Foreign Firms and Host-Country Productivity: Does the Mode of Entry Matter?*

Ragnhild Balsvik† Stefanie A. Haller‡

6 January 2006

Abstract

Foreign direct investment is often considered an important source of knowledge spillovers. However, results from the empirical literature relating overall foreign presence to host country productivity are ambiguous. We argue that this may be because different modes of entry may have different effects on productivity. Using 24 years of comprehensive panel data for Norwegian Manufacturing, we find that greenfield entry has a negative impact on the productivity growth of domestic plants, while entry via acquisition affects local productivity positively. The net effect is a small positive effect of an overall change in foreign presence on local productivity growth.

Keywords: mode of foreign entry, productivity growth, competition, spillover effects

JEL Classification: D24, L1, F21

*We are grateful for valuable comments from and discussions with Carlo Altomonte, Davide Castellani, Chiara Criscuolo, Holger Görg, Lisa Lynch, Jarle Møen, Øivind Anti Nilsen, Kjell Gunnar Salvanes, Fabio Schiantarelli and seminar participants at the Nordic International Trade Seminars in Helsinki, 2005. All remaining errors are our own.

†Norwegian School of Economics and Business Administration, Helleveien 30, 5045 Bergen, Norway; email: ragnhild.balsvik@nhh.no

‡Economics Department, European University Institute, Via della Piazzuola 43, 50133 Firenze, Italy; email: stefanie.haller@iue.it

1 Introduction

A large empirical literature has examined whether foreign presence in an industry gives rise to productivity spillovers to local firms in the same industry. A recent survey by Görg and Greenaway (2004) suggests that the literature on so-called intra-industry spillovers has not come up with a clear-cut answer.[1] A reason put forward is that multinational enterprises (MNEs), in addition to being potential sources of knowledge spillovers, are potential sources of competition. While a positive effect of foreign presence on host country firms is usually interpreted as evidence of knowledge diffusion or technology transfer, the possibility that competition could also be at work when a positive spillover effect is observed is often overlooked. Entry of new and efficient firms that increase product market competition, may enhance productivity in domestic firms by forcing them to reduce x-inefficiencies or to adopt new technologies faster than they otherwise would. Bartelsman et al. (2004) provide evidence of this Schumpeterian argument for a number of developed and developing countries; they find a positive correlation between turnover rates and productivity growth of incumbents. More directly, Aghion et al. (2005) demonstrate that foreign entry in the UK increases the incentives of firms to innovate in order to survive the increased competition. Of course, such a positive impact of foreign competition on host country firms may take time to materialise, see Sembenelli and Siotis (2005) for evidence from Spain. In the short run at least, foreign firms are equally likely to steal market shares from domestic firms and, thereby, force them up their average cost curves. This implies that the measured productivity of domestic firms will be lower and we will observe a negative effect from foreign entry (Aitken and Harrison (1999)).

Traditionally, the spillover-literature has measured foreign presence as the share of industry employment in foreign-owned firms, which represents the accumulated foreign direct investments (FDI) in the sector. This measure combines new foreign entrants with foreign-owned firms that have been in the market for some time. We argue that a change in competitive pressure due to foreign presence should primarily come from new foreign entrants, and not from foreign-owned firms that have already established their position in a sector. In turn, if knowledge externalities take time to materialise, spillovers are more likely to originate from foreign firms that have been in the market for a while. Our argument implies that the estimated effects of overall

[1] Among more recent studies, Aitken and Harrison (1999) find a negative effect for Venezuela, as does Konings (2001) for Poland, Bulgaria and Romania, and Djankov and Hoeckman (2000) for the Czech republic. On the other hand Haskel et al. (2002) and Keller and Yeaple (2002) find evidence of positive spillovers for the UK and the US, respectively.

foreign presence on domestic productivity could conceal very different effects from new foreign entrants and existing foreign firms. To investigate this, we decompose the usual measure of foreign presence into one term representing the existing foreign-owned firms in a sector and another term representing the new foreign entrants. Once we focus explicitly on the recent foreign entrants, we are also able to take account of the fact that foreign ownership can come about either by greenfield entry or by foreign acquisition of assets in existing domestic firms.

There are several reasons to suggest that the competition effect of foreign entry and the potential for spillovers from foreign entry may differ according to the mode of entry. We address differences in the potential for spillovers first. On the one hand, domestic firms acquired by foreign owners are likely to be more integrated in the host country economy than greenfield entrants; hence, the existing linkages with other local firms may serve as a channel for spillovers. On the other hand, if the most efficient foreign investors are more likely to choose greenfield entry[2], the new knowledge stock that forms the basis for potential spillovers may be larger with greenfield entry than with foreign acquisitions. Regarding possible competition effects, the likely differences between greenfield and acquisition entry derive from the way these two alternatives affect industry market structure.[3] While greenfield entry increases production capacity and therefore also competition, acquisitions do not necessarily have an immediate impact on market structure. Moreover, competition or efficiency-enhancing effects may take longer to materialise if an acquisition involves substantial restructuring in the acquired plant.

Our aim in this paper is to investigate whether the mode of foreign entry matters for the effects FDI has on host country firms. The approach is in the spirit of the spillover literature, where there have not been studies distinguishing between the recent foreign entrants and the existing foreign firms or between different modes of entry. There have, however, been previous efforts to refine the spillover question by splitting FDI into different subgroups. One example is studies examining whether the degree of ownership matters for the extent of spillovers from FDI (e.g. Blomström and Sjöholm (1999), Dimelis and Louri (2002) and Smarzynska Javorcik and Spatareanu (2003)). Another example are efforts to distinguish between technology sourcing and technology exploitation as motives for FDI (Driffield and Love (2002), Driffield et al. (2005)).[4] And finally, Castellani and Zanfei (2005) look into the importance

[2]See Smarzynska Javorcik and Saggi (2004) for a theoretical argument and empirical evidence.

[3]See e.g. UNCTAD (2000, p.145) for an informal description and Haller (2005) for a more formal exposition.

[4]The argument that the motivation for FDI may matter for spillovers goes back to

of firm heterogeneity in terms of the markets they serve for generating and absorbing spillovers.

We use a large panel data set of Norwegian manufacturing industries for the period 1978-2001. Our results from estimating an augmented production function suggest that a change in foreign presence measured as the change in the share of overall employment in foreign-owned plants relative to total employment in a sector, has a significant but small positive effect on the productivity growth of domestic firms in low-concentration sectors. When we specifically account for the change in foreign presence due to both greenfield entry and foreign acquisitions, we find opposite effects of the two modes of entry. The impact of greenfield entry on domestic productivity growth is negative and seems to be caused by domestic plants not adjusting their use of inputs (in particular labour) when reducing their output due to market share losses. Thus, greenfield entry can be associated with a negative competition effect. In contrast, we find a positive and significant effect of foreign acquisitions in low-concentration sectors. This suggests that existing linkages between the acquired plant and other domestic plants may facilitate knowledge spillovers. There seems to be no effect of recent foreign entry on the productivity growth of domestic plants in high-concentration sectors. Our results are robust to a number of different specifications.

The remainder of this paper is structured as follows. In Section 2 we discuss our strategy for estimating the impact from greenfield entry and entry by acquisition on the productivity of domestic firms. In Section 3 we describe the data sources and give an overview of the development of foreign ownership and foreign entry in Norwegian manufacturing. We present our results in Section 4, and examine their robustness in Section 5. Section 6 briefly concludes.

2 Empirical specification

In order to examine the impact of foreign presence and different modes of foreign entry on the productivity of domestic firms, we use an approach commonly adopted in the spillover literature and start with an augmented

Fosfuri and Motta (1999), who demonstrate in a theoretical model that MNEs without firm specific advantages may have technology sourcing motives for FDI. If technology sourcing is the motive for FDI, one should not expect spillovers.

production function of the following form

$$\ln Y_{it} = \beta_K \ln K_{it} + \beta_M \ln M_{it} + \beta_H \ln H_{it} + \sum_{k=0}^{T} \beta^k FP_{I,t-k} + \gamma \mathbf{Z}_{it} + \upsilon_i + \upsilon_t + \varepsilon_{it}. \tag{1}$$

In equation (1) $\ln Y$, $\ln K$, $\ln M$, and $\ln H$ are the natural logs of output, capital, hours and materials in plant i, year t.[5] $FP_{I,t-k}$ captures foreign presence at the 5-digit industry level and $\mathbf{Z}$ includes a set of competition variables. υ_i and υ_t are plant and time specific effects.

We employ a set of variables similar to those first proposed by Nickell (1996) to control for competition. These include industry concentration ($CR5_{It}$), market share (MS_{it}), profit margin (PM_{it}) and a measure of openness ($OPEN_{It}$). As our concentration measure we use the sum of market shares of the five largest plants defined at the 5-digit industry level.[6] Technological differences across industries imply very different requirements in terms of size and scale for firms to be able to operate in their respective environments, see Sutton (1996). High market shares, therefore, need not indicate a lack of competition. However, as argued by Nickell (1996), changes in market structure over time are still going to be reasonably good measures of changes in competition. The profit margin measure (PM_{it}) is thought to capture possible rents that may be available to shareholders and workers in the form of higher pay and lower effort. The expected signs on the concentration measure, market share and profit margin are negative: higher profit margins allow scope for lower effort and thus lower productivity, and higher market shares or concentration ratios are associated with lower effort and productivity levels. As higher efficiency would raise both profit margins and market shares, these variables are potentially endogenous, which could result in positive coefficients. We follow Haskel et al. (2002) and Disney et al. (2004) and address this problem by lagging both measures. We use one-period lags and note that endogeneity gives rise to an upward bias in the estimated coefficients. The variable $OPEN_{It}$ is defined as imports over the sum of exports and imports, and the idea is that increased import competition acts as a disciplining force that has a positive effect on productivity.[7]

[5] The definitions of input and output rely to a large extent on previous work with this data, e.g. Griliches and Ringstad (1971), Simpson (1994), Møen (1998) and Klette (1999). For the construction of all variables, see the variable definitions in the Appendix.

[6] We have 132 5-digit sectors in our estimations.

[7] Due to data limitations, $OPEN_{It}$ is defined at the 3-digit industry level. We also experimented with the import penetration ratio (imports divided by domestic consumption) as an alternative measure, and our results are not sensitive to which measure of

Bartelsman et al. (2004) find a positive correlation between turnover rates and productivity growth of incumbents, which suggests that industries with a high turnover of firms are characterised by higher productivity. Thus, as an additional control variable we use the sum of entry and exit rates as a measure of gross turnover in the industry ($Turnover_{It}$). We also lag this variable by one period due to possible endogeneity. Turnover is also likely to be a good measure of industry-specific business cycles since entry and exit are closely correlated with the business cycle.

In equation (1), FP_{It} is the variable of main interest. In line with the previous spillover literature, in our first specification we take the variable to represent the overall stock of foreign presence measured as the share of industry employment in foreign-owned plants at the 5-digit ISIC level:

$$FP_{It} = \frac{\sum_{i \in FO_{It}} (Empl)_{it}}{(Total\ empl)_{It}}, \tag{2}$$

where FO_{It} is the set of all foreign-owned plants in sector I, year t. As the effects from foreign presence may take time to materialise, we include 2 lags of foreign presence in our estimations. We experimented with different lag structures; more than two lags were not significant in any of our regressions.

To eliminate plant and industry specific effects we estimate equation (1) in first differences[8], thus our regression equation is

$$\begin{aligned} \Delta \ln Y_{it} = {} & \alpha_K \Delta \ln K_{it} + \alpha_M \Delta \ln M_{it} + \alpha_H \Delta \ln H_{it} \\ & + \sum_{k=0}^{2} \beta_1^k \Delta FP_{I,t-k} + \gamma_1 \Delta MS_{i,t-1} + \gamma_2 \Delta PM_{i,t-1} \\ & + \gamma_3 \Delta CR5_{I,t} + \gamma_4 \Delta OPEN_{I,t} + \gamma_5 Turnover_{I,t-1} \\ & + \upsilon_t + \xi_{it}. \end{aligned} \tag{3}$$

import competition we use. We feel more comfortable using $OPEN_{It}$ as we do not need to combine different data sources for its construction.

[8]An alternative method to eliminate unobserved plant specific effects is to use fixed effects estimation (within-transformation). The choice between these estimation strategies hinges on the properties of the idiosyncratic error term in equation (1). Fixed effects is efficient if the idiosyncratic error terms are not serially correlated, which implies that the within-transformed error terms should be negatively correlated. The residuals (excluding the plant specific effect) from a fixed effects estimation of (1) exhibit positive autocorrelation with an estimated ρ of 0.37. First differencing is efficient if the first-differenced error terms are not serially correlated. In our case, the residuals from the first-differenced equation (3) exhibit weak negative serial correlation with an estimated ρ of -0.17. These properties of the residuals support the choice of using first differences as our method of eliminating plant specific effects.

We estimate equation (3) on the sample of firms that are Norwegian owned throughout their presence in our panel. In all our regressions, we include year dummies to control for common year specific shocks to all manufacturing plants, and industry dummies (3-digit level) to account for industry specific linear time trends in the levels of the dependent variable.

ΔFP_{It} represents the change in foreign presence in the industry from $t-1$ to t given as

$$\Delta FP_{It} = \frac{\sum\limits_{i \in FO_{It}} (Empl)_{it}}{(Total\ empl)_{It}} - \frac{\sum\limits_{i \in FO_{I,t-1}} (Empl)_{i,t-1}}{(Total\ empl)_{I,t-1}}, \tag{4}$$

where FO_{It} is the set of foreign-owned plants in industry I at time t. A change in foreign presence can come about by greenfield entry of foreign plants, foreign acquisitions, employment expansion or contraction in existing foreign-owned firms, and also by withdrawal of foreign-owned firms through divestures or plant closures. To the extent that the effect of recent entrants is different from that of long established foreign-owned firms, empirical studies of spillovers from FDI which use the overall foreign presence measure may generate ambiguous results because the measure is a combination of these different causes of change in foreign presence. In particular, when discussing the possible competition effects of FDI, we argue that one should pay attention to the recent foreign entrants. Sembenelli and Siotis (2005), in their analysis of the effect of FDI on the price cost margins of Spanish firms, interpret the negative short-term effects of foreign presence as a competition effect and longer-term positive effects as spillovers. As their measure of foreign presence captures the stock of FDI in the sector, they are not able to explicitly identify the impact of the recent foreign entrants. The same caveat applies to Aghion et al. (2004): in their study of entry and productivity growth in the UK, they associate foreign entry with the first difference of overall foreign presence.

Thus, in our second specification we proceed to isolate the impact of the recent foreign entrants on the productivity of domestic plants. Although the overall change in foreign presence ΔFP_{It} could be caused by many factors, we focus here on greenfield and acquisition entry, and group the remaining possible changes into one term. The set of foreign-owned firms FO_{It} at time t can be split into the sets of greenfield entrants (GE_{It}), acquisition entrants (AE_{It}), and the set of remaining foreign-owned plants that have been present in the sector for at least one year ($FO1_{It}$), thus $FO_{It} = GE_{It} \cup AE_{It} \cup FO1_{It}$. Using these definitions of the different groups of foreign plants in year t, we can rewrite equation (4) in the following way

$$\Delta FP_{It} = \frac{\sum\limits_{i \in GE_{It}} (Empl)_{it}}{(Total\ empl)_{It}} + \frac{\sum\limits_{i \in AE_{It}} (Empl)_{it}}{(Total\ empl)_{It}} \tag{5}$$
$$+ \left(\frac{\sum\limits_{i \in FO1_{It}} (Empl)_{it}}{(Total\ empl)_{It}} - \frac{\sum\limits_{i \in FO_{I,t-1}} (Empl)_{i,t-1}}{(Total\ empl)_{I,t-1}} \right)$$
$$\equiv G_{It} + A_{It} + \Delta F_{It}.$$

The first term G_{It} in equation (5) represents the change in foreign presence between $t-1$ and t that is attributable to greenfield entry. It is the employment-weighted greenfield entry rate; i.e. the sum of employment in those plants in industry I that are greenfield entrants in year t expressed as a share of total employment in the industry that year. Similarly, A_{It} represents the change in foreign presence due to foreign acquisitions; i.e. the employment share of plants in industry I that are acquired by foreign owners between $t-1$ and t. G_{It} and A_{It} represent the flow of new FDI into the sector differentiated by the mode of entry. The last term ΔF_{It} equals the two terms in brackets, and represents the remaining change in foreign presence between $t-1$ and t. ΔF_{It} captures employment expansion or contraction of existing foreign-owned firms relative to total industry employment, and also withdrawal of foreign firms through divestures or plant closures.

As the variables of main interest are foreign presence and foreign entry, we should take into account that the estimated relationship between these variables and productivity could be biased by selection on survival. Suppose for example, that foreign greenfield entry occurs primarily in sectors with good market growth prospects. In such sectors, even low productivity firms may survive, creating a negative correlation between foreign entry and productivity among surviving firms. Conversely, if foreign entry increases competitive pressure such that only the best firms survive, there will be a positive correlation between foreign entry and productivity among surviving firms. Thus, the selection bias could work in both directions and the overall bias is not known. To address this potential problem we use a Heckman selection model as one of our specifications when estimating equation (3) with both (4) or (5) representing the change in foreign presence.

The effect of a change in foreign presence on productivity growth may depend on the market structure of the industry. On the one hand, it could be argued that information about new technologies may spread more easily in a small and transparent market. This would imply that spillovers may be larger in concentrated industries. On the other hand, greenfield entry in a concentrated industry may have a larger impact on the competitive pressure in the industry than greenfield entry in a less concentrated industry. At least in the short run, this could lead to reduced domestic market shares or even a reduction in output prices. A similar effect might be generated if a foreign acquisition in a concentrated industry puts an end to collusive behaviour in that industry. To take account of the possibility that the effect of foreign entry may depend on the market structure of an industry, one of our specifications includes interaction terms and lagged interaction terms between the change-in-foreign-presence variable(s) under consideration and the 5-firm concentration measure.

3 Data

Our main data source is the annual census of all Norwegian manufacturing plants collected by Statistics Norway. The Norwegian Manufacturing Statistics are collected at the plant level, where the plant is defined as a functional unit at a single physical location, engaged mainly in activities within a specific activity group. The plant-level variables include detailed information on production, input use, investment, location, and industry classification. We use the ISIC Rev. 2 industry classification in our analysis.[9]

We drop plants with less than 8 employees throughout their lives, and observations of plants not in ordinary production (service units or plants under construction).[10] The resulting sample contains 150,000 observations from 10,400 plants for the period 1978-2001, with an average plant size of 43 employees. In terms of employment and output, the sample contains more than 90% of total manufacturing output and employment.

Information about foreign ownership for the period 1990-2001 is obtained from the SIFON-register, which is a record of foreign ownership of equity in Norwegian firms. The SIFON-register contains information about the value and share of equity held by the largest foreign owner of the firm, the total share of equity held by foreign owners and the country of origin of the largest owner.[11] The register was initiated in 1972, and while only direct foreign ownership was recorded before 1990, from 1990 onwards also indirect

[9] For more detailed descriptions of the Manufacturing Statistics, see the documentation in Halvorsen et al. (1991) and Møen (2004).

[10] In addition, we drop plants that in the Norwegian Manufacturing Statistics are classified as "small" (defined as having less than 5 or 10 employees) throughout their life. The information for these plants comes mainly from administrative registers and is therefore less extensive than for large plants. In particular, there is no investment information, which means that we are unable to construct capital measures for this group.

[11] See Simpson (1994) for more details about the SIFON-register.

foreign ownership is documented.[12] Before 1990, the Manufacturing Statistics contains a variable where plants are classified into three ownership classes; plants that are part of firms where less than 20%, between 20-50%, or more than 50% of the equity is directly foreign owned. This information is obtained from earlier versions of the SIFON-register. We have chosen to treat indirect and direct foreign ownership equally after 1990, which means that we classify plants as foreign owned when either the direct or the indirect foreign ownership of equity is above the 20% threshold.[13]

It is likely that registration of indirect foreign ownership in 1990 was somewhat incomplete as this was the first year when this type of foreign ownership was recorded. It is also likely that the degree of underreporting of indirect foreign ownership declined during the early 1990s. Figure 1 illustrates the development of foreign ownership in our sample, and shows a dramatic increase in foreign presence during the 1990s. This increase in foreign presence is a combination of a trend increase in foreign ownership as well as a result of the extended definition and recording of foreign ownership. The rate of increase in the number of indirectly foreign-owned plants during the 1990s was higher than that of directly foreign-owned plants, and by 2001 the number of indirectly foreign-owned plants exceeded the number of plants with direct foreign ownership interests. Global trends in corporate ownership structures may partly explain this shift towards indirect foreign ownership, but it is unlikely that indirect foreign ownership in Norwegian manufacturing was nonexistent during the 1980s. Thus, our sample is likely to underestimate the extent of foreign ownership before the early 1990s.

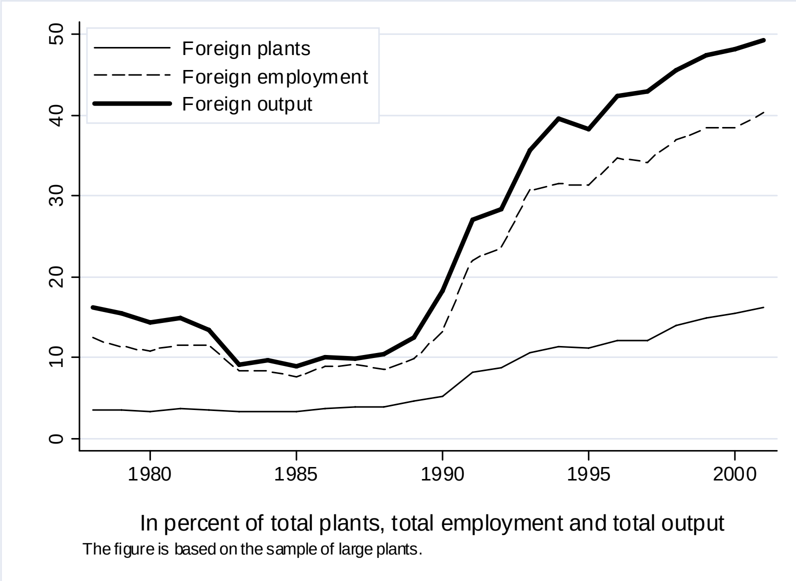
In the Norwegian Manufacturing Statistics each plant is assigned an identification number which it keeps throughout its life. A plant will even keep its previous identification number when it re-enters the panel after a time of inactivity as long as production restarts in the same geographic location. Mergers or buy-outs at the firm level do not affect the plant identification code. Since our data are from a census, we avoid the problem of possible false entries and exits due to plants not being sampled.

When defining entry and exit our main concern is the treatment of plants that are present in the panel for one or more years and then absent for some years before they reappear in the panel again. Although the logic of the census would imply that a plant is not in operation if it is not observed in the census, we assume that when a plant is missing from the census for one

[12] A firm has direct foreign ownership interests if foreigners own part of the equity of the firm. Firms of which 50% or more is owned by another firm based in Norway (mother), and where the foreign equity stakes are in the mother, are classified as indirectly foreign owned.

[13] We report how this affects our results in the robustness analysis in section 5.

Figure 1: Foreign presence in Norwegian manufacturing



or two consecutive years, this is due to lack of registration rather than a temporary closure. When a plant disappears for three or more consecutive years before it reappears in the census, we regard it as temporarily closed and thus count an extra exit and entry for that plant. We also define as temporarily closed those plants that are missing for two consecutive years, but reappear with a new owner (a new firm identification number). Thus we define a plant as an entrant in year t if it appears for the first time in year t, or reappears in that year after a temporary closure. Similarly we define an exit in year t if the plant is present in year t and temporarily closed in $t+1$, or absent all subsequent years.[14]

In Table 1 we show the average annual number of foreign and domestic plants per 5 year period during the 1980s and 1990s, as well as the average yearly greenfield entry and acquisition numbers. Figure 2 then displays the net foreign and domestic entry rates, and the net foreign acquisition rate, calculated for overlapping 5 year periods. The foreign net entry rate is very small for the whole period, while the domestic net entry rate is negative, with a peak in exits during the recession in the early 1990s. This creates a trough in the net entry rate. The negative net entry rate reflects the overall trend in the economy of moving resources out of manufacturing into the services sector. During the period of analysis the number of observations

[14]Less than 2.5% of the plants in the sample have what we define as temporary closures.

Table 1: Annual number of foreign and domestic plants and foreign entrants

	Domestic plants	Foreign plants	Greenfield entry	Acquisition entry
1980-84	6,914	225	5	24
1985-89	6,492	223	8	35
1990-94	5,445	400	14	103
1995-99	4,775	590	24	91

Note: Averages over 5-year periods.

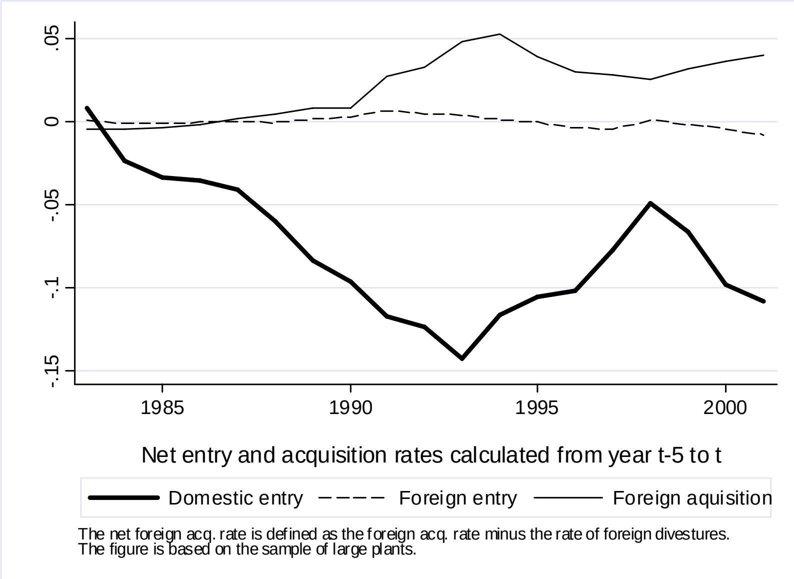
in our sample decreased from 6,990 in 1978 to 4,850 in 2001. During the same period total manufacturing employment declined by 33% from 330,000 in 1978 to 220,000 in 2001.[15] By comparing the development in foreign acquisitions with the foreign and domestic net entry rates in Figure 2, we can conclude that the increase in foreign presence in Norwegian manufacturing over the last 25 years is mainly due to net exit of domestic plants and foreign acquisitions of domestic plants.

For the econometric analysis we clean the data with respect to missing observations and outliers.[16] First, we drop plants with missing information on inputs or output for 80% or more of their life. We then drop observations with negative profit margins and negative value added. We also exclude sector 342, "Printing, publishing and allied industries" from our sample. Klette (1999), in his estimations of markups and scale parameters using the same data, concluded that the results from this sector were implausible and should be ignored. The printing sector has experienced a dramatic technological change over the period: it went from manual typesetting to computerized printing. Thus, the changes in this sector may be so large that results are not representative. Alternatively, there may be particular data problems affecting productivity estimates for the printing and publishing sector. When we include this sector, the results - except for the foreign presence (FP)

[15] Haskel et al. (2002) report a similar trend for UK manufacturing employment, a decline of 36% from 1980 to 1992.

[16] We experimented with several cleaning procedures. In one alternative we define multiple outliers on plant level changes in output, materials use and hours from one year to the next according to the method by Hadi (1994), and defined as outliers all observations in the 1st and 99th percentile. In another alternative, we defined as outliers all observations with cost shares of capital, materials, or labour in the 1st and 99th percentile of observations for each year and 3-digit industry. All cleaning procedures drop observations evenly across 2-digit industries, and drop more observations after 1995. The main conclusions in section 4 hold for all cleaning procedures.

Figure 2: Net foreign and domestic entry rates



variable - go in the same direction as our main results in Section 4, but the coefficients are 2-3 times as large. By excluding the printing sector (ISIC 342), we are thus making it more difficult for ourselves to obtain significant results.

Our cleaned sample contains 112,000 observations from 9,110 plants. This constitutes 75% of our initial sample from 1978-2001. Average plant size is almost the same (it increases from 43.0 to 43.9 employees), and the share of foreign plants is virtually unaffected. The number of plants per year in our cleaned sample is 5,410 in 1978, down to 3,630 in 2001.

4 Results

We estimate the first-differenced equation (3) on those plants that are Norwegian owned throughout their presence in our sample. Summary statistics of the regression variables for the domestic plants sample are presented in Table 6 in the Appendix. The results of estimating equation (3) using the overall change in foreign presence as defined in equation (4) are presented in the first column of Table 2. All inputs are significant. The coefficients on market share, concentration, and profit margin have the expected negative sign. This indicates that reduced competitive pressure has a negative effect on productivity, although the concentration index is only significant at the

10% level. The measure of openness has a positive coefficient, hence higher imports enhance domestic productivity, while the turnover rate is not significant. The change in overall foreign presence is entered with its current value and two lags. Only the coefficient on the current change in foreign presence is significantly different from zero and has a positive sign, but the effect is small. In the row with $\sum \Delta FP$ we sum the three coefficients on the change in foreign presence: their accumulated effect is positive, but not significant. This is in line with previous results for Norway reported by Grünfeld (2002).

As argued in section 2, the effect of a change in foreign presence on productivity growth may depend on the market structure of the industry. Thus, in column 2 we include interaction terms between the 5-firm concentration measure and the change in foreign presence. This gives an indication of whether a change in foreign presence in concentrated sectors has a different effect from a change in foreign presence in less concentrated sectors. Including the interaction terms results in a significant and positive accumulated effect. The signs of the interaction terms go in opposite directions. In order to investigate these effects further, we split our sample at the median concentration level and run the regression of column 1 in Table 2 on these two samples separately. These results show a positive effect of foreign presence in low-concentration sectors, and no significant effect of foreign presence in high-concentration sectors.[17]

By virtue of observability, our sample consists only of those plants that survive. Hence, if foreign presence affects the probability of survival, our earlier estimates may be biased. In the last column of Table 2 we re-estimate column 2 using the 2-step Heckman selection procedure where survival is conditioned on investment and capital, see e.g. Haskel et al. (2002). This is to capture the idea that investment which is observable but not correlated with current output can pick up unobservable shocks to productivity. It can be considered a "reduced" form of the more structural approach to the exit decision taken in Olley and Pakes (1996). In this equation, selection is determined by the plants' investment shares[18] and capital in logs, each from levels up to their 4th powers. The results are very similar to those in column 2 without the selection correction. The variables in the selection probit are

[17] The sum of the three coefficients on the change in foreign presence is 0.108 with p-value 0.009 in the low-concentration sectors (sectors with $CR5_{It} < 0.25$) and in high-concentration sectors the effect is 0.009 with p-value 0.628. Using the Herfindahl-Hirschman index as an alternative concentration measure in the regressions of Table 2 gives very much the same results.

[18] As zeros in investment are meaningful observations (see Nilsen and Schiantarelli (2003) for Norway), we prefer to scale investment by dividing by annual averages instead of taking logs.

Table 2: Foreign Presence and Domestic Productivity

Dependent variable $\Delta \ln Y_{it}$	(1)	(2)	(selection)
$\Delta \ln K_{it}$	.058 (.003)**	.058 (.003)**	.055 (.003)**
$\Delta \ln M_{it}$	.520 (.005)**	.520 (.005)**	.528 (.005)**
$\Delta \ln H_{it}$	.290 (.007)**	.290 (.007)**	.281 (.006)**
$\Delta MS_{i,t-1}$	$-$.332 (.065)**	$-$.332 (.065)**	$-$.298 (.064)**
$\Delta PM_{i,t-1}$	$-$.375 (.009)**	$-$.375 (.009)**	$-$.378 (.009)**
$\Delta CR5_{I,t}$	$-$.025 (.014)$^{(*)}$	$-$.026 (.014)$^{(*)}$	$-$.021 (.014)
$\Delta OPEN_{I,t}$	.074 (.018)**	.074 (.018)**	.070 (.018)**
$Turnover_{I,t-1}$	.015 (.013)	.015 (.013)	.025 (.013)*
$\Delta FP_{I,t}$	.021 (.009)*	.036 (.024)	.034 (.023)
$\Delta FP_{I,t-1}$	$-$.001 (.010)	$-$.006 (.027)	.013 (.028)
$\Delta FP_{I,t-2}$	.005 (.009)	.056 (.026)*	.048 (.026)*
$(\Delta FP * CR5)_{I,t}$		$-$.024 (.035)	$-$.021 (.035)
$(\Delta FP * CR5)_{I,t-1}$		.008 (.041)	$-$.025 (.041)
$(\Delta FP * CR5)_{I,t-2}$		$-$.086 (.038)*	$-$.062 (.040)
$\sum \Delta FP_I$ [$p-value$]	.026 [.125]	.086 [.044]	.094 [.025]
R^2	.79	.79	–
χ^2 (1) $\rho(SE)$	–	–	11.54 $-$.049(.014)
N	61,929	61,929	63,623
$Plants$	6,558	6,558	6,558

Notes: **,*,$^{(*)}$ indicate significance at 1%, 5%, and 10% respectively. Year and 3-digit industry dummies included in all regressions. Robust standard errors adjusted for clustering at the plant level in round parentheses.

jointly significant, as indicated by the χ^2 value. The selection term ρ is also significant. We also tried to condition survival on a probit of so-called hazard variables that have been found to determine exit, see e.g. Bernard and Jensen (2002). The hazard variables are plant age, age squared, plant size (measured as the number of employees), labour productivity, a multiplant dummy that takes value one if the plant is part of a multiplant firm, and foreign presence. This selection equation yields similar results.

As argued earlier, the measure of foreign presence used combines the effects from recent foreign entrants and employment changes in longer-term foreign firms. In addition, the measure is not able to distinguish between different modes of foreign entry. Thus, we proceed by splitting the overall change in foreign presence according to equation (5). Results are presented in Table 3. The estimated coefficients on the input and competition variables do not change much when we split the change in foreign presence variable, thus the coefficients on inputs and competition variables are not reported.

In column 1 of Table 3 the coefficients on greenfield entry are negative, with the first lag of greenfield entry being significant. Their accumulated effect is negative and significant at the 5% level. Regarding acquisitions, only the current foreign acquisition rate is significant with a positive sign. The accumulated effect of foreign acquisitions is positive and significant at the 10% level, but it is small in economic terms. The effect of the remaining change in foreign presence ΔF_I is close to zero and insignificant.

In column 2, we add the interaction terms between the components of change in foreign presence and concentration in order to investigate whether the effects of foreign entry on productivity growth differ according to the level of industry concentration. The coefficients on current greenfield entry and its first lag are negative and significant; and their accumulated effect is substantially larger in absolute terms than in column 1. The interaction terms between greenfield entry (and lagged greenfield entry) and the concentration measure are positive and significant. This suggests that the negative effect of foreign entry is particularly strong in less concentrated industries. Industries with high levels of concentration are hardly affected at all, indicating that plants in these sectors are better able to face the increase in competition from foreign greenfield entry.

In the case of foreign acquisitions, the coefficients on the acquisition rate are positive in column 2 but, as in column 1, only the coefficient on the current acquisition rate is significant. The positive accumulated effect of acquisitions is significant at the 1% level, and as in the case of greenfield entry, the effect is substantially larger in absolute terms than in column 1. The interactions between the acquisition terms and the concentration index are negative, suggesting that in highly concentrated industries acquisitions

Table 3: Modes of Foreign Entry and Domestic Productivity

Dependent variable $\Delta \ln Y_{it}$	(1)	(2)	(selection)
$G_{I,t}$	$-.040$ (.061)	$-.399$ (.196)*	$-.508$ (.202)**
$G_{I,t-1}$	$-.100$ (.050)*	$-.687$ (.195)**	$-.666$ (.204)**
$G_{I,t-2}$	$-.043$ (.054)	.007 (.223)	$-.167$ (.223)
$A_{I,t}$	.032 (.012)**	.082 (.031)**	.079 (.031)**
$A_{I,t-1}$	.002 (.013)	.052 (.034)	.048 (.034)
$A_{I,t-2}$	.002 (.014)	.055 (.035)	.063 (.036)$^{(*)}$
$\Delta F_{I,t}$	.013 (.017)	$-.008$ (.042)	$-.011$ (.041)
$\Delta F_{I,t-1}$	.007 (.017)	$-.039$ (.047)	.022 (.047)
$\Delta F_{I,t-2}$	.005 (.015)	.051 (.043)	.013 (.044)
$(G * CR5)_{I,t}$		.497 (.260)$^{(*)}$	.653 (.269)**
$(G * CR5)_{I,t-1}$		.812 (.243)**	.785 (.253)**
$(G * CR5)_{I,t-2}$		$-.064$ (.285)	.161 (.289)
$(A * CR5)_{I,t}$		$-.083$ (.046)$^{(*)}$	$-.081$ (.045)$^{(*)}$
$(A * CR5)_{I,t-1}$		$-.084$ (.051)$^{(*)}$	$-.081$ (.051)
$(A * CR5)_{I,t-2}$		$-.092$ (.053)$^{(*)}$	$-.100$ (.053)$^{(*)}$
$(\Delta F * CR5)_{I,t}$		.040 (.064)	.048 (.062)
$(\Delta F * CR5)_{I,t-1}$		.082 (.073)	$-.013$ (.072)
$(\Delta F * CR5)_{I,t-2}$		$-.072$ (.066)	.007 (.068)
$\sum G_I$ [$p-value$]	$-.183$ [.054]	-1.079 [.000]	-1.341 [.000]
$\sum A_I$ [$p-value$]	.036 [.065]	.190 [.000]	.190 [.000]
$\sum \Delta F_I$ [$p-value$]	.025 [.311]	.003 [.961]	.024 [.716]
R^2	.79	.79	–
χ^2 (1) $\rho(SE)$	–	–	11.16 $-.049(.015)$
N	61,929	61,929	63,623
$Plants$	6,558	6,558	6,558

Notes: **,*,$^{(*)}$ indicate significance at 1%, 5%, and 10% respectively. Input coefficients not reported. Year and 3-digit industry dummies included in all regressions. Robust standard errors adjusted for clustering at the plant level in round parentheses.

have a negative impact on the productivity of domestic firms. Regarding the remaining change in foreign presence, ΔF_{It}, introducing the interaction terms does not give a clearer picture of any effect of these changes in foreign presence on the productivity growth of domestic plants. Also with the interaction terms included, the accumulated effect of the ΔF-terms remains insignificant.

In the third column of Table 3 we re-estimate column 2 using the Heckman selection model described above. The individual coefficients have mostly the same sign and significance level as in column 2. The result for the accumulated effect of greenfield entry is stronger, i.e. more negative, while the results on foreign acquisitions and the remaining change in foreign presence are not affected. Again conditioning selection on hazard variables and the G_{It}, A_{It} and ΔF_{It} measures gives similar results.

As in the case of an overall change in foreign presence, we split the sample into low- and high-concentration sectors and estimate the regression of column 1 in Table 3 on these two samples separately.[19] The results for the low-concentration sectors are presented in the first column of Table 4. The effect of greenfield entry is negative, while foreign acquisitions have a positive effect on the productivity growth of domestic plants. As an example, the coefficient on the first lag of greenfield entry implies that a one percentage point increase in last year's greenfield entry rate is associated with a decrease in current productivity growth of 0.52 percent. From the second column of Table 4 we find no significant effect of greenfield foreign entrants on productivity growth in high-concentration sectors. The effect from foreign acquisitions in high-concentration sectors is ambiguous. The current acquisition rate is positive and significant, whereas the second lag is negative and significant which results in an insignificant accumulated effect. The remaining change in foreign presence (ΔF) has a positive effect, suggesting a small spillover effect from the foreign plants that are not recent entrants into the sector. In small and transparent industries, the domestic firms may be in a better position to appropriate knowledge from foreign firms and thus benefit from spillovers. We obtain similar results as in Table 4 if we use the Herfindahl index as an alternative measure of concentration and split the sample at its median.

[19] Note that when splitting the sample at the median of $CR5 = 0.25$, the low-concentration sample contains 18 of 132 5-digit sectors (7 of these are in the food sector and 5 in the metal industry).

Table 4: Modes of Foreign Entry and Domestic Productivity in Low- and High-Concentration Sectors

Dependent variable $\Delta \ln Y_{it}$		
	(low conc)	(high conc)
$G_{I,t}$	$-.107$ (.164)	$-.002$ (.068)
$G_{I,t-1}$	$-.524$ (.167)**	.004 (.047)
$G_{I,t-2}$	.050 (.192)	$-.024$ (.057)
$A_{I,t}$	.046 (.034)	.027 (.014)*
$A_{I,t-1}$	.074 (.032)*	$-.015$ (.014)
$A_{I,t-2}$	.124 (.033)**	$-.034$ (.015)*
$\Delta F_{I,t}$	.040 (.042)	.012 (.019)
$\Delta F_{I,t-1}$	$-.017$ (.046)	.015 (.018)
$\Delta F_{I,t-2}$	$-.067$ (.038)$^{(*)}$	.032 (.017)$^{(*)}$
$\sum G_I$	$-.581$	$-.022$
[$p-value$]	[.020]	[.819]
$\sum A_I$	.244	$-.022$
[$p-value$]	[.000]	[.316]
$\sum \Delta F_I$	$-.044$	.060
[$p-value$]	[.447]	[.034]
R^2	.80	.79
N	34,576	27,353
$Plants$	3,789	3,028

Notes: **,*,$^{(*)}$ indicate significance at 1%, 5%, and 10% respectively. Coefficients on inputs and competition variables not reported. Year and 3-digit industry dummies included in all regressions.Robust standard errors adjusted for clustering at the plant level in round parentheses.

To summarise, we find a significant and positive effect of an overall change in foreign presence on the productivity growth of domestic plants in low-concentration sectors. However, when focusing explicitly on foreign entrants, we find that this is the result of two opposing effects from the recent foreign entrants. Greenfield entry has a negative impact on the productivity growth of domestic plants in less concentrated industries. Entry via acquisition affects domestic productivity growth positively. The effect of greenfield entry is stronger in absolute terms than that of acquisitions, but since foreign acquisition is the most frequent mode of entry, the acquisition effect dominates in the effect of an overall change in foreign presence (cf. Table 2).

For the low-concentration industries, the negative effect of greenfield entry on productivity could be due to a market stealing effect as argued by Aitken and Harrison (1999). When repeating the regression of column 1 in Table 4 without controlling for the use of inputs, we find that the accumulated effect of greenfield entry in the low-concentration sectors is stronger on output (-1.549 [.001]) than on productivity (-0.581 [.020] from column 1 of Table 4). Given that our data do not contain information about prices, we do not know whether this is primarily a price or a quantity effect. Using profit margins as the left-hand side variable instead of output, with the remaining competition variables as right-hand side controls, yields no strong evidence of a price effect: two of the coefficients on G_I are positive while one is negative and the accumulated coefficient for the G_{It} variables is not significant (.122 [.350]). We also looked at how greenfield entry affects the use of materials and labour by using the change in these inputs as our dependent variable while controlling for competition in addition to the foreign entry variables on the right-hand side. These regressions give accumulated coefficients on $\sum G_{It}$ equal to (-1.706 [.021]) for material inputs and ($-.802$ [.134]) for hours, and none of the individual coefficients on the G_I-terms were significant. Thus it seems that plants in low-concentration sectors are able to reduce their use of materials as their output falls due to greenfield entry, but the negative effect on labour use is not significant. All in all, we take these results as suggesting that the transitory decline in productivity growth that seems to follow greenfield entry in sectors with low concentration rates is primarily caused by the domestic firms not sufficiently adjusting their use of labour in the short run.

Turning to the effect of foreign entry by acquisition, our results show that acquisitions are associated with higher productivity growth for domestic plants in low-concentration sectors, with the largest effect 2 years after entry. Given that we did not expect any (immediate) changes in market structure in the acquisition case, it is plausible that we do not find a negative competition effect. In fact, foreign acquisitions appear to give the existing firms in the market time to adapt, possibly because they are themselves handicapped by substantial in-house restructuring after a takeover. In addition, established links from the acquired plant to other domestic plants may serve as a channel for knowledge spillovers.

5 Robustness Analysis

In Table 5, we report the results for a number of robustness checks. The regressions in the upper panel of Table 5 are all variations of equation (3) as reported in column 2 of Table 3. In the lower panel of the table we report the same variations of equation (3) on the sample of low-concentration sectors, thus the results in the lower panel are comparable to column 1 of Table 4. We only report the sum of coefficients on G_I, A_I and ΔF_I.[20]

In columns 1 and 7 of Table 5, we report the results of a more general specification of equation (3) in which we allow the coefficients on inputs to vary across 3-digit industries by interacting the inputs with industry dummies. Our specifications in Tables 3 and 4 constrain the input elasticities to be the same for all manufacturing industries. This might disregard important differences between industries and thus bias our estimates of the effects of foreign entry. However, the overall effects of foreign entry and acquisitions are very similar to the results reported in column 2 of Table 3 and column 1 of Table 4.

Production function estimation has been shown to yield poor results when important unobservables that vary both across plants and over time, such as productivity shocks, are omitted. This suggests that differencing and controlling for plant fixed effects may yield poor estimates of input use and, moreover, it may not be sufficient to render the error term ε_{it} in equation (1) white noise. Olley and Pakes (1996) show that such unobservable shocks can be proxied for by investment behavior, on the assumption that these shocks influence current investment, but - since investment takes time - not current output. Their approach requires that plants do not undertake zero investment, which is not the case for about 25% of the observations in our sample. Instead, Levinsohn and Petrin (2003) propose using intermediate inputs rather than investment to address the underlying simultaneity problem. To make sure that our results are not affected by this problem, we estimate total factor productivity (TFP) as the residuals of a Cobb-Douglas production function at the 2-digit level according to the Levinsohn-Petrin method.[21]

[20] Detailed results are available from the authors on request.

[21] In the absence of an appropriate deflator we use the share of energy in material use to proxy for unobserved productivity shocks.

Table 5: Robustness

Dep. var.	$\Delta \ln Y_{it}$	Δ ln TFP$_{it}$	Δ TFP$_{it}$	Δ ln LP$_{it}$	$\Delta \ln Y_{it}$	$\Delta \ln Y_{it}$
Check	3-digit inp. coeff.	levpet residuals	translog index	labour prod.	Direct foreign	Majority foreign
Full sample with concentration interactions (cf. Table 3 col (2))						
	(1)	(2)	(3)	(4)	(5)	(6)
$\sum G_I$	-1.066	-1.107	-1.324	-1.551	-1.438	-2.342
[$p-value$]	[.000]	[.000]	[.000]	[.001]	[.041]	[.001]
$\sum A_I$	.199	.206	.206	.124	.242	.207
[$p-value$]	[.000]	[.000]	[.000]	[.174]	[.003]	[.001]
$\sum \Delta F_I$	$-.016$	.086	.032	$-.109$	$-.021$	$-.091$
[$p-value$]	[.810]	[.214]	[.617]	[.430]	[.809]	[.373]
R^2	.81	.06	.07	.03	.79	.79
N	61,929	61,922	61,924	61,929	61,929	61,929
Plants	6,558	6,558	6,558	6,558	6,558	6,558
Low-concentration sectors only (cf. Table 4 col (low conc))						
	(7)	(8)	(9)	(10)	(11)	(12)
$\sum G_I$	$-.698$	$-.574$	-1.062	$-.747$	$-.494$	-1.641
[$p-value$]	[.003]	[.025]	[.000]	[.112]	[.308]	[.002]
$\sum A_I$	.264	.272	.247	$-.063$	.353	.160
[$p-value$]	[.000]	[.000]	[.000]	[.478]	[.001]	[.006]
$\sum \Delta F_I$	$-.066$	.008	$-.049$	$-.092$	$-.150$	$-.238$
[$p-value$]	[.244]	[.896]	[.368]	[.444]	[.123]	[.012]
R^2	.81	.07	.08	.03	.80	.80
N	34,576	34,574	34,576	34,576	34,576	34,576
Plants	3,789	3,789	3,789	3,789	3,789	3,789

In columns 2 and 8 of Table 5 we report the results of using this measure as our dependent variable in estimating equation (3) omitting the inputs on the right hand side. The results are similar to our original specifications.

In columns 3 and 9 we use as our measure of productivity growth a superlative index of total factor productivity growth used by Aghion et al. (2005), which is derived from a flexible translog specification of the production technology, see Caves et al. (1982a, 1982b).[22] The results from using this measure are very similar to those of the specification in Table 3. The accumulated effect of greenfield entry is stronger in absolute terms. In column 4 and 10 of Table 5 we report results for labour productivity. Labour productivity will not be affected by potentially poor measurement or poor estimation of the capital stock variable. Also here, the results for greenfield entry point in the same direction as our previous results; but the effect of acquisitions is not significant.

As noted in Section 3, from 1990 onwards our definition of foreign ownership includes both directly and indirectly foreign-owned plants. We reestimate our original specifications with our foreign entry and acquisition variables based on, respectively, direct foreign ownership at the 20% threshold in columns 5 and 11 of Table 5, and on majority foreign ownership (direct + indirect) in columns 6 and 12. In both cases the coefficients on greenfield entry in the upper panel (columns 5 and 6) are negative and stronger than in the reference equation, and this also holds for majority foreign greenfield entry in the low-concentration sectors (column 12). This is in line with earlier results suggesting that the effects from majority foreign-owned enterprises are largest (e.g. Smarzynska Javorcik and Spatareanu (2003)). Overall, we conclude that our results are not sensitive to how foreign ownership is defined or to the measure of total factor productivity used.

6 Conclusions

Our aim in this paper was to bring new insights into the spillover debate by distinguishing between new and existing foreign firms, and furthermore between different modes of foreign entry. In our data, an overall change in foreign presence has a small positive impact on productivity growth of domestic plants in low-concentration sectors, and no effect in more concentrated sectors. The effect in low-concentration sectors is generated by the recent foreign entrants, with opposite effects from greenfield entrants and foreign acquisitions. The impact of greenfield entry on domestic productivity

[22] Details on the construction of this index are presented in the Appendix.

growth is negative in low-concentration sectors. The negative effect of greenfield entry on the productivity growth of domestic plants in low-concentration sectors seems to be primarily due to these plants not adjusting their use of inputs (in particular labour) in the short run. The negative competition effect associated with greenfield entry in low-concentration sectors is not found for acquisitions. We find a positive effect of foreign acquisitions on the productivity growth of domestic plants in these industries, with the largest effect 2 years after entry. This suggests that established links from the acquired plant to other domestic plants may serve as a channel for knowledge spillovers. In highly concentrated sectors we find no significant effect of either of the recent entrants on domestic productivity growth.

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A Appendix

Table 6: Summary statistics

Variable	Mean	Std. Dev.	Min.	Max.	N
Levels					
$\ln Y_{it}$	9.522	1.230	4.304	14.521	61,929
$\ln K_{it}$	7.257	1.253	1.792	12.300	61,929
$\ln M_{it}$	8.694	1.440	0.417	14.402	61,929
$\ln H_{it}$	3.368	1.070	-3.937	8.593	61,929
MS_{it}	0.017	0.047	0	1	61,929
PM_{it}	0.140	0.094	0	0.918	61,929
investment	0	0	-0.007	0.020	61,929
$CR5_{It}$	0.674	0.260	0.091	1	2,581
HHI_{It}	0.193	0.173	0.007	1	2,581
$OPEN_{It}$	0.645	0.192	0.034	0.956	2,581
$turnover_{It}$	0.069	0.080	0	1	2,581
FP_{It}	0.203	0.257	0	0.987	2,581
G_{It}	0.002	0.020	0	0.734	2,581
A_{It}	0.024	0.091	0	0.951	2,581
F_{It}	0.177	0.243	0	0.987	2,581
Differences					
$\Delta \ln Y_{it}$	0.012	0.313	-6.203	4.246	61,929
$\Delta \ln K_{it}$	0.034	0.319	-4.395	3.517	61,929
$\Delta \ln M_{it}$	0.025	0.428	-7.014	6.110	61,929
$\Delta \ln H_{it}$	-0.012	0.342	-7.336	7.293	61,929
ΔMS_{it}	0	0.012	-0.684	0.688	61,929
ΔPM_{it}	-0.003	0.085	-0.857	0.831	61,929

Note: Summary statistics for industry level variables are reported for 5-digit industry-year cells.

Data and Variable Definitions

A_{It} Employment in plants that were acquired by a foreign owner between years t and $t-1$ as a share of 5-digit industry employment in year t.

$CR5_{It}$ Joint market share of the 5 largest plants in a 5-digit industry in terms of output relative to industry output.

F_{It} Employment in foreign-owned plants present in year t and in year $t-1$ as a share of 5-digit industry employment in year t.

FP_{It} Employment in foreign-owned plants as a share of 5-digit industry employment in year t.

G_{It} Employment in foreign-owned plants present in year t but not in year $t-1$ as a share of 5-digit industry employment in year t.

H_{it} Number of person hours in the plant. Since only blue-collar hours are reported prior to 1983, and only total hours from 1983, we estimate total hours before 1983 by using information on the blue-collar share of the total wage bill. Rented labour hours are calculated from the costs of rented labour using the calculated average wage for own employees.

HHI_{It} Herfindahl-Hirschman index defined as the sum over the squares of each plant's market share in its 5-digit industry.

K_{it} Our estimate of capital services uses the following aggregation:

$$K_{it} = R_{it} + (0.07 + \delta^m)V_{it}^m + (0.07 + \delta^b)V_{it}^b,$$

where R_{it} is the cost of rented capital in the plant, V_{it}^m and V_{it}^b are the estimated values of machinery and buildings at the beginning of the year, $\delta^m = 0.06$ and $\delta^b = 0.02$ are the depreciation rates that we use. We take the rate of return to capital to be 0.07. The values for depreciation rates and the rate of return to capital are also used by Salvanes and Førre (2003) using the same data. The estimated values of buildings and machinery are obtained from information on fire insurance values. To reduce noise and avoid discarding too many observations with missing fire insurance values, we smooth these values using the perpetual inventory method. Fire insurance values are not recorded after 1995, thus from 1996 we estimate capital values by adding investments and taking account of depreciation. Where possible, we also use estimates of firm level capital values (distributed to the plant level according to employment shares) as starting values for plants with entry after 1995. These capital values are obtained from recent work to improve on capital estimates in Norwegian manufacturing (see Raknerud et al. (2003)). We use separate price deflators for inputs and output and for investment in buildings and machinery obtained from Statistics Norway. The aggregation level for the price deflators is according to the sector classification used in the National Accounts, which is somewhere in between the 2- and 3-digit ISIC level.

LP_{it} Labour productivity defined as output per hour.

M_{it} Total cost of materials used. Since this variable in the data includes rented labour and capital, we subtract these and allocate them to the labour and capital measures respectively.

MS_{it} Plant output as a share of 5-digit industry output.

$OPEN_{It}$ Rate of imports over imports plus exports ($OPEN_{It} = M_{It}/(M_{It}+X_{It})$). Import and export data are taken from the OECD ITCS International Trade Data SITC Rev. 2 and have been converted to 3 digit ISIC Rev. 2 codes using a conversion table provided by Maskus (1989). The data are converted into NOK using the annual average exchange rate provided in the International Financial Statistics.

PM_{it} Net output less material and wage costs divided by 5-digit industry output.

$Turnover_{It}$ (Total number of plants entering in year t + total number of plants exiting in year t)/(Total number of plants in year t)

ΔTFP_{it} The measure of TFP growth is derived from a flexible translog specification of the production technology.

$$\Delta TFP_{it} = \Delta \ln Y_{it} - \sum_{z=M,K,H} \widetilde{\alpha_{it}^{z}} \Delta \ln x_{it}^{z}, \tag{6}$$

where x_{it}^{z} is the quantity used of factor z in plant i at time t. The Divisia share $\widetilde{\alpha_{it}^{z}}$ is defined as $\widetilde{\alpha_{it}^{z}} = (\alpha_{it}^{z} + \alpha_{it-1}^{z})/2$ where α_{it}^{z} is the cost share of factor z relative to total output value Y in plant i at time t. We impose constant returns to scale. Since there could be substantial noise in the observed factor shares α_{it}^{z}, we apply a smoothing procedure proposed by Harrigan (1997). Assuming a translog production technology, constant returns to scale (CRS), and standard market-clearing conditions, α_{it}^{z} can be expressed as follows:

$$\alpha_{it}^{z} = \psi_i + \varphi_{It} + \sum_{z=M,H} \omega_{It} \ln(\frac{x_{it}^{z}}{x_{it}^{K}}) \tag{7}$$

where ψ_i is a plant-specific constant, φ_{It} an industry-time-specific constant and where we normalize relative to capital use to impose CRS. If the observed factor shares deviate from the left-hand side of this equation by an i.i.d. measurement error term, then the parameters can be estimated by running separate fixed effects panel data regressions for each industry I. We estimate equation (7) separately for each 3-digit ISIC industry, and use the fitted values from (7) as the factor shares in the calculation of (6).

Y_{it} Gross production value net of sales taxes and subsidies.