WHY ARE FOREIGN FIRMS MORE PRODUCTIVE THAN DOMESTIC FIRMS?

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Abstract

In analyzing firm productivity and efficiency in Belgium, this paper empirically shows that foreign firms are significantly more productive than domestic firms. Large differences in productivity between foreign firms and domestic firms exist even after controlling for other firm characteristics put forward by theoretical models formalizing heterogeneity between firms. The productivity differential between foreign firms and domestic firms is explained by differences in scale and technical efficiency. Stochastic production frontiers using the translog form indicate that foreign firms exploit economies of scale more optimally through their large scale and capital intensive production processes. In addition foreign firms are found to be significantly more (technical) efficient than domestic firms in all industries. The differences are found to be largest between foreign firms and single-nation Belgian firms, while Belgian MNEs resemble strikingly well the foreign subsidiaries active in Belgium in terms of returns to scale and efficiency. Together these results confirm the importance of firm specific advantages by MNEs. Firms self select and only the most efficient firms become MNEs (foreign as well as Belgian owned) as they know have to compensate their liability of foreigness.

JEL-codes: F23, L10, M20.
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1. *Introduction*

An early and robust finding in the international business literature is the higher productivity of multinational firms' affiliates relative to domestic firms in host countries; an observation that is typically explained by the importance of firm specific ownership advantages embedded in MNEs (Dunning (1970), Dunning and Pearce (1977), Haex (1979), Davies and Lyons (1991), Dunning (1993)). In contrast the industrial organization literature has only recently discussed firm heterogeneity in productivity. Following the development of theoretical models formalizing the concept of firm heterogeneity (Jovanovic (1982), Pakes and Ericson (1987), Jovanovic and Lach (1989), Hopenhayn (1992), Pakes and McGuire (1994), Ericsson and Pakes (1995)), the importance of heterogeneity in productivity has been extensively established in recent empirical work (Roberts and Tybout (1996), Bartelsman and Doms (2000)). These recent insights may qualify the evidence on the relative high productivity of MNEs' subsidiaries, as simple comparisons of productivity may then obscure differences in observable firm characteristics between MNEs and domestic firms. The first objective of this paper is to analyze productivity differences between foreign subsidiaries and domestic firms in Belgium, independent of other (observable) firm characteristics. Further on, while the focus of this paper is on the productivity differential between foreign MNEs' affiliates and domestic firms, throughout the paper also differences in productivity between single-nation Belgian owned firms (i.e. firms with no subsidiaries abroad) and Belgian-owned multinational firms will be discussed.

Size is typically assumed to be an important source of productivity differences between foreign firms and domestic firms, with foreign firms believed to exploit economies of scale more optimally. Productivity differences between foreign subsidiaries and domestic firms may additionally be explained by differences in technical efficiency between both groups of firms, if firm specific advantages cause foreign subsidiaries to attain higher output levels from a given input bundle of production factors. A second objective of this paper is then to analyze how differences in scale and technical efficiency contribute to differences in productivity between foreign firms and domestic firms. The limited empirical evidence reported only for developing countries thus far, points to a higher technical efficiency of MNEs relative to domestic firms (Pitt and Lee (1981) Sleuwaegen and Goedhuys (2000)).

The data for the empirical analysis come from a unique database of firms active in Belgium over the period 1990-1995, distinguishing between single-nation Belgian owned firms, Belgian MNEs abroad and subsidiaries of foreign MNEs. The database is constructed on the basis of the files of Central Balance Sheet Office which collects the annual reports (including balance statements and profit/loss accounts) for all firms active in Belgium. Consequently, this database includes a broad range of firm information on variables like net assets, employment, profit/loss… which are directly reported in the annual reports, but also other variables like value added, productivity, capital intensity, human capital intensity… which could be constructed on the basis of information in the annual reports. Since the Central Balance Sheet Office also assigned an industry code (NACE-CLIO nomenclature) to each firm, firms could easily be classified in industries. The data about foreign subsidiaries and Belgian MNEs came from the Federal Planning Office in Belgium, with foreign subsidiaries defined as firms that are at least 50% foreign owned, and Belgian MNEs defined as Belgian owned firms with at least one affiliate/subsidiary abroad.

2. The multinational firm (MNE) and heterogeneity in productivity

The existence of an aggregate production function based on the representative firm is the traditional presumption underlying the earlier literature on productivity (growth). Differences in productivity between firms were not allowed and productivity growth was assumed to occur through a shift in the production technology common to all firms in the industry. This research focused mainly on growth accounting and the estimation of factor demands using aggregate and/or industry data (see for an overview Nadiri (1970)). More recent research in industrial organization however has increasingly acknowledged the heterogeneity between firms, thereby shifting the unit of analysis towards the level of the individual firm (for an overview see Roberts and Tybout (1996), Bartelsman and Doms (2000))

Different theoretical models of industry dynamics have formalized firm heterogeneity in productivity, thereby linking productivity differentials to observable firm characteristics. By modeling an unknown and time-invariant efficiency level for individual firms, Jovanovic (1982) showed that firm productivity varies initially but eventually settles down to a constant level. As firms only learn about their true efficiency by effectively operating and producing, a process of natural selection arises whereby less efficient firms leave the industry while more efficient firms grow to their optimal size. This selection mechanism results in younger firms being on average smaller, more heterogeneous but less productive than older firms. In contrast to this ‘passive learning’ by firms, several models starting with Pakes and Ericson (1987) stressed the importance of ‘active learning’ by firms through investments in productivity enhancement (Jovanovic and Lach (1989), Pakes and McGuire (1994), Ericsson and Pakes (1995)). By endogeneizing efficiency and production costs, these models showed that high productive firms may experience losses in productivity because of the uncertainty of these investments. While reporting similar results for heterogeneity on the firm level Hopenhayn (1992) also discussed differences in productivity between industries. As such he demonstrated that industries characterized by large and sunk cost investments show larger dispersion in productivity, since higher fixed costs with a sunk cost character may act as a barrier to entry and exit while at the same time accommodating more low productive firms in the market.

Another source of heterogeneity has been largely discussed in the international business literature, as several researchers reported MNEs' affiliates to be more productive than domestic firms in host countries (Dunning (1970), Dunning and Pearce (1977), Haex (1979), Davies and Lyons (1991), Dunning (1993)). Given the distinctive characteristics of MNEs relative to domestic firms simple comparisons of the relative productivity of MNEs' affiliates and domestic firms may however obscure differences in firm characteristics. Globerman et al (1994) found no productivity differences between foreign-owned firms and Canadian-owned firms in Canada, after controlling for firm characteristics like age, size and capital intensity. In contrast, Doms and Jensen (1998) reported a significant residual productivity differential between foreign firms and US firms to exist, even after taking into account observable firm characteristics in combination with industry and location variables. The higher productivity of foreign firms supports the possession of firm specific advantages by MNEs; firms do not become multinational unless they are good at something (Caves (1996)).

Aggregate productivity figures for the manufacturing industry in Belgium support the general finding that foreign MNEs' affiliates show higher average levels of labor productivity[1] than Belgian firms (table 1). Since MNEs typically concentrate in higher productive industries (Howenstine and Zeile (1992, 1994), Dunning (1993), Caves (1996)), industry composition effects may bias these figures and consequently regression analysis was undertaken by pooling the observations over industries and over the years 1990 to 1995, and by including industry and year dummies. The results in table 2 indicate that foreign firms (FORMNE) in Belgium are on average 38% more productive than the average Belgian owned firms.

[1] Defined by value added divided by employment (in FTE), where value added figures are expressed in real terms using the price deflator for the whole manufacturing sector. This paper focuses on differences in labor productivity, given the difficulties (measurement error, availability of investment data on the firm level...) in computing total factor productivity (TFP). While TFP is nevertheless theoretically preferable, previous research on productivity showed that the basic insights are not

INSERT TABLES 1 AND 2 HERE

Distinguishing within the group of Belgian firms between single-nation Belgian firms and multinational Belgian-owned firms[2], shows that in line with the results of Doms and Jensen (1998), foreign subsidiaries are especially more productive relative to single-nation domestic firms. The productivity level of Belgian owned MNEs (BELMNE) is only slightly less than this of foreign MNEs' affiliates, illustrating the large heterogeneity within the group of Belgian owned firms.

According to the aforementioned theoretical models firm characteristics have been included in the subsequent analyses. The positive coefficient of firm age (AGE) supports the common prediction of the models of Jovanovic (1982) and Pakes and Ericsson 1987), namely that young firms are on average less productive than older firms. At the same time this finding contradicts a pure vintage capital model in which new firms embody the latest technology and consequently attain higher productivity levels. Also the positive coefficient of firm size (SIZE)[3] is consistent with the passive and active learning models of Jovanovic (1982) and Pakes and Ericsson (1987), since younger firms are also typically relatively small. Furthermore, the smaller scale of operation may prevent the full exploitation of scale economies resulting in lower productivity. In line with Pakes and Ericsson (1987), the results further suggest that firms are able to enhance their productivity through R&D-investments (RD)[4]. While R&D-investments may not bring the expected increase in productivity for individual firms given the typical uncertain character of these investments, it is expected that on average R&D-investments increase firm productivity. Further on, the importance of capital intensity (PHYSCAP)[5] in explaining productivity differences between foreign firms and domestic firms is also clearly demonstrated, in line with previous research showing that MNEs' affiliates employ more capital intensive methods than their indigenous competitors (see Dunning (1993) for an overview).

While firm characteristics seem to partially explain differences in productivity between firms, the large significant coefficient of FORMNE nevertheless indicate that there remains a

affected by using labor productivity instead of TFP, on the condition that the analysis controls for differences in capital intensity between firms.

[2] Defined as firms having at least one affiliate or subsidiary abroad.

[3] The variable SIZE is measured in terms of employment.

[4] The dummy-variable RD indicates that firms are investing in R&D-activities.

residual productivity differential between foreign firms and the average domestic (i.e. Belgian-owned) firm. The results for the FORMNE and BELMNE variable are furthermore largely consistent with the importance of firm specific advantages (marketing and managerial skills, product differentiation, proprietary technology…) in order for firms to become multinational.

3. ***Differences in scale and technical efficiency between foreign firms and domestic firms***

3.1 Productivity, economies of scale and technical efficiency

Size is typically assumed to be an important source of productivity differences between foreign firms and domestic firms, with foreign subsidiaries believed to exploit economies of scale more optimally. The typical large scale, capital intensive production processes of foreign firms are believed to incorporate larger opportunities for the realization of scale economies. Comparing firm characteristics between foreign firms and domestic firms indeed suggests that consistent with previous research (see for an overview Dunning (1993)), foreign subsidiaries in Belgium use larger scale and higher capital intensive production processes than domestic firms (table 3). However, the large residual productivity between foreign firms and domestic firms found in the regressions even after taking into account observable firm characteristics (table 2), suggests that scale is not the only reason for the productivity differential between foreign firms and domestic firms. Productivity between firms also varies if some firms are able to attain higher levels of outputs from a given input of production factors. This is captured by the concept of technical efficiency that measures to what extent the maximum potential output is realized given the bundle of inputs and the observed scale[6]. While productivity is expressed as the (average) ratio of output over input(s), efficiency compares the observed to the optimal values of production.

INSERT TABLE 3 HERE

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[5] The variable PHYSCAP is defined as physical fixed assets over employment.
[6] Debreu (1951) and Farrel (1957) introduced the first measures of technical efficiency, based on the formal definition by Koopmans (1951).

This paper hypothesizes that foreign firms since they tend to be larger than the average domestic firm, should be better able to take advantage of potential scale economies. While previous research showed that MNEs are typically active in industries most subject to economies of scale (Horst (1972), Pugel (1981), Dunning (1993), Caves (1996)), no evidence is however found about the scale advantage of MNEs within industries. Further on following the theory of the multinational firm, this paper also hypothesizes that foreign subsidiaries are more efficient than single-nation domestic firms, reflecting the importance of firm specific advantages transferred across borders within MNEs. Firms self-select and only the most efficient foreign firms become multinational (Caves (1996)) since they know international production involves extra costs (i.e. liability of foreigness). Ownership advantages enables them to overcome the competitive disadvantages of operating in a foreign environment, despite additional investments (e.g. in communication facilities) which have no direct 'productive' use (Hymer (1970)).

3.2 The basic model

In order to test these hypotheses, the production frontier has been estimated on the level of individual industries using the stochastic frontier approach[7]. In contrast to the so-called deterministic frontier models (including the technique of Data Envelopment Analysis (DEA)), the stochastic approach is able to discriminate between inefficiency and statistical noise (i.e. due to factors outside the control of firms). In order to prevent mistakes of specifying the wrong parametric production function, a translog function has been used for estimating the industry production frontiers (Christensen et al (1973), Kim (1992)). In contrast to other production function like Cobb-Douglas, CES… this form is not restricted to be homothetic and allows for flexible substitution elasticities between input factors[8]. Furthermore the translog function, which can be represented as a second order approximation to any arbitrary production function, allows for returns to scale to vary over the input domain. Given the large differences in production processes of foreign firms and domestic firms, the assumption of fixed substitution elasticities and economies of scale may be too restrictive.

With the production function representing the technology of the industry and collecting all the technically efficient methods/techniques of production, the industry stochastic frontier has

[7] Developed by Aigner, Lovell and Schmidt (1977) and Meeusen and Van Den Broeck (1977); see for an overview Fried, Lovell and Schmidt (1993), and Cornwell and Schmidt (1996).
[8] Consequently, the optimal capital-labor ratios may differ between large (MNE) firms and small (domestic) firms.

been estimated on firm-level (i-index) panel data (t-index) with production factors capital and labor, is then expressed as:

$$\begin{aligned} \ln(VA_{i,t}) = {} & b_0 + b_1\ln(CAP_{i,t}) + b_2\ln(EMPL_{i,t}) + b_3 TIME + \\ & b_4(1/2)*[\ln(CAP_{i,t})]^2 + b_5(1/2)*[\ln(EMPL_{i,t})]^2 + b_6\ln(CAP_{i,t})*\ln(EMPL_{i,t}) + \\ & b_7\ln(CAP_{i,t})*TIME + b_8(EMPL_{i,t})*TIME + b_9(1/2)*TIME^2 + \\ & v_{i,t} - u_i \end{aligned} \tag{1}$$

where $VA_{i,t}$ is the deflated value added of firm i in year t, , $CAP_{i,t}$ the deflated capital stock, $EMPL_{i,t}$ employment expressed in FTE, TIME a time trend, $v_{i,t}$ a two sided i.i.d. error representing random factors and u_i being a non-negative one-sided error capturing technical inefficiency of firm i[9].

Expression (1) has been estimated for 17 individual industries (NACE-2) using firm data for the years 1990-1995; the Hausman-test indicated that fixed effects panel estimation is favored above random effects panel estimation because of consistency reasons since regressors may be correlated with the disturbances $v_{i,t}$. Using fixed effects panel estimation also avoids making a distibutional assumption for the non-negative error term u_i capturing technical inefficiency at the firm level.

A first range of tests indicated that the translog form is appropriate in estimating the production frontier on the industry level; the hypothesis that the coefficients of the second order terms in expression (1) were 0, was rejected in 15 industries out of the 17 industries[10]. The less flexible forms like Cobb Douglas and CES production functions typically used in most empirical work may then report biased results.

In order to check if the production technology in an industry could be modeled by the same production function for all firms together, additionally a Chow test (1960) was done to identify differences between foreign subsidiaries, single-nation Belgian owned firms and Belgian-owned. While in 3 industries differences in production technology between foreign firms and domestic firms (single-nation Belgian firms and Belgian MNEs) were found on the 0.001 significance level, the estimation of the production frontier for the group of foreign subsidiaries separately in these industries resulted in implausible results. Since these results seem to be attributed to the relative low number of foreign subsidiaries in these particular industries, in the following of this paper production frontier has been estimated for all firms

[9] Using panel data in estimating expression (1) guarantees that more precise estimates are obtained for firm technical inefficiency but this at the expense of another assumption, namely that firm efficiency does not vary over time. The relatively short time period considered makes that this assumption is however not too restrictive.

together for all industries. As such, all firms in an industry were found to chose from a common set of production techniques, nevertheless the apparent different characteristics (in scale, capital intensity…) between foreign firms and domestic firms. The large flexibility of the translog function with respect to economies of scale and substitution elasticities (and in addition the panel fixed effects estimation), allow important differences between firms to exist.

Table 4 presents the estimation results for the production frontiers of the 17 industries. While the TIME-variable is essentially included to capture disembodied technical change, the negative coefficient of this variable for several industries suggests that TIME merely picks up capacity utilization effects changing during the considered time period. The years 1993 and 1994 were characterized by a significant slowdown in the demand for manufactured products, resulting in a large capacity staying idle. As the industry production frontier measures the maximum attainable output for the different bundles of production factors, economies of scale are computed on the basis of the output elasticities for the different input factors, while technical efficiency is determined by the deviation of the individual firms from this production frontier.

INSERT TABLE 4 HERE

In order to test that foreign firms are better able to exploit economies of scale more optimally, returns to scale are computed for each firm i in year t following Tybout and Westbrook (1995):

$$\text{Returns to scale}_{i,t} = b_1 + b_2 + (b_4 + b_6)*\ln(CAP_{i,t}) + (b_5 + b_6)*\ln(EMPL_{i,t}) + (b_7 + b_8)*TIME \qquad (2)$$

This returns to scale index is averaged across years for each individual firm and then averaged again separately for the group of foreign MNEs' affiliates and domestic firms (table 5). The results suggest that the relatively small scale of domestic firms prevent them to realize important economies of scale; the translog form allows economies to scale to vary over the

[10] The results indicated that in the industries office-data machinery and other transport a Cobb-Douglas production function is appropriate.

input domain and shows that below a certain scale of operation decreasing returns to scale prevail. Domestic firms seem to be unable to expand their size beyond this scale, while foreign firms typically operate beyond this scale and hence are better able to exploit economies of scale. The average returns to scale index for foreign firms is significantly larger and closer to 1 than this for domestic firms; in several industries this index was not significantly different from 1 indicating that foreign firms operate in the region of constant returns to scale. These results lend support for our first hypothesis and show that the superior productivity of foreign firms is partially attributable to the larger scale of operation of foreign subsidiaries.

INSERT TABLE 5 HERE

In order to test the hypothesis that foreign MNEs' affiliates are more efficient than domestic firms, technical inefficiency is computed by averaging the yearly deviations of the firm's output level from the industry production frontier. The levels of technical inefficiency are computed by normalizing the production frontier in terms of the best (i.e. most efficient) firm in the sample since firm inefficiency (u_i) is calculated on the basis of the estimated fixed panel effects (a_i) (Cornwell and Schmidt (1996)):

$$u_i = \max(a_i) - a_i \qquad (3)$$

INSERT TABLE 6 HERE

The results in table 6 show that as hypothesized foreign firms are more (technically) efficient than the average domestic firm, with in some industries the level of inefficiency for domestic firms almost doubling that for foreign firms. In all industries the level of technical inefficiency is significantly lower for foreign firms than for (all) domestic firms. Doing a non-parametric-test based on the ranking of firms according to their deviation from the base industry frontier confirms these results; the null-hypothesis that foreign firms and domestic firms were equally distributed in the ranking of firms was rejected in all 17 industries with foreign firms found to be located significantly closer to the production frontier.

In addition to this higher level and rank of technical efficiency, the results also show that the dispersion in inefficiency is significantly smaller among foreign firms than among domestic firms. These findings support the hypothesis that foreign firms have to be highly efficient in order to overcome their competitive disadvantage of operating in a foreign environment. The results suggest that only the most efficient firms become multinational and that additional investments and costs of operating in a foreign country do not result in a lower efficiency relative to domestic firms.

The larger variance within the group of domestic firms is (partially) explained by the differences between single-nation Belgian owned firms and Belgian MNEs. The results in table 7 indicate that Belgian MNEs are significantly more efficient than their single-nation competitors, while their efficiency is not statistically different from the efficiency level of foreign subsidiaries in Belgium, suggesting that Belgian MNEs resemble more foreign subsidiaries than single-nation Belgian firms. Likewise, important differences in returns to scale are found to exist between Belgian MNEs and single-nation Belgian owned firms, while the exploitation of economies of scale appears to be the same between Belgian MNEs and foreign subsidiaries. Together these results confirm the stated hypothesis about returns to scale and technical efficiency, and indicate that the importance of firm specific ownership advantages for firms (be it Belgian owned or foreign owned) to become multinational (Caves (1996)).

INSERT TABLE 7 HERE

A firm-specific inefficiency model

In order to analyze the specific effect of multinationality on technical efficiency independent of other firm characteristics, a so-called firm-specific efficiency model is estimated. The objective is to identify systematic differences in technical efficiency among heterogeneous groups of firms within industries. Following Reifschneider and Stevenson (1991), the stochastic (base) production frontier of the preceding analysis is enlarged with extra regressors indicating firm characteristics[11]. Hence the inefficiency level u_i is decomposed in systematic influences related to specific firm characteristics ($Z_{i,t}$) and one non-negative random error w_i capturing the residual unexplained firm technical inefficiency:

$$u_i = g(Z_{i,t}, b) + w_i \quad (4)$$

Assuming that firm characteristics only affect the level of technical efficiency thereby shifting the production frontier up- or downwards, the firm-specific efficiency model becomes:

$$\begin{aligned} \ln(VA_{i,t}) = {} & b_0 + b_1\ln(CAP_{i,t}) + b_2\ln(EMPL_{i,t}) + b_3TIME + \\ & b_4(1/2)*[\ln(CAP_{i,t})]^2 + b_5(1/2)*[\ln(EMPL_{i,t})]^2 + b_6\ln(CAP_{i,t})*\ln(EMPL_{i,t}) + \\ & b_7\ln(CAP_{i,t})*TIME + b_8(EMPL_{i,t})*TIME + b_9(1/2)*TIME^2 + \\ & b_{10}\ln(AGE_{i,t}) + b_{11}DUMRD_i + b_{12}FORMNE_i + b_{13}BELMNE_i \\ & v_{i,t} - w_i \end{aligned} \quad (4)$$

The base production frontier is enlarged with the firm characteristics that were also discussed in the analysis of the average labor productivity, except for firm size and capital intensity whose effects are captured in the input factors capital and labor. Following Jovanovic's model (1982) of passive learning and competitive selection, age is hypothesized to shift the (firm specific) production frontier upwards[12]. Since firms only learn about their true efficiency level over time, young and smaller firms are on average less efficient than older firms; the less efficient firms in the successive entry cohorts will exit while the more efficient will survive and grow. According to the active learning model of Pakes and Ericson (1987), the variable DUMRD is also hypothesized to positively affect firm efficiency, as R&D investments are expected to increase the technical efficiency of firms.

If foreign subsidiaries are highly efficient in order to compensate for their liability of foreigness, it is expected that the foreign-owned variable (FORMNE), indicating if a firm is foreign owned, shifts upwards the firm specific production frontier even after controlling for other firm characteristics. While several studies analyzed the link between MNEs and productivity, the effect of multinationality on efficiency has only received little attention. Pitt

[11] Another approach, frequently used in the literature, estimates first the technical inefficiency of individual firms, and regress these estimates then on firm characteristics by OLS. This approach however may lead to biased results in the first step (because of omitted variable bias) and in the second step (estimated u_i is one-sided).

[12] Jovanovic's model is originally formulated in terms of a time-invariant cost efficiency parameter; given the absence of input factors and input prices in this model and because of the assumption that

and Lee (1981) reported in their analysis of the Indonesian weaving industry that foreign firms are more efficient while also Sleuwaegen and Goedhuys (2000) found a positive effect for European firms in the manufacturing industry of Côte d'Ivoire. Given the significant differences in efficiency between single-nation Belgian owned firms and Belgian MNEs, also a dummy variable indicating if a Belgian firm has subsidiaries abroad (BELMNE), has been included.

The firm specific efficiency model in expression (4) is again estimated for the 17 individual industries; given that time-invariant were included (FORMNE, BELMNE and DUMRD), random effects panel estimation was necessary. While simultaneity problems due to correlation between input levels and firm inefficiency w_i[13] may arise using these estimator, Schmidt and Sickles (1984) pointed out that the random effects model is most suitable for short panels

While firm characteristics like age and R&D-investment contribute to the dispersion of technical efficiency between firms, the significance and the size of the coefficients of the FORMNE- and BELMNE-variables clearly show the importance of multinationality in explaining firm-level differences in efficiency (table 8). The firm specific production frontier model largely confirms the significant differences found between the simple comparison of the levels of technical efficiency between foreign firms and domestic firm in table 6. In 13 out of the 17 industries foreign firms are more efficient than single-nation domestic firms even after controlling for other firm characteristics. The results clearly confirm the central hypothesis of this paper that foreign firms are highly efficient since they know they have to compensate for their liability of foreigness in order to compete successfully in a foreign environment. The evidence for the differences in efficiency between single-nation Belgian owned firms and Belgian MNEs is somewhat weaker, as the coefficient of BELMNE-variable is only positive significant in 5 out of the 14 industries where Belgian MNEs were active.

The results largely confirm the passive learning hypothesis, as in 10 industries age is reported to have a positive effect on technical efficiency. Again the results contradict a pure vintage capital model whereby young firms embody the latest technology and are consequently more efficient than older incumbents (like in a pure capital vintage models). Also the active learning hypothesis finds support as the results for the DUMRD variable show that in 10 industries doing R&D shifts the production frontier upwards. The binary character of the

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efficiency differences between firms exist irrespective of the scale of operation, cost efficiency can be interpreted as technical efficiency.

R&D-variable, which only indicates if a firm is permanently investing in R&D, may explain the insignificance of this variable in the other industries. In order to assess the contribution of R&D to firm efficiency more accurately, information about the type of R&D (fundamental versus applied, product versus process) and R&D-budgets is necessary.

INSERT TABLE 8 HERE

5. Conclusion

In analyzing firm productivity and efficiency in Belgium, this paper empirically shows that foreign firms are significantly more productive than domestic. Large differences in productivity between foreign subsidiaries and domestic firms exist even after controlling for other firm. However, , once one distinguishes between single-nation Belgian owned firms and Belgian MNEs, it becomes clear that the group of domestic firms is in itself heterogeneous with foreign subsidiaries especially more productive than single-nation domestic firms. The results further show that consistent with theoretical models formalizing firm heterogeneity in productivity, older, larger and R&D-active firms are on average more productive.

The productivity differential between foreign firms and domestic firms is explained by differences in scale and technical efficiency. Stochastic production frontiers using the translog form indicate that foreign subsidiaries exploit economies of scale more optimally through their large scale and capital intensive production processes. In addition foreign firms are found to be significantly more (technical) efficient than domestic firm in all industries, with foreign firms to be located significantly closer to the production frontier. Furthermore the dispersion of inefficiency among foreign firms is much smaller relative to domestic firms. Again the differences are found to be largest between foreign firms and single-nation Belgian firms, while Belgian MNEs resemble strikingly well the foreign subsidiaries active in

[13] It can be expected that highly efficient firms are more likely to expand; another source of correlation is measurement error in the explanatory variables.

Belgium in terms of returns to scale and efficiency. Together these results confirm the importance of firm specific advantages by MNEs. Firms self select and only the most efficient firms become MNEs (foreign as well as Belgian owned) as they know have to compensate their liability of foreigness.

While this paper relates productivity differences to differences in efficiency and specific firm characteristics, more research is needed in order to identify the exact sources of these efficiency differences between MNEs and domestic firms. Analyzing how and why MNEs are able to create firm specific advantages is a future direction of research in analyzing differences not only between MNEs and domestic firms, but also between MNEs themselves.

Further on, this paper focused on the differences in productivity and efficiency within the group of foreign subsidiaries and domestic firms separately, but did not analyze the effect the presence of foreign firms may have on the performance of domestic firms. The literature has reported positive spillovers of foreign direct investment on the productivity of domestic firms especially in industrializing countries. Data availability only for a rather short time period did not allow to do a similar analysis for an industrialized country as Belgium.

Table 1: Differences in labor productivity[14], domestic firms and foreign firms

	domestic firms	***foreign firms***
1990	1739	2350
1991	1643	2246
1992	1742	2464
1993	1696	2374
1994	1793	2628
1995	1808	2707

[14] In millions BEF.

Table 2: Differences in productivity between domestic firms and foreign firms, OLS results[15]

N = 100002	***PROD*[16] *All firms***	***PROD*[17] *All firms***	***PROD*[23] *All firms***
CONSTANT	7.284 (0.029)	7.267 (0.029)	5.807 (0.028)
FORMNE	0.383 (0.009)	0.386 (0.009)	0.161 (0.009)
BELMNE		0.325 (0.024)	0.122 (0.022)
SIZE			0.046 (0.001)
PHYSCAP			0.194 (0.001)
AGE			0.023 (0.002)
RD			0.059 (0.009)
INDUSTRYDUMMIES	Yes	Yes	Yes
YEARDUMMIES	Yes	Yes	Yes
R^2	0.081	0.083	0.262

All coefficients are different from zero at the 0.0001 significance level

[15] Productivity (PROD), size (SIZE), capital intensity (PHYSCAP) and age (AGE) are all expressed in logarithmic form.
[16] The reference group is the whole group of domestic firms (all Belgian owned firms).
[17] The reference group is the group of single-nation Belgian owned firms.

Table 3: Labor productivity, capital intensity and average in individual industries, Belgium, 1995

	Labor productivity[18]		Capital intensity[19]		Scale (net assets)[20]		Scale (employment)[21]		Share in total[22]	Foreign
	Average	Foreign firms/ domestic firms	Average	Foreign firms/ domestic firms	Average	Foreign firms/ domestic firms	Average	Foreign firms/ domestic firms	manufacturing	presence
Iron and steel	2.698	1.306	2.594	1.646	954	3.865	368	2.348	0.066	0.427
Non-ferrous metals	2.401	1.199	2.110	0.710	442	12.837	209	17.441	0.018	0.893
Extraction of minerals	3.092	1.000	2.408	0.879	63	5.895	26	6.705	0.010	0.352
Non-metallic minerals	2.268	1.386	1.880	1.444	63	19.618	33	13.852	0.059	0.551
Chemicals	3.592	1.221	3.556	1.172	463	6.199	130	5.291	0.173	0.688
Pharmaceuticals	4.659	2.740	2.241	1.613	332	17.899	148	11.098	0.040	0.937
Metal articles	1.697	1.287	1.013	1.521	20	16.078	20	10.572	0.074	0.325
Mechanical engineering	1.918	1.208	0.865	1.414	35	14.738	41	10.423	0.055	0.572
Office-data machinery	1.621	1.053	0.628	1.096	11	6.530	17	5.957	0.002	0.355
Electrical engineering	2.246	1.313	0.697	1.675	57	25.814	82	15.412	0.074	0.760
Motor vehicles	2.078	1.634	1.056	1.480	158	35.920	150	24.269	0.060	0.857
Other transport	1.587	1.324	0.726	0.981	42	30.833	58	31.475	0.011	0.745
Instruments	1.909	1.630	0.855	1.765	13	49.930	15	28.296	0.008	0.640
Food and drink	2.288	1.271	2.014	1.162	54	13.886	27	11.948	0.131	0.379
Tobacco	2.711	1.129	1.445	1.514	164	27.108	113	17.910	0.006	0.876
Textiles	1.449	0.978	1.113	0.902	46	4.812	42	5.337	0.042	0.169
Leather and footwear	1.189	2.265	0.483	1.163	10	11.555	21	10.200	0.019	0.249
Timber and wood	1.417	1.063	0.922	0.903	14	5.164	15	5.721	0.029	0.061
Paper, printing, publish.	2.129	1.519	1.577	1.660	29	17.935	18	10.802	0.080	0.339
Rubber and plastics	2.034	1.122	1.483	1.256	62	11.153	42	8.883	0.039	0.574
Other	1.292	1.068	0.660	0.973	7	16.500	10	17.289	0.005	0.204
Total manufacturing	2.226	1.467	1.600	1.411	54	20.111	34	14.016	1.000	0.532

18 Defined as value added (1990 prices) in millions BEF over employment (FTE); weighted average over firms with employment weights since total industry (manufacturing) value added is divided by total industry (manufacturing) employment.
19 Defined as net assets in millions BEF over employment (FTE); weighted average over firms with employment weights since total industry (manufacturing) net assets are divided by total industry (manufacturing) employment.
20 Defined as net assets in millions BEF over the number of firms.
21 Defined as employment (FTE) over the number of firms.
22 In terms of value added.

Table 4: Base production frontier, panel fixed effects results

(number of firms)	***CAP***	***EMPL***	***TIME***	CAP^2	$EMPL^2$	***CAP*EMPL***	$TIME^2$	***TIME*CAP***	***TIME*EMPL***	*Log Likelihood*
Iron and steel (162)	0.029	0.373*	-0.189**	0.017	0.101*	-0.037	0.037**	0.016	-0.015	-276
Extraction of minerals (189)	0.183**	0.451**	0.212	0.018*	0.028	-0.056	-0.003	0.022*	-0.022	-390
Non-metallic minerals (1254)	0.076**	0.504**	-0.064**	0.001	0.040**	-0.002	0.010**	0.012**	-0.004	-949
Chemicals (740)	0.088**	0.488**	-0.019	0.009	0.065**	-0.046**	0.009**	0.017**	-0.018**	-814
Metal articles (3756)	0.130**	0.594**	-0.073**	0.012**	0.027**	-0.037**	0.013**	0.012**	-0.008**	-1362
Mechanical Engineering (1210)	0.056*	0.596**	-0.082**	-0.009*	0.044**	0.006	0.015**	0.012**	-0.007	-915
Office- data machinery (135)	0.154*	0.745**	0.028							-283
Electrical engineering (955)	0.057*	0.560**	-0.041*	0.005	0.034*	-0.006	0.009**	0.005	-0.001	-921
Motor vehicles (332)	0.104*	0.551**	-0.068*	0.017*	0.073**	-0.053*	0.014**	0.021**	-0.014	-304
Other transport (210)	0.192**	0.702**	0.003							-278
Instruments (453)	0.070*	0.350**	-0.015	-0.001	0.060*	-0.015	0.004	0.012*	-0.002	-398
Food, drink, tobacco (3664)	0.065**	0.467**	-0.026	0.009**	0.035**	-0.018	0.006**	0.012**	-0.008**	-2645
Textiles (1239)	0.114**	0.696**	-0.018	0.021**	0.022*	-0.029**	0.005*	0.014**	-0.017**	-1483
Leather and footwear (1527)	0.162**	0.627**	-0.035	0.012**	0.018**	-0.042**	0.003	0.014**	-0.006	-1747
Timber and wood (2371)	0.143**	0.535**	-0.035**	0.019**	0.101*	-0.043**	0.007**	0.011**	-0.009**	-1641
Paper, printing, publish. (3658)	0.173**	0.385**	-0.038**	0.013**	0.075**	-0.055**	0.008**	0.006**	-0.001	-2691
Rubber and plastics (786)	0.129**	0.602**	-0.022	0.012**	0.034*	-0.040**	0.009**	0.023**	-0.023**	-406

*: $p < 0.001$; **: $p < 0.01$

Table 5: Returns to scale, domestic firms and foreign firms

	RETURNS TO SCALE		
	domestic firms	***foreign firms***	***Δ in scale***
Iron and steel	0.876	1.422	****
Extraction of minerals	0.816	0.992 [a]	***
Non-metallic minerals	0.761	0.968 [a]	****
Chemicals	0.692	0.838	****
Metal articles	0.752	0.757	**
Mechanical Engineering	0.811	0.980 [a]	****
Office- data machinery	0.899	0.899	
Electrical engineering	0.731	0.963	****
Motor vehicles	0.827	1.065	****
Other transport	0.895 [a]	0.895 [a]	
Instruments	0.592	1.014 [a]	****
Food, drink, tobacco	0.679	0.923	****
Textiles	0.864	0.937	****
Leather and footwear	0.786	0.734	***
Timber and wood	0.767	0.870	****
Paper, printing, publish.	0.678	0.850	****
Rubber and plastics	0.752	0.784	****

[a]: not different from 1 on the 0.01 significance level;

****: $p < 0.0001$; ***: $p < 0.001$; **: $p < 0.01$; *: $p < 0.05$

Table 6:Technical inefficiency, domestic firms and foreign firms

	AVERAGE LEVEL OF TECHNICAL INEFFICIENCY				***DISPERSION OF TECHNICAL INEFFICIENCY[23]***		
	domestic firms	***foreign firms***	***Δ in level***	***Δ in rank (Wilcoxon-test)***	***domestic firms***	***foreign firms***	***Δ in level***
Iron and steel	2.275	1.952	*	**	0.721	0.841	
Extraction of minerals	2.566	1.632	***	****	0.928	0.711	
Non-metallic minerals	2.047	1.353	****	****	0.702	0.506	***
Chemicals	4.193	2.924	****	****	0.832	0.576	****
Metal articles	2.622	1.706	****	****	0.639	0.477	****
Mechanical Engineering	2.135	1.698	****	****	0.643	0.472	****
Office- data machinery	1.391	0.927	*	*	0.666	0.344	*
Electrical engineering	1.878	1.050	****	****	0.718	0.339	****
Motor vehicles	1.727	1.273	****	****	0.646	0.320	****
Other transport	3.885	3.102	***	***	0.794	0.855	
Instruments	2.334	0.785	****	****	0.875	0.314	****
Food, drink, tobacco	2.660	1.597	****	****	0.728	0.466	****
Textiles	1.972	1.648	****	****	0.627	0.445	**
Leather and footwear	2.562	1.689	****	****	0.667	0.655	
Timber and wood	2.741	2.081	****	****	0.670	0.307	****
Paper, printing, publish.	3.855	2.786	****	****	0.775	0.628	**
Rubber and plastics	1.803	0.902	****	****	0.675	0.412	****

****: p < 0.0001; ***: p < 0.001; **: p < 0.01; *: p < 0.05

[23] Dispersion = standard deviation

Table 7:Returns to scale and technical inefficiency, domestic firms (Belgian MNEs and single-nation Belgian owned firms)[24]

	RETURNS TO SCALE			***AVERAGE LEVEL OF TECHNICAL INEFFICIENCY***		
	single-nation Belgian firms	***Belgian MNEs***	***Δ in scale***	***single-nation Belgian firms***	***Belgian MNEs***	***Δ in level***
Iron and steel	0.847	1.566 [b]	****	2.492	2.266 [b]	
Non-metallic minerals	0.758	0.925 [a b]	****	2.056	1.347 [b]	****
Chemicals	0.689	0.812 [b]	****	4.212	3.334	***
Metal articles	0.752	0.754 [b]		2.625	1.814 [b]	****
Mechanical Engineering	0.809	0.990 [a b]	****	2.138	1.866 [b]	**
Office- data machinery	0.899	0.899 [b]		1.405	0.807 [b]	
Electrical engineering	0.730	0.878 [b]	***	1.882	1.096 [b]	****
Food, drink, tobacco	0.678	0.899 [b]	****	2.664	1.716 [b]	****
Textiles	0.863	0.937 [b]	****	1.978	1.495 [b]	**
Leather and footwear	0.786	0..724 [b]	***	2.565	1.671 [b]	**
Timber and wood	0.767	0.877 [b]	****	2.744	2.033 [b]	**
Paper, printing, publish.	0.678	0.871 [b]	****	3.858	2.859 [b]	****
Rubber and plastics	0.757	0.773 [b]		1.808	1.023 [b]	***

[a] : not different from 1 on the 0.01 significance level;
[b] : not different from foreign subsidiaries
****: $p < 0.0001$; ***: $p < 0.001$; **: $p < 0.01$; *: $p < 0.05$

[24] No Belgian owned MNEs were found in the industries: extraction of minerals, motor vehicles, other transport, instruments.

Table 8: Firm specific production frontier, panel random effects results

(number of firms)	***CONSTANT***	***CAP***	***EMPL***	***TIME***	***CAP²***	***EMPL²***	***CAP*EMPL***	***TIME²***	***TIME*CAP***	***TIME*EMPL***	***AGE***	***DUMRD***	***FORMNE***	***BELMNE***
Iron and steel (162)	0.435**	0.225*	0.773**	-0.137	0.039**	0.078**	-0.113**	0.035**	0.023*	-0.030	-0.041	0.135	0.302**	0.236
Extraction of minerals (189)	0.775**	0.278**	0.550**	0.030	0.025**	0.079**	-0.090**	-0.004	0.018**	-0.018*	0.165	0.333	0.287	
Non-metallic minerals (1254)	0.497**	0.126**	0.541**	-0.085*	0.007**	0.046**	-0.018**	0.010**	0.009**	0.001	0.158**	0.321**	0.400**	0.431*
Chemicals (740)	0.494**	0.172**	0.630**	-0.033*	0.018**	0.066**	-0.064**	0.009**	0.013**	-0.012**	0.067**	0.276**	0.644**	0.393*
Metal articles (3756)	0.561**	0.136**	0.562**	-0.102**	0.012**	0.028**	-0.038**	0.013**	0.010**	-0.002**	0.183**	0.584**	0.702**	0.608**
Mechanical Engineering (1210)	0.417**	0.209**	0.850**	-0.082**	0.010**	0.025**	-0.045**	0.016**	0.028	-0.001	0.001	0.046	0.189**	-0.006
Office- data machinery (135)	0.211	0.177**	0.837**	0.008							0.070	0.114	0.131	0.077
Electrical engineering (955)	0.311**	0.083**	0.580**	-0.028**	0.007**	0.037**	-0.127*	0.001	0.002	0.006**	0.238**	0.422**	0.348**	0.298
Motor vehicles (332)	0.255**	0.225**	0.771**	-0.109**	0.029**	0.058**	-0.087**	0.007	0.012	-0.009	0.321	0.114	0.223**	
Other transport (210)	0.329*	0.115**	0.970**	0.001							0.034	-0.024	0.329*	
Instruments (453)	0.287**	0.090**	0.245**	-0.047**	0.005	0.066**	-0.014**	0.004**	0.008**	0.004	0.183**	0.660**	0.801**	
Food, drink, tobacco (3664)	0.280**	0.122**	0.507**	-0.055**	0.016**	0.046**	-0.017**	0.005**	0.009**	-0.001	0.181**	0.331**	0.514**	0.463**
Textiles (1239)	0.195**	0.260**	0.800**	-0.036	0.032**	0.012*	-0.051**	0.008*	0.001	-0.001	0.002	0.051	0.067	0.131
Leather and footwear (1527)	0.096**	0.190**	0.630**	-0.053**	0.014**	0.028**	-0.045**	0.002*	0.012**	-0.001	0.138**	0.487**	0.533**	0.607
Timber and wood (2371)	0.543	0.295**	0.819**	-0.043**	0.029**	0.038**	-0.081**	0.005*	-0.001	0.006	0.038**	0.126*	0.044	0.086
Paper, printing, publish. (3658)	0.236**	0.306**	0.763**	-0.049**	0.033**	0.060**	-0.102**	0.009**	-0.001	0.010**	0.035**	0.126*	0.245**	0.109
Rubber and plastics (786)	0.343**	0.177**	0.646**	0.002	0.016**	0.039**	-0.051**	0.004	0.018**	-0.014**	0.176**	0.411**	0.441**	0.641*

*: $p < 0.001$; **: $p < 0.01$

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