owned firms with multinational activity in order to isolate the potential importance of international activity per se, as different from nationality.

Note that in all regressions in Table 4, industry and time dummy variables are included, as specified in Equation 5.

Clearly higher skill- and capital intensity as well as R&D expenditure increases labor productivity.[17] Experiments with different lags for the R&D variable do not change the results

[16] T-tests on R&D expenditures, instead of R&D intensities, and the shares of wages to high-skilled, instead of absolute wages to high-skilled, gives similar results.

[17] The Hausman χ^2 test reveals no endogeneity in Tables 4 and 5. The Breusch and Pagan LM test indicates

Table 4: Determinants of labor productivity in Swedish manufacturing.

Dependent variable: $\ln Lpr$	(1)	(2)	(3)	(4)	(5)
Foreign	0.05 (6.10)***	0.05 (6.05)***	0.02 (2.19)**	0.02 (2.24)**	0.07 (1.90)**
Swedish multinationals		0.07 (8.67)***			
$\ln\left[\frac{K}{L}\right]$		0.12 (22.72)***	0.12 (22.68)***	0.12 (22.68)***	0.11 (13.79)***
$\ln\left[\frac{S}{L}\right]$		0.08 (12.32)***	0.08 (13.34)***	0.08 (13.34)***	0.09 (8.57)***
R&D expenditures (t-1)		0.80 (3.59)***	7.89E-08 (3.53)***	8.38E-08 (3.36)***	0.02 (4.35)***
[R&D][foreign](t-1)				-1.80E-08 (-0.46)	-0.94E-2 (-1.98)**
log(size)		0.26 (0.50)	0.01 (2.05)**	0.01 (2.04)**	0.70E-2 (0.76)
No.obs	19964	15759	15759	15759	7701
Sw. MNF premium -over foreign-owned firms (F-test)		0.02 (0.03)**			
Hausman (DWH) χ^2				2.39 (0.12)	
R^2	0.27	0.37	0.36	0.36	0.36
[Industry][foreign](F-test)			15.87***		

Note: OLS estimations heteroskedasticity-robust t-statistics in parenthesis, *** , ** , * significant at the one-, five- and ten percent level. In column (2) we add Swedish MNFs. A F-test of the linear combination of difference between foreign-owned firms and Swedish MNFs concludes that the labor productivity is higher in Swedish MNFs. In column (3) we report the estimates from Equation 5. In column (4) we test the hypothesis that R&D in foreign-owned firms is less important. In column. (5) we estimate Equation 5 using the log of R&D. Unreported time and four-digit industry dummies is always included.

much. While the variable R&D expenditure is positive and significant, the R&D intensity (not reported), i.e. R&D as a share of value added or gross production cost, is not. Our interpretation is that this supports the picture of each firm - irrespective of size - producing one single product, the quality improvement of which depends on the absolute amount of R&D spending and not on the intensity; this stresses the role of R&D as a fixed cost (see Hansson & Lundberg (1995)).

In all regressions in Table 4, the foreign ownership variable is positive and strongly significant. Thus our results indicate that - other things being equal - foreign-owned firms have a productivity

omitted time invariant effects (fixed or random) and thus that a panel estimator is appropriate. The Hausman test for random effects indicates that the fixed effect estimator should be preferred.

advantage over domestic firms in general.

Table 4 has also been estimated by using robust regressions (not reported) where outliers are down-weighted. The previous results are robust with respect to possible effects of outliers.

In column 2 we have separated Swedish multinational from local domestic firms. Since we lack explicit information on the status of being a local versus an multinational Swedish firm we use a proxy. When a firm reports any export to a foreign affiliate we consider it a multinational firm, otherwise a local domestic firm. The results show that both Swedish multinationals and affiliates to foreign MNFs show higher productivity (other things equal) than purely local - non-MNF - domestic firms, so: to be international is important, not nationality per se. A F-test of the linear combination of a potential Swedish MNF premium over foreign-owned firms (from the coefficients in column 2) indicates that labor productivity is higher in Swedish MNFs than in purely local domestic firms. When comparing Swedish multinational firms to domestic local firms in column (2) in Table 4 the premium for being a Swedish multinational is 7% higher labor productivity.

Another result is that the effect on labor productivity of a given increase in R&D seems to be less in foreign-owned firms than in domestic firms, since the interaction variable of R&D with ownership is insignificant in column (4) and negative and significant in column (5). A possible interpretation could be that efficiency and product quality of foreign affiliates in Sweden are more dependent on the R&D efforts of the parent company in the home market than on their own R&D.

In column (5) we use the log of R&D as a check of robustness. If we exclude all firms not reporting any R&D activity, the productivity advantage of foreign ownership increases; it still holds that the marginal effect of R&D is lower in foreign-owned firms. About 1/3 of the sample firms report R&D expenditures.[18] The magnitude of foreign ownership premium, as compared to domestic firms productivity, increases but the size variable becomes insignificant.[19] Foreign firms that report R&D expenditures have significantly higher labor productivity than domestic firms with R&D expenditure, but on the margin the effect of more R&D expenditures is negative in foreign firms.

[18] As a further check of robustness (not reported) we have taken advantage of the whole sample by inputing a small number for firms reporting zero R&D. The results are qualitatively the same as the results in column (5) in Table 4 and 5 for the ownership dummy. The only difference is that the R&D expenditures become insignificant in the TFP regressions.

[19] Different measures of size, e.g. the employment normalized on mean industry employment, do not affect the significance or magnitudes of the parameter estimates.

Table 5: Determinants of total factor productivity in Swedish manufacturing.

Dependent variable: $\ln TFP$	(1)	(2)	(3)	(4)	(5)
Foreign	0.02 (3.24)***	0.04 (5.37)***	0.02 (2.76)***	0.02 (2.75)***	0.11 (3.09)***
Swedish multinationals		0.05 (6.12)***			
R&D expenditures (t-1)		0.60E-8 (4.09)***	6.00E-08 (4.07)***	6.05E-08 (3.36)***	0.82E-2 (2.35)**
[R&D][foreign](t-1)				-2.13E-09 (-0.08)	-0.01 (-2.64)***
log(size)		-0.07 (-6.87)***	-0.50E-2 (-1.66)*	-0.01 (-1.66)*	0.21E-2 (0.34)
No observations	18636	15462	15462	15462	7681
Sw. MNF premium -over foreign-owned firms (F-test)		0.36E-2 (0.46)			
Hausman (DWH) χ^2				4.05 (0.04)**	
R^2	0.83	0.83	0.82	0.83	0.85
[Industry][foreign](F-test)			8.04***		

Note: OLS estimations. heteroskedasticity-robust t statistics in parenthesis, *** , ** , * significant at the one-, five- and ten percent level. In column (2) we add a variable for Swedish MNFs. A F-test of the linear combination of difference between foreign-owned firms and Swedish MNFs rejects the hypothesis of a Swedish MNF premium. In column (3) we report the estimates from eq. 5. In column (4) we test the hypothesis that R&D in foreign-owned firms is less important. In column (5) we estimate Equation 5 using the log of R&D. The OLS estimates reports heteroskedasticity-robust t statistics. Unreported time and four-digit SNI92 industry dummies is always included.

The potential for transfer of knowledge from a foreign MNF to its Swedish affiliates, and therefore the productivity effect of foreign ownership, might be different in different industries. To explore this possibility we computed a set of interaction variables as the product of the foreign ownership dummy and the industry dummy.

$$H_{it} = \lambda_j F_{it}$$

where λ_j is the industry 4-digit code. The interaction variable has been added to the equation in column (3) in Tables 4 and 5. The null hypothesis – that the coefficients of the whole set of these variables are jointly zero – is rejected, which means that the effect of foreign ownership on labor productivity is not the same for all industries. A possible interpretation is that the extent of firm-specific advantages – superior technical or commercial know-how – of the MNFs, to local firms, is more important in some industries than in others. Table 5 shows the effects of foreign ownership

directly on the calculated TFP of the firm, corresponding to A_{it} in Equation 7. From the OLS results in Table 5 it is evident that the previous results with regard to ownership premium in labor productivity estimations (4) are robust. Controlling for firm and industry characteristics affecting productivity, foreign-owned firms seem to have a productivity edge over domestic firms. This result is quite stable and does not depend on the measurement of productivity (labor productivity or TFP) nor on the measurement of other variables or the estimation technique. Again, when comparing firms with R&D expenditures in column 5 the magnitude of foreign ownership is stronger when taking the log of R&D expenditures.

4.3 The role of initial productivity for acquisition by a foreign MNF

If foreign investors select domestic firms with an above-average productivity, our main conclusions so far could be wrong. The causal interpretation and the validity of the results depend on the direction of the effects. We use the instrumental variable approach to perform a Durbin Wu Hausman (DWH) test of endogeneity, Davidson and MacKinnon (1993). From Table 3 it was evident that foreign-owned firms are older and larger. By using firm age, size (squared) and regional dummies, we instrument for foreign ownership.

The probit model allows estimations of the dichotomous (0-1 left hand variable) foreign ownership. The estimated errors from the probits is used in the DWH tests. In the first two columns in Table 6 we show the probit estimates of the reduced form equations for the (endogenous) explanatory variable "foreign ownership", based on Equation 5 and 7 respectively. The estimated coefficients for the instruments age and the region dummy is strongly significant according to the z-values and the F-tests in column (1) and (2). The DWH tests cannot reject the null, i.e. that foreign ownership is exogenous.

An alternative methodology is to estimate the probability of being taken over by foreign owners during the period 1990-2000. For this we select the within-sample 385 foreign takeovers during the period and firms that were always domestically owned. Girma and Görg (2003) use age and age square, size and size square to test the hypothesis that these trajectories influence the probability of being acquired by a foreign owner. Lichtenberg and Siegel (1987) estimate ownership changes on US plant level data using firm size (log of employment) and initial productivity. McGuckin & Nguyen (1993) estimate a function similar to Licthenberg and Siegel on US firm data but also include small firms and allow for non-linearities and employment normalized

by industry. They find, in contrast to Lichtenberg and Siegel, that initial productivity indeed affects the probability of a firm being acquired. Criscuolo and Martin (2003), for the UK did however find evidence that the US advantage in the UK lies in the ability to take over already productive plants.

Table 6: Determinants of foreign ownership and foreign acquisitions

Dependent variable:	foreign-owned	foreign-owned	Foreign acquisition
$\ln\left[\frac{S}{L}\right]$	0.19 (6.91)***		-0.04$_{(t-2)}$ (-0.66)
$\ln\left[\frac{K}{L}\right]$	0.03 (1.96)**		0.11$_{(t-2)}$ (2.48)**
ln(size)	0.17 (9.62)***	0.17 (10.42)***	0.12$_{(t-2)}$ (2.25)**
R&D expenditures$_{(t-1)}$	-0.15E-8 (-2.63)***	-0.13E-8 (-2.43)**	0.57E-8$_{(t-2)}$ (0.05)
market4share			0.07$_{(t-2)}$ (0.22)
relTFP$_{ijt-2}$			0.57$_{(t-2)}$ (1.59)
relLpr$_{ijt-2}$			-1.41$_{(t-2)}$ (-2.61)***
age	0.98E-2 (4.98)***	0.01 (5.72)***	0.61E-2 (1.11)
size^2	-0.43E-7 (-1.27)	-0.49E-7 (-1.49)	
Region dummy	F = 1308.61	F= 1338.95	F=1571.44
Log likelihood	-5627.25	-5738.58	-843.39
Number of observations	13793	14036	5853
Pseudo R2	0.30	0.30	0.22

Note: Dependent variable in column (1) and (2) is the reduced form predictions used to instrument for the foreign ownership dummy. Instruments are age, size square and a region dummy. In column (3) the dependent variable is the acquisition year. z-values within parenthesis. Unreported time and industry (four digit SNI92) is always included. In column (3) we test the hypothesis that foreign firms acquire domestic firms with above average relative productivity, market share and exports.

We test the hypothesis that important determinants of firm acquisitions are the educational- and capital status in the firm as well as firm size, age, market share, industry and the region within which the firm operates. The level of R&D expenditures does not differ between foreign and domestic firms according to Table 3 and we expect R&D expenditures to have little (if any) impact on the probability of being acquired.

According to the matching theory of Licthenberg and Siegel, firms with a low level of productivity are more likely to be acquired than firms with a high productivity and thus we should expect a negative relation between initial productivity and the probability of being acquired. From Table 6 (column 3) it is evident that historical values of capital intensity, ln(size) (in terms of the absolute number of employees) positively affects the probability of being acquired by a foreign investor. Relative total factor productivity, R&D expenditure and market share have, on the other hand, no effect on the probability of being acquired, while relative labor productivity negatively effects the probability of being acquired.[20]

These results also confirm the results from a similar study of foreign acquisitions in Swedish manufacturing during the period 1985-1994 by Modén (1998). Modén concluded that acquired firms were not of a higher than average productivity type (in terms of both labor- and total factor productivity) and that the incidence of being acquired was not dependent upon the R&D spending.

4.4 The effects of ownership on the rate of growth of productivity

Since we found no evidence of reverse causality, we expect the rate of growth in productivity to be higher in foreign-owned firms. In Table 7 given R&D and controlling for time and industry effects, foreign-owned firms have a higher rate of growth in both labor and total factor productivity than domestic firms.

Lagged productivity is negatively related to the growth in productivity. The results thus give strong support for the hypothesis of β-convergence in labor productivity as well as total factor productivity.[21]

A higher rate of growth in capital intensity and a higher R&D intensity increases the rate of growth in labor productivity, while the rate of change in skill intensity has no significant effect. Larger firms have slower rate of growth as compared to smaller firms. When standardizing by industry (in column (2) and (4)) the magnitude and significance of foreign ownership weakens, but remains significant at the 10% level.

[20] Not reported, but with very similar results, are separate estimates with labor productivity, and total factor productivity. Furthermore estimates with relative productivity defined at different industry aggregations gave qualitatively the same results.

[21] To deal with serial correlation due to the lagged dependent variable (among others), and panel heteroskedasticity in Table 7, we use panel corrected standard errors (PCSE's). Though not reported, the corrected estimates are even more significant than the reported estimates.

Table 7: Determinants for the growth in productivity in Swedish manufacturing.

Dependent variable:	$\triangle \ln Lpr$	$\triangle \ln Lpr$	$\triangle \ln TFP$	$\triangle \ln TFP$
$\triangle \ln\left[\frac{K}{L}\right]$	0.01 (2.18)**	0.01 (1.96)*		
$\triangle \ln\left[\frac{S}{L}\right]$	-0.93E-2 (-0.99)	-0.60E-2 (-0.67)		
R&D intensities $_{t-2}$	0.85E-2 (2.27)**	0.87E-2 (2.41)**	0.40E-2 (2.90)***	0.38E-2 (2.67)***
$\triangle$ln(size)	-0.05 (-1.76)*	-0.03 (-1.21)	-0.06 (-4.70)***	-0.06 (-4.84)***
Foreign	0.03 (5.10)***	0.02 (3.50)***	0.01 (3.29)**	0.80E-2 (1.78)*
lnLpr $_{t-1}$	-0.24 (-9.97)***	-0.36 (-12.3)***		
lnTFP $_{t-1}$			-0.05 (-8.21)***	-0.19 (-13.17)***
Number of observations	12715	12715	12472	12472
Industry (four-digit)	No	Yes***	No	Yes***
R^2	0.14	0.24	0.28	0.36

Note: Prais-Winsten regression, heteroskedastic panels corrected t-values in parenthesis. Unreported time dummies is always included. *** , ** , * significant at the one-, five- and ten percent level. We use lagged productivity in levels as a measure of convergence.

4.5 Mode of entry

The previous results indicate that there is indeed a productivity premium for multinational firms. As was evident in Table 1 the foreign greenfields in Sweden constitute only 20 percent of all foreign firms. Could it be that the greenfield operations are the most productive and dominantly drive the previous results? Caves (1982) analyze different entry modes. Greenfield operations are expected to be more risky than takeovers, due to the lack of information on the new market. Svensson (1996) suggests on the other hand, that a new venture, as opposed to an acquisition, can be tailor-made to fit the existing organization in the parent company. In an acquired firm, the existing assets have to be adapted to the interests of the parent, which may be difficult (especially for small firms). The acquisition price will then be high and the expected rate of return low.

In a study by Modén et al. (2004) for Poland it was found that foreign greenfields have the highest labor productivity while foreign privatizations show the largest productivity increase.

Table 8: Differences in productivity by mode of foreign entry.

	lnLpr		lnTFP	
Dependent variables:.	(1)	(2)	(3)	(4)
Foreign. greenfields	0.03 (2.20)**	0.07 (4.49)***	0.04 (3.16)***	0.07 (4.77)***
Foreign other	0.01 (1.69)*	0.05 (5.44***	0.01 (1.94)**	0.04 (4.54)***
Swedish. multinationals		0.07 (8.66)***		0.05 (6.11)***
$\ln\left[\frac{S}{L}\right]$	0.08 (13.33)***	0.08 (12.34)***		
$\ln\left[\frac{S}{L}\right]$	0.12 (22.68)***	0.12 (22.72)***		
R&D (t-1)	0.79E-9 (3.54)***	0.80E-09 (3.60)***	0.60E-9 (4.09) ***	0.60E-09 (4.11)***
log(size)	0.01 (2.06)**	0.26E-2 (0.51)	-0.57E-2 (-1.63)	-0.01 (-3.01)***
Number of observations	15759	15759	15462	15462
R^2	0.36	0.36	0.83	0.83

Note: Estimates of Equations 5 and 7. Huber-White corrected t-values in parenthesis. *** , ** , * significant at the one-, five- and ten percent level. Unreported time and four-digit industry dummies is always included. In columns (1) & (2) the dependent variable is log real value added per employee. In columns (3) & (4) the dependent variable is log total factor productivity.

We can separate foreign greenfields from foreign acquisitions in our data. To investigate the relative importance of foreign greenfields, we reestimate Equation 5 and Equation 7 where we differentiate foreign-owned firms by mode of entry.

We performed several tests of linear combinations based on the results from Table 8.The tests indicate that there is no significant difference between greenfields and other foreign-owned firms w.r.t labor productivity. There is a difference, though, between greenfield and other modes of foreign entry in the total factor productivity estimations in column (3) and (4), i.e. greenfields operations have higher total factor productivity than acquired firms. Finally, when comparing foreign greenfields and Swedish multinationals we find no significant difference w.r.t labor or total factor productivity

4.6 Within-firm estimates

We assume firm specific heterogeneity and its necessary to control for unobservables, e.g. the quality of the labor and capital. In order to eliminate unobserved firm effects due to a firm-specific variable that vary across firms but not over time, Griffith & Simpson (2001) use a two step method suggested by Hsiao (1986). In the first stage the within firm-estimator is applied on the productivity equations using only firms with constant nationality that we observe five or more times. In the next step the predicted (and then by calculating the mean over time) residuals $\overline{\hat{\eta}_i + \hat{e}_{it}}$ are regressed on the foreign ownership dummy F_{it} using OLS. For firms that change

Table 9: Within firm estimates

Dependent variable	lnLpr	lnTFP	lnLpr	lnTFP
First stage estimates:				
Foreign			0.60E-2	0.05
			(0.45)	(3.10)***
$\ln\left[\frac{K}{L}\right]$	0.04		0.04	
	(7.77)***		(8.00)***	
$\ln\left[\frac{S}{L}\right]$	-0.03		-0.97E-2	
	(-3.74)***		(-1.04)	
R&D Expenditures	0.13E-8	0.63E-9	0.89E-9	0.61E-9
	(9.96)***	(4.17)***	(7.89)***	(4.95***
ln(size)	-0.89E-2	-0.10	0.21E-2	-0.09
	(-0.76)	(-7.07)***	(0.19)	(-7.37)***
age	0.03	0.09	0.03	0.09
	(15.97)***	(40.42)***	(14.19)***	(44.01)***
age^2	-0.32E-2	-0.75E-4	-0.22E-3	-0.56E-4
	(-5.77)***	(-1.14)	(-4.08)***	(-0.91)
Number of observations	12566	12212	16965	16162
Year	Yes	Yes	Yes	Yes
Within firm estimates	Yes	Yes	Yes	Yes
Second stage estimates:				
Dependent variable	$\overline{\hat{\eta}_i + \hat{e}_{it}}$	$\overline{\hat{\eta}_i + \hat{e}_{it}}$		
Foreign	0.03	0.09		
	(2.49)**	(2.22)**		
Number of observations	1819	1825		

Note: In column (1) & (2) the two step procedure is applied on firms with constant nationality. In the top half of the table the within estimator is applied on lnLpr and lnTFP. In the next step the residuals are regressed on the foreign ownership dummy by using OLS. In column (3) & (4) the within estimator is applied on firms changing nationality and domestic firms with constant nationality.

nationality we apply the within firm estimator directly. We have estimated specifications similar to those of Griffith & Simpson as complements to Equations 5 and 7, in Table 9. Following Griffith & Simpson and adding age and age square variable to 5 and 7 we reduce some of the predicted residuals from the first step. In contrast to Griffith and Simpson we also include domestic firms with constant nationality when we estimate the within estimator on firms changing nationality in order to compare firms that become foreign with those that remain domestic in Table 9.

When we consider unobservable differences in firms with constant nationality, again, a higher capital intensity increases labor productivity, but skill intensity is now negatively related to labor productivity. One possible explanation could be a pro-cyclical pattern in skill intensity; if firms are more likely to reduce blue collar (than white collar) workers during recessions, we will observe a negative relation between skill intensity and labor productivity. The coefficients for the ownership premium are higher both in terms of labor and total factor productivity, as compared to previous OLS results in Table 4 and 5. For the group of firms that change nationality, we consider the same variables as for the firms that had constant nationality. The ownership dummy now illustrates the difference in the level of productivity in firms that change nationality as compared to domestic firms with constant nationality and firms that became domestically-owned during the period. The results suggest that firms changing nationality have a higher level of productivity after the ownership change, as compared to firms that were always (or became) domestic.

5 Conclusion

The study uses data for all firms in the Swedish manufacturing industry with more than 50 employees for the period 1990-2000, a period during which foreign ownership increased strongly. It was found that the variation in labor productivity across Swedish manufacturing firms is explained by differences in capital intensity, skill intensity and R&D-activity. Given the values of the control variables, however, productivity is also affected by ownership. On average, foreign firms seem to have a 2 to 7 percent productivity advantage over domestic firms. The same results hold when productivity is measured by total factor productivity.

Another finding is that the effect on productivity of a given increase in R&D seems to be lower in foreign-owned firms, presumably because the R&D of the foreign-owned firms may be of a different kind, e.g. mainly for adapting products of the parent MNF to a national market. By

using the reduced form predictions to perform a Durbin-Wu-Hausman test, we find no evidence for endogeneity of the ownership variable. Moreover, the probability for a domestic firm of being acquired by a foreign MNF does not depend on its initial relative productivity (but on firm capital intensity and size). Another result is that the rate of growth in labor and total factor productivity is shown to be higher in foreign-owned firms. By controlling for unobservables, the within-firm estimates suggest that the estimated foreign ownership premium in firms with constant nationality is 3% and 9% respectively for labor and total factor productivity, and 0.5% and 5% for firms changing nationality. We also conclude that the difference between foreign and domestic firms varies between different sectors. Given these results there should, for example, be scope for positive effects of foreign presence on the productivity of domestic firms through various channels including knowledge spillovers.

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6 Appendix

6.1 Total factor productivity

Gunnarsson and Mellander (2001) provide evidence on the importance of using disaggregated data when constructing a productivity measurement. We assume that deflated sales value, Y, is produced using four factors of production; capital K, skilled labor S, unskilled labor U, and intermediate goods M. We assume a general production function

$$Y_{it} = A_{it}F(K_{it}, S_{it}, U_{it}, M_{it})$$

where A_{it} is a Hicks neutral efficiency parameter measuring total factor productivity. As a first step in constructing a total factor productivity index one has to choose a functional form. The Cobb-Douglas production function assumes that all inputs are substitutes, whereas the Translog allows for complementarity between inputs. We use the Divisia Törnqvist index in order calculate changes in the input mix.[22] This index is based on a Translog production function. We calculate TFP as the ratio of deflated sales value to an index of input volumes (a Törnqvist quantity index of inputs).[23]

$$TFP_t = \frac{Y_t}{f(X_{1t}, ..., X_{nt})}$$

or put differently

$$\ln TFP_t = \ln Y_t - \ln X_t$$

similarly, the growth in TFP:

$$\triangle \ln TFP_t = \triangle \ln Y_t - \triangle \ln X_t$$

An important assumption in the calculations is that time is continuos. The majority of economic data is however not continuous and therefore a discrete approximation is often used, e.g. the Divisia index. In the Törnqvist (1936) index the weights used to aggregate the inputs are simply arithmetic averages of the corresponding cost shares in periods $t-1$ an t i.e. average cost share

$$\varpi_{it} = \frac{1}{2}\left(\frac{P_{i,t-1}X_{i,t-1}}{\sum_{K=1}^{n} P_{k,t-1}X_{k,t-1}} + \frac{P_{i,t}X_{i,t}}{\sum_{K=1}^{n} P_{k,t}X_{k,t}}\right)$$

[22] This index fulfills important properties such as invariance and independence, se e.g. Diewert ([9], [10]).

[23] Harper, Berndt & Wood [23], Gunnarsson och Mellander [18].

We calculate rental prices for capital separately for machinery and buildings, see Gunnarsson & Mellander (2001), Harper Berndt & Wood (1989), according to

$$P_{K,t} = P_{I,t-1}\left[r_t + \bar{\delta}_K + (\bar{\delta}_K - 1)\frac{P_{I,t-1}}{P_{I,t-2}}\right]$$

where $P_{K,t}$ is rental price for capital, $P_{I,t-1}$is the appropriate investment price index, r is the nominal long term interest rate, $\bar{\delta}_K$ is the average rate of depreciation.

6.2 Tables

Table 10: Description of variables

Variable name	Description
R&D	Deflated R&D expenditure in SEK, from the Financial Statistics.
Lpr	Value added, deflated by the industry producer price index, per employee.
relTFP$_{ijt}$ & relLpr$_{ijt}$	Relative TFP & relative Lpr: Productivity of the ith firm relative to average productivity, in industry j (four-digit) at time t.
export intensity	Export as a share of total output.
$\frac{K}{L}$	The deflated book value stock of capital over total employment.
$\frac{S}{L}$	The percentage share of employees with a post-secondary education.
market4share	Sales in firm i relative to total sales in the industry at the four digit level.
Y	Sales.
size	Firm size, measured as employment of the ith firm.
industry dummy	Industry dummies defined at four-digit level.
Year	Yearly time dummies.
F	Takes the value 1 if firm i is a foreign-owned firm and 0 otherwise.
age	Age of the firm, truncated at 1973 (from the FIEF database).
region	Local municipality (kommun) in Sweden (290 in total)

Table 11: Foreign ownership. In percentage of total employment in each industry 1990 and 2000

SNI92 industry codes		1990	2000
15	Manufacture of food products and beverages	19.5	30.0
16	Tobacco products	0	49.8
17	Textiles	14.8	23.6
18	Wearing apparel	1.1	13.9
19	Luggage, handbags and footwear	2.1	3.3
20	Wood and products of wood and cork	5.3	13.6
21	Pulp, paper and paper products	14.7	34.0
22	Publishing, printing and reproduction	4.2	10.2
23	Manufacture of coke and refined petroleum	20.6	82.0
24	Chemicals, chemical products and man-made fibres	27.6	74.6
25	Rubber and plastic products	24.4	23.4
26	Non metallic mineral products	32.1	50.2
27	Basic metals	8.8	27.1
28	Fabricated metal products	13.8	9.9
29	Machinery and equipment	26.1	33.3
30	Electrical and optical equipment	38.3	20.4
31	Electrical machinery and apparatus	42.8	30.1
32	Radio, television and communication equipment and apparatus	27.8	17.4
33	Medical, precision and optical instruments, watches and clocks	23.6	32.1
34	Motor vehicles, trailers and semitrailers	6.2	50.6
35	Other transport equipment	6.6	22.5
36	Other manufacturing	12.7	10.1
	Total manufacturing industry SNI92: 2 digit 15-36	16.9	27.5

Table 12: Foreign ownership in percent of total employment by county 1990 and 2000

Counties:		1990	2000
1	Stockholms län	16.9	28.5
3	Uppsala län	21.0	7.1
4	Södermanlands län	25.2	21.4
5	Östergötlands län	30.7	28.6
6	Jönköpings län	10.4	16.8
7	Kronobergs län	10.5	15.7
8	Kalmar län	19.5	25.2
9	Gotlands län	0	3.0
10	Blekinge län	13.7	54.9
12	Skåne län	20.4	31.5
13	Hallands län	16.7	20.8
14	Västra Götalands län	18.1	31.9
17	Värmlands län	19.6	37.9
18	Örebro län	18.6	27.9
19	Västmanlands län	43.2	34.9
20	Dalarnas län	6.5	36.9
21	Gävleborgs län	10.3	12.6
22	Västernorrlands län	19.5	23.7
23	Jämtlands län	8.2	0.4
24	Västerbottens län	12.1	9.8
25	Norrbottens län	5.4	2.6