Foreign direct investment and productivity analysis

Sophia Dimelis

Department of Informatics
Athens University of Economics and Business
76 Patission Street
10434 Athens, Greece
Email: dimelis@aueb.gr

Helen Louri

Department of Economics
Athens University of Economics and Business
76 Patission Street
10434 Athens, Greece
Email: lourie@aueb.gr

ABSTRACT

This study analyzes the production efficiency gains in terms of technology transfer and labour productivity changes caused by diverse degrees of foreign ownership using a sample of 4056 manufacturing firms operating in Greece in 1997. Departures from normality of labour productivity and its logarithm led to the adoption of the robust technique of quantile regression. Interesting results include a positive effect on labour productivity of foreign ownership, which stems exclusively from full and majority owned affiliates and becomes significant only in the middle quantiles. Productivity spillovers benefiting local firms are also differentiated, with minority holdings exercising a stronger effect in most quantiles.

JEL classification: F23; O30.

Keywords: productivity, spillovers, multinationals, FDI.

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1. Introduction

Foreign direct investment (FDI) is a welcome event in many host countries in the hope that foreign firms use advanced technology in both their production and distribution processes, which makes them more efficient than domestic firms. Technology, being the proprietary asset foreign firms want to exploit by investing abroad, has certain public good qualities, which cannot be fully internalized. Even wholly owned foreign affiliates produce externalities benefiting local firms, through training local employees hired next by domestic firms and thus enhancing success of technology imitation or simply through backward and forward linkages. In partially owned affiliates technology can be more easily copied by the domestic partners and diffused in the domestic sector. Potential increases in local competition following foreign entry may also be considered as externalities contributing to productivity spillovers.

Blomstrom and Kokko (1998) argue that productivity spillovers occur when multinational firm (MNF) affiliates "lead to productivity or efficiency benefits in the host country's local firms" (p. 249). They put forward three reasons for which such spillovers may be important. Due to imperfections in the market for technology leading to high transaction costs, MNFs often prefer to produce internationally rather than license their products. Hence, the only way for local firms to gain access to higher technologies is through attracting skilled employees from MNFs or reverse engineering. A second reason is that technology diffusion is found to be principally affected by direct contact, which is encouraged by foreign entry. Finally, the industries, which MNFs select, are usually characterized by high entry barriers due to high capital, technology and marketing intensity. Competition is reduced in such industries and subsequently inefficiencies arise. MNFs possess the necessary qualifications for a successful entry bringing along increased competition and subsequently forcing domestic firms to become more efficient.

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The purpose of this paper is to examine the role of foreign presence in enhancing efficiency, testing first the hypothesis that the ownership structure adopted by the MNFs causes different productivity shifts, as suggested in the literature.[2] Then, productivity spillovers are analyzed and their relationship to the ownership structure is also explored. In addition to the usual productivity determinants, the consequences of financial structure on the efficiency of firms are also taken into account.

As a first step, the empirical distribution of productivity is analyzed and is found to be highly skewed with a long right tail. Formal testing leads to a rejection of the usual assumption of normality or lognormality of labour productivity. In this case the use of least squares to estimate the conditional labour productivity function would yield coefficient estimates not representative of the entire firm distribution. For this reason, the quantile regression technique is employed as more appropriate. Namely, by estimating conditional quantile equations, we are able first to test for differences in the effects exerted on productivity by independent variables at various quantiles and second to take into account any possible bias due to long tails and unobserved heterogeneity among firms. The estimates of this technique are considered robust as opposed to the inefficient estimates produced by standard least squares.

Our empirical findings, based on a sample of 4056 manufacturing domestic and foreign firms producing in Greece in 1997, challenge the Blomstrom and Sjoholm (1999) conclusion that the degree of foreign involvement does not matter. Explanations for the contrasting results are to be found in the different degree of economic development between the economies examined and the different methodology used, which in our case produced more detailed results. Thus, policy suggestions with regard to attracting FDI cannot be generalized, but should take into account the development stage of an economy as well as the productivity distribution involved and the selected objectives.

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[2] There is a large literature on the relative performance of foreign vs. domestic firms and the resulting efficiency benefits. But the distinction between ownership shares and their different effects on efficiency is, to our knowledge, made only by Blomstrom and Sjoholm (1999).

The rest of the paper is organized as follows: section 2 analyzes the theoretical framework underlying our empirical analysis, section 3 presents the data, section 4 explains the quantile regression model and section 5 discusses the empirical findings. Finally, section 6 concludes.

2. Theoretical framework

2.1 Foreign ownership and productivity: advantages and spillovers

Firms expand their production abroad if they possess some knowledge-based assets, which, acting as a joint input across plants, give rise to scale economies at the firm level (Markusen, 1995). The existence of such economies, that provide a cost advantage to multi-plant over single-plant firms, may be combined with a reduction in transport costs, if production is located nearer to markets. Thus, the observed increasing substitution of the more efficient foreign production for exports can be easily understood (Barrell and Pain, 1997).

If observabilty, verifiability and contractability of the exact input-output relations and the disposition of output were possible, so that a MNF would not risk seeing its name or technology used beyond any agreement, then licensing would be preferred to foreign direct investment. But such conditions fail to hold. The public good properties of technology lead to imperfect markets and thus ownership of foreign affiliates is encouraged (Nakamura and Xie, 1998). The degree of ownership (full, majority, minority) selected depends on the expected net returns, since the increase in expected profits accompanying a higher degree of ownership is counterbalanced by the subsequent increase in monitoring costs. The ownership structure MNFs adopt can be conceived of as a mechanism to protect proprietary rights, which cannot be fully contracted out, and, at the same time, as an incentive device for reducing monitoring costs (Barbosa and Louri, 2001).

The degree of ownership MNFs select is thought to affect the productive efficiency enjoyed by their affiliates as well as the diffusion of technology to the local firms. The intensity of foreign participation is likely to influence the incentive of parent firms to transfer intangible assets (such as technology and management skills) to their affiliates. A fully owned affiliate would be most efficient, since the parent firm would have no inhibition to transfer its top technology to it. A partially owned affiliate leads to uncertainty as to the future use of its knowledge-based assets by the local partners, encouraging the parent firm to transfer older and perhaps less efficient technology. As the degree of foreign ownership decreases, the possibility of misappropriation of its knowledge-based assets by the local partner is enhanced. Thus, it is expected that the higher the degree of foreign ownership, the more advanced the technology transferred and, subsequently, the more efficient production will be.

On the other hand, imitation, being a channel through which spillovers are realized, is easier when domestic agents form a partnership with the foreign firm. Ownership confers residual rights of control over the partnership assets. The higher the control of the domestic agents, the more difficult monitoring of their actions will be and, subsequently, the easier it will be to appropriate the knowledge-based (intangible) assets which have public good properties. Thus, productivity spillovers for the local economy should be stronger when foreign firms are in minority positions.

2.2 Productivity models

The hypotheses we seek to test in this paper can be formulated within a neoclassical production theory framework. Assuming a Cobb-Douglas production function and adopting its *intensive form*[3], we obtain, after taking logarithms, equation (1) that relates output per worker (Y_i /L_i) of the ith firm to the capital-labour ratio (K_i / L_i):

$$ln\ (Y_i / L_i) = \alpha_0 + \alpha_1\, ln\ (K_i / L_i) + e_i \qquad (1)$$

where e_i is a random disturbance term accounting for stochastic variations in the technical or productive capabilities of the ith firm, measurement errors or missing variables.

To allow for differences in productivity between domestic and foreign firms a dummy variable, *Foreign*, with the value of 1 if the firm is foreign-owned (partially or wholly) may be introduced in (1). According to the theory, different degrees of foreign ownership cause different shifts in the level of productivity. To test this

[3] The intensive form results under the assumption of constant returns to scale, which has to be tested. Serious econometric problems, such as simultaneity due to the endogeneity of the explanatory

assertion, two separate dummy variables, *Min* and *Maj* taking the value of 1 if the share of the foreign firm is ≤ 50% or >50% respectively may replace *Foreign.*[4]

Another problem that may arise in estimating (1) is the presence of heterogeneity across firms. There are several sources of heterogeneity, some of which are taken into account by allowing the factors that determine them to enter explicitly the regression equation. The literature suggests the use of size as well as financial information concerning the firm.[5] Thus, a group of *j* variables, X_{ij} = size, leverage, and liquidity for each firm *i* is introduced. Size is expected to increase productivity, as larger sized firms may benefit from scale economies (Baldwin, 1996). Two financial variables, namely the leverage of the firm defined as the ratio of short and long-term debt to net worth and the liquidity ratio defined as working capital over total assets are also introduced. These variables may reflect either the consequences of financial pressure (Nickell, Wadhwani and Wall, 1992; Nickell and Nicolitsas, 1999) or the ability of the firm to exploit investment opportunities (Caballero, 1997; Hubbard, 1998) both expected to increase efficiency. Product market characteristics, taken into account by an *Industry* dummy, may also be of importance in determining productivity. By elaborating the information used, problems of heterogeneity bias and possible collinearity with the error term from the omission of statistically significant regressors are mitigated. Thus, an augmented form of the production function is finally estimated:

$$ln\,(Y_i / L_i) = \alpha_0 + \alpha_1\,(K_i / L_i) + \sum \alpha_{2j}\,lnX_{ij} + \alpha_3\,Foreign_i + \alpha_4\,Industry_i + e_i, \quad i=1, \ldots, N \qquad (2)$$

Firms, however, may also differ in productivity for reasons that are not directly measured such as for example quality characteristics of the firms, the entrepreneur's ability, other skills, etc. This unobserved heterogeneity may render the dependent variable in (2), and subsequently the error term e_i, being independently but not

variables, multicollinearity, and heteroskedasticity, which may arise when using cross-sectional data, are thus avoided.

[4] Full ownership and the parity option may also be tested as separate foreign ownership categories. In our case they did not produce any statistically significant different results from the two options presented. Hence they were integrated in the *Maj* and the *Min* ownership variables respectively.

[5] The skill level of labour is another variable often included in productivity estimations but there are no reliable data on it for our sample.

identically distributed across firms. The latter violates one of the basic assumptions of the standard regression model about the residuals of (2), which become non i.i.d. A possible non-normality of the dependent variable will further yield the residuals non-Gaussian. In situations where such problems arise, it has been suggested in the literature to apply the technique of quantile regressions.[6] This technique was introduced by Koenker and Bassett (1978) and enables the estimation of the model's parameters at different quantiles rather than the mean regression line employed by the least squares estimation technique. In our empirical analysis we will employ both techniques so as to provide a more complete picture of the conditional distribution of the dependent variable, and the partial effects the independent variables exert on different quantiles of it. A detailed presentation of the quantile regressions is provided in section 4.

3. Data and Descriptive Statistics

The study makes use of a sample of 4056 manufacturing firms operating in Greece in 1997. Individual firm information has been derived from the ICAP directory, which provides financial data based on the accounts of all Plc. and Ltd. firms in Greece together with their employment, fixed capital, sales, industry as well as degree and origin of foreign ownership. The firms included are rather large-sized and produced more than 85% of manufacturing sales in 1997.

Tables 1 and 2 present a summary of the sample and descriptive statistics of the variables used in the analysis by type of ownership (domestic, foreign, majority and minority).[7] As shown in Table 1, our sample consists of 4056 firms, of which 3840 are domestic and 216 are foreign affiliates. The latter amount to 5.3% of the total sample and exhibit a slight preference for majority (118 or 2.9%) versus minority (98 or 2.4%) ownership. In spite of the small proportion of foreign firms in the sample, the share of foreign in total sales is more than 26%, while the corresponding share of total assets is about 25%. Two thirds of that belong to the majority owned foreign firms. Moreover, the statistics reported in Table 2 reveal that, on average, sales,

[6] See for example the study by Mata and Machado (1996), who examined the importance of industry attributes for the distribution of firms' start-up size.

[7] Domestic firms are firms owned 100% by Greek agents. Foreign firms may be partially or fully owned by foreign agents.

capital and total assets of the foreign majority-owned firms exceed by far the respective means of both the domestic and the foreign minority-owned firms.

These facts are better documented in Table 3, which reports the ratios of foreign to domestic means. The relative mean sales of foreign firms (mean of foreign sales to mean of domestic sales) is 6.32, while the relative mean total assets is 5.92, indicating that foreign firms are about six times larger than domestic firms. In terms of capital intensity as measured by the capital input per worker (K/L), foreign ownership also makes a difference. Thus, the employee of a foreign affiliate has four times more capital to work with as compared to the employee of a domestic firm and produces 1.83 times more output which increases to 1.97 in majority owned affiliates.[8] Finally, the financial variables in Tables 2 and 3 reveal a (slight) preference of foreign firms for higher leverage and liquidity both increasing in the degree of foreign ownership.

When examining the distribution of labour productivity in our sample, it becomes noticeable from the quantile functions in Figure 1a that it is highly skewed, as compared to the normal, with more than two thirds of the firms producing less than the mean.[9] The coefficients of skewness and kurtosis are 6.30 and 84.82 respectively and the Jarque-Bera test for the normality assumption is rejected at p=0.00. Even after taking logs the distribution of productivity departs from normality as indicated in Figure 1b. Although the coefficients of skewness and kurtosis are improved (-1.05 and 11.14 respectively), the hypothesis of normality is still not accepted at p=0.00 (Jarque-Bera test).[10] These findings contrast sharply with the usual assumption of log-normality in the relevant literature[11] and suggest a more elaborate econometric treatment to deal with such distribution characteristics. A more detailed analysis of

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[8] The data available from the company accounts report only sales. Although value added is regarded as superior to sales in measuring output, both are used in the literature. Arguments for their alternative use can be found in Jorgenson (1987), Nickell et al. (1992), Mayes (1996) and Oulton (1998b).

[9] The normal and lognormal curves drawn have the mean and standard deviation of the respective distributions they are compared with.

[10] The assumption of normality was also strongly rejected (p=0.00) when using the Shapiro-Francia test, suggested as more appropriate with non-aggregated data. The results are similar when examining productivity of domestic firms only. The coefficients of skewness and kurtosis are 6.01 and 79.23 respectively and the Jarque-Bera test rejects the assumption of normality at p=0.00.

[11] See, for example, Oulton (1998c) who stresses that there is a long tail of under-performing companies but assumes (without testing) lognormality of labour productivity in the UK. See, also, Globerman et al. (1994), Blomstrom and Sjoholm (1999) among others.

our empirical productivity distribution characteristics in comparison with those of the normal is provided in the appendix using scattered diagrams.

4. Empirical Model

Our theoretical model (2) can take the general form

$$y_i = \mathbf{x}_i'\boldsymbol{\beta} + e_i \qquad (3)$$

where $y_i = \ln(Y_i / L_i)$, $\mathbf{x}_i$ is the vector of all the independent variables in (2), $\boldsymbol{\beta}$ is the vector of parameters to be estimated and e_i is the error term assumed to be independently and identically distributed with symmetric distribution function around zero. OLS regressions provide parameter estimates $\hat{\boldsymbol{\beta}}$ with all the desired properties if e_i is normally distributed. This method predicts the mean of the dependent variable y_i conditional on the values of the vector of independent variables $\mathbf{x}_i$.

As argued in section 2.1, when dealing with large cross-sections of firms like this one, the OLS estimates may not be representative of the entire distribution of the dependent variable if not identically distributed across firms. As already mentioned, Figures 1a and 1b of the productivity distribution quantiles indicate skewed distributions with long tails largely departing from normality according to the appropriate tests. The non-normality of our dependent variable in the linear regression (3) will affect the distribution of the error term e_i which is assumed to be normally distributed for the least square estimators $\hat{\boldsymbol{\beta}}$ to have the desired properties. In our case, however, there is strong evidence that the error term does not satisfy the normality assumption rendering the $\hat{\boldsymbol{\beta}}$ estimators inefficient or asymptotically inefficient.[12] The need to deal with situations of non-Gaussian distributions has led to the development of alternative estimation techniques which, relative to least squares, place less weight on outliers and are known as robust estimation techniques.[13] Among this class of techniques the quantile regression technique introduced by Koenker and Bassett (1978) is chosen as more appropriate.

[12] See the Jarque-Bera test statistics of the OLS error estimates in Table 4.

[13] Robustness implies that the distribution of an estimator or test statistic should alter only slightly when the distribution of the error term alters slightly.

More specifically, the parameters of (3) are estimated at various quantities of the conditional $F_i(y|x)$ distribution of $y_{i.}$, which gives us a more complete picture of the way labour productivity is affected by the various independent variables. The quantile regression model is defined as

$$y_i = \mathbf{x}_i^{'}\boldsymbol{\beta}(\mathrm{q}) + e_i \qquad (4)$$
$$= Q_q(y_i) + e_i \ , \quad 0 < q < 1$$

where **β**(q) is the vector of parameters to be estimated for a given value of the distribution's quantile q in (0,1); $Q_q(y_i)$ denotes the qth quantile of the conditional distribution of y_i given the known vector of regressors $\mathbf{x}_i$. The quantile regression model therefore provides predictions of a specific quantile q of the conditional distribution of y_i and can be considered as the generalization of the sample quantile of an i.i.d. random variable.[14]

The estimation of the quantile parameters **β**(q) has been implemented by solving the following minimization problem

$$\min_{\beta} \sum |e_i| h_i = \sum |y_i - \mathbf{x}_i^{'}\boldsymbol{\beta}| h_i \qquad (5)$$

with $$h_i = \begin{cases} 2q & if \quad e_i > 0 \\ 2(1-q) & if \quad e_i < 0 \end{cases}$$

For q=0.5 we obtain the median and problem (5) is equivalent to the problem of minimum absolute deviations. For the estimation of quantiles other than the median, the residuals are weighted appropriately depending on whether they are positive or negative.[15] The elements of **β**(q) were estimated using the method suggested by Koenker and Bassett (1982) and improved by Rogers (1993). However, in cases of heteroskedastic errors the estimated standard errors are understated by this method. For this reason robust standard errors were obtained by using the option of bootstrapping procedures introduced by Gould (1992; 1997).[16]

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[14] The qth sample quantile of an i.i.d. random variable y denoted by θ_q , is the value of y for which the probability p(y<θ_q)= F(θ_q)=q, where F is the distribution function of y. For more details on the sample and regression quantiles see Judge et al. (1988, chapter 20).

[15] The problem was solved by the linear programming algorithm suggested by Armstrong, Frome, and Kung (1979). Similar computational techniques were also suggested by Koenker and Bassett (1978).

Estimating (5) for various values of q results in a sequence $\hat{\boldsymbol{\delta}}$ of regression quantile estimates:

$$\hat{\boldsymbol{\delta}}' = [\hat{\boldsymbol{\beta}}'(q_1), \hat{\boldsymbol{\beta}}'(q_2), ..., \hat{\boldsymbol{\beta}}'(q_m)], \qquad 0 < q_1 < q_2 < ... < q_m < 1$$

The properties of the estimators $\hat{\boldsymbol{\beta}}(q)$ as well as the necessary and sufficient conditions for the uniqueness of $\hat{\boldsymbol{\delta}}$ are given by Koenker and Bassett (1978, 1982). From an empirical point of view then the important question that arises is to test statistically how different the above estimated parameter vectors $\hat{\boldsymbol{\beta}}(q)$ are across the various quantile regressions. To perform such hypotheses tests we need the entire variance-covariance matrix of $\hat{\boldsymbol{\delta}}$. This can only be obtained asymptotically and was implemented in this paper using bootstrapped sampling methods.

5. Empirical Findings

The neoclassical production function specified in section 2.2 and generalized in section 4 was estimated using the sample of cross-sectional data previously described. We first examine the foreign-ownership effect on productivity and then look at the productivity spillover effects.

5.1 Productivity determinants: OLS Estimates

Table 4 presents the least squares estimates of labour productivity equations (1) and (2). Before running these regressions, the hypothesis of constant returns to scale was tested and upon acceptance[17] we proceeded with the estimation of the above equations. In the first OLS regression of Table 4 the capital-labour ratio and the dummy *Foreign* taking into account foreign-ownership (majority and minority) enter. In the subsequent regressions this dummy was replaced by two separate dummies for majority and minority foreign ownership (*Maj* and *Min* respectively), while a number of other explanatory variables was introduced in a step-wise manner. The constant in each regression measures the effect of the remaining firms, namely the firms that are domestically owned. Each regression was run with 19 industry dummies to capture

[16] The statistical analysis in this paper was performed by STATA, Version 6.0, 1999.
[17] At p=0.00 (X^2=0.44).

industry-specific effects at the two-digit level.[18] The second OLS regression reported in Table 4 includes all the variables shown in (2).

The coefficients of both capital-labour ratio and majority foreign ownership are positive and statistically significant indicating that capital intensity as well the presence of majority foreign-ownership affiliates increase measured productivity. The size of the firm, capturing the extent of scale economies, proxied by the logarithm of total assets as well as the two financial variables, leverage and liquidity, accounting for the effect of financial structure on firm performance, are also found to exercise significant effects.[19]

In general, that foreign-owned firms have a substantial productivity lead in manufacturing and other services over domestically-owned firms is already an established result in the literature (see, e.g. Caves, 1974; Globerman, 1979; Davies and Lyons, 1991; Globerman, Ries and Vertinsky, 1994; Coe and Helpman, 1995; Barrel and Pain, 1997; Oulton, 1998b) although Globerman et al. (1994) as well as Saunders (1980) found no productivity differences between Canadian and foreign firms *ceteris paribus*. However, this study stresses that the productivity advantage of foreign ownership stems from the full and majority foreign-owned firms only as opposed to the minority foreign- and the domestically-owned ones.[20] This result contradicts the recent evidence provided by Blomstrom and Sjoholm (1999) from Indonesian manufacturing data that no difference in the effect on productivity exists between minority and majority foreign ownership. The contradiction should be attributed to the differing level of development of the two countries as well as to the more detailed methodology used here.

However, in our case the OLS estimates are not reliable due to the existence of non-Gaussian disturbances as explained in sections 2 and 4. The estimated regression lines provide an estimate of the central tendency of the productivity distribution, which may not be representative of the entire distribution. It is important, therefore, to

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[18] A Chow test was performed between high and low technology industries to test for any possible different responses between these two groups of firms. The null hypothesis of equal responses was accepted at $p=0.20$ ($F=2.88$).

[19] Other variables, such as the age of the firm and its FDI origin (Globerman et. al., 1994; Oulton, 1998b) were also tried but were found to be insignificant.

test whether the estimated regression line (3), which is a measure of the mean conditional distribution of y_i, remains unchanged as we move away from its mean. As a first step we estimated the regression line separately using the lower and upper quartiles of the distribution of $y_i = \ln(Y_i / L_i)$ and tested for the equality of coefficients between the two ends by performing a Chow test. The value of the F-statistic (F=408.35) resulted in rejection of the hypothesis of equality at p=0.00. These results imply that the specific characteristics of the data require a more comprehensive treatment of the conditional distribution of our dependent variable, as provided by quantile regressions.

5.2 Quantile Regression Results

Table 4 also includes the regression estimates for five different quantiles of the labour productivity distribution. The numbers in parentheses are the t-values computed from bootstrapped standard errors as explained earlier in section 4. To further evaluate the importance of the differences in the quantile parameter estimates presented in Table 4, we proceed in the relevant hypotheses testing. More specifically, we test for the equality of coefficients between any two quantiles as well as jointly for all quantiles. The tests were performed using the F-statistic, the computation of which requires an estimate of the variance-covariance matrix of the quantile coefficients. This was obtained by estimating simultaneously the relevant quantile regressions as a system. Table 5 reports the corresponding p-values for the above tested hypotheses.

The results in Tables 4 and 5 indicate that there exist statistically significant differences in the coefficients between and among the various quantile regression estimates for most independent variables. In particular, the coefficient of ln(K/L) (elasticity of capital) varies significantly from 0.30 to 0.49 as we move from the upper quantile (0.90) to the lower quantile (0.10) of the labour productivity conditional distribution at significance levels less than 1%. The most productive firms are less sensitive to capital intensity being more sensitive to other determinants, such as size and leverage.

[20] The hypothesis of equality between the coefficients of *Maj* and *Min* is rejected at p=0.00 (F=8.61).

On the other hand, the effect of the majority foreign owned firms dummy seems to be strengthened in the centre of the distribution, but weakened towards the tails. It is interesting to notice that the in-between coefficient differences of *Maj* are significant in the joint test among all five quantiles at p=0.00. No significant differences were found in the *Min* effects, which remain insignificant across all quantiles. The estimates that apply to the financial variables, namely leverage and liquidity, were highly significant in all cases with strong variability across quantiles. We can observe that the leverage coefficients become increasingly important as we move up in the conditional distribution, probably reflecting the fact that it is the most productive firms that respond more intensively to financial pressure than the less productive ones. The opposite picture prevails in the liquidity coefficient, which seems to be a more important productivity enhancing factor for the less productive firms.

With respect to the main issue of this paper, that is the effect of foreign (*Maj* or *Min*) ownership on a firm's labour productivity, the quantile results made it clear that all the effect comes from the majority part and peaks towards the median increasing its size and significance. We can interpret these results as evidence that foreign ownership does not matter among the very productive or, at the other extreme, the least productive firms. It is in the middle-productivity range that majority owned foreign firms confirm their superior efficiency by causing a positive productivity shift.

5.3 Productivity spillovers

To test the existence of productivity spillovers in the local economy, the effect of the relative size of foreign presence on the productivity of the domestic firms is estimated. Three alternative measures of foreign presence are tried: the share of foreign firms in an industry's sales, employment and capital. We first try to estimate the general foreign effect on domestic productivity. Then, two different shares belonging respectively to minority and majority holdings are formed. *Min* is the share of sales, employment or capital of firms with minority foreign ownership and *Maj* is the corresponding share of firms with majority foreign ownership. According to the theory, we would expect the sign of *Min* to be positive and stronger than that of *Maj*, which we expect to be either smaller or non-significant. As can be seen in Table 6, the general spillover effect of foreign presence is positive and significant irrespective of the measure used. The productivity of domestic firms increases as the relative presence of foreign firms becomes stronger. It is clear that domestic firms benefit from the presence of foreign firms in their respective industries.

When the effects of *Maj* and *Min* are estimated separately, they are both positive and significant when sales are used, while the size of the first is half that of the second. More definite answers are provided when either employment or capital is taken into account. Capital must proxy best the effect of spillovers, since most of them stem from its use. The effect of *Maj* is not only one sixth that of *Min* but is also non-significant.[21] However, in the quantile regression estimates (Table 7), while the effect of *Min* is always positive and significant, the effect of *Maj* is non-significant for the least productive firms and becomes significant only for the upper 25 percent of the distribution doubling its size for the upper 10 percent. High productivity domestic firms are more strongly influenced by the presence of foreign firms in general, while low and medium productivity domestic firms are only influenced by the presence of *Min* affiliates. It could be the case that they do not have the means to absorb the positive spillovers of the more 'distant' full or majority foreign owned affiliates, while the high productivity domestic firms do not have difficulties in capturing positive externalities from any type of affiliate in their industry.

The quantile effects exercized by the other explanatory variables on domestic firms' labour productivity are similar to those estimated when using the entire sample as are the results from the hypotheses testing of equality between the quantile estimates (Table 8). These findings confirm the existence of statistically significant differences between the various quantile effects as well as jointly among all quantiles with the exception of the *Min* effects indicating the strong influence of spillovers from the minority owned firms on the productivity of local firms irrespective of the quantile examined.

6. Conclusions

Three main hypotheses are tested in this paper:

(a) Is labour productivity influenced by the degree of foreign ownership? (b) Does the degree of foreign engagement in an industry affect the extent of productivity

[21] The hypothesis of equality between the coefficients of *Maj* and *Min* is rejected at $p=0.04$ ($F=4.08$).

spillovers? And (c) is the effect of foreign involvement different at various points of the productivity conditional distribution?

A sample of 4056 manufacturing firms (5% of which are foreign, producing 26% of manufacturing sales) operating in Greece in 1997 is used. The empirical answers provided by our analysis support the theoretical proposition that the higher the degree of foreign ownership, the more efficient production is. Thus, productivity in an economy is improved with the entry of foreign affiliates, which are either owned fully or at least in major part by foreign firms. Productivity is also affected by the existence of financial constraints. Higher liquidity underlying the potential for quick exploitation of investment opportunities and higher leverage accounting for either financial pressure or realization of many (positive net rate or return) investment projects (even by resorting to debt) increase firm efficiency levels. Finally, when spillovers stemming from foreign affiliates and benefiting domestic firms are measured, the findings agree again with the literature that it is minority foreign holdings that are most important for the domestic economy and especially for the lower productivity local firms.

Such findings contrast markedly with the findings of Blomstrom and Sjoholm (1999) which indicate that the degree of foreign ownership affects neither the level of labour productivity nor the extent of spillovers in Indonesian manufacturing industry. Apparently, the different development levels between the two economies impact upon the way the two economies absorb the beneficial effects of FDI. In less developed economies any degree of foreign presence seems to exert a significant influence, while in more developed economies the effects are diversified. The varying response of high and low productivity firms underlines also the need to avoid single summary estimates when indications of non-normality or serious heterogeneity exist.

The policy suggestions with respect to attracting FDI that follow such findings are that (a) fully or majority owned foreign affiliates should be favoured when an immediate increase in the general efficiency level is desired, while (b) joint ventures with foreign firms holding a minority share should be encouraged if spillovers, causing efficiency gains in domestic firms, are pursued. The differences in the responses between high and low productivity firms should also be taken into account in the design of the appropriate policy.

APPENDIX

Figure A
The Quantile Functions of Productivity (Y/L) and its logarithm
against the Normal Quantile Function

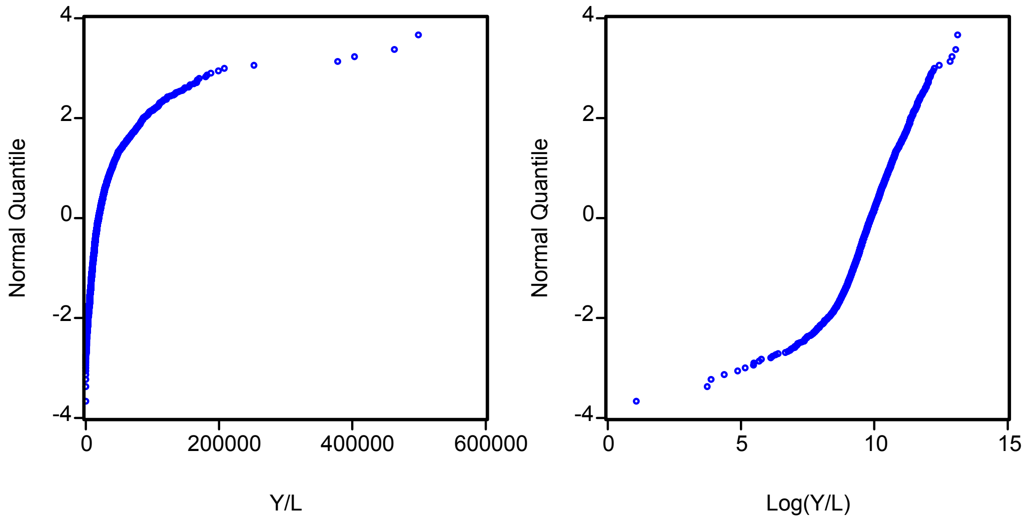

Figure A allows the comparison of the labour productivity distribution (or its logarithm) with that of a normal by plotting their quantile functions against each other. Thus, if the distribution of labour productivity (Y/L) was normal or lognormal, a straight line (along the diagonal) would result in the above scatter diagrams. Deviations from the straight line, as in this case, indicate departures from normality. In particular, the concave shape of the line in the first diagramme indicates that the distribution of Y/L is positively skewed with a long right tail. On the other hand, the line in the second diagramme of log(Y/L) is straight in the middle, but curves towards the two ends, becoming convex at the left and slightly concave at the right. In sum, the distribution of labour productivity in our sample deviates completely from the normal, while its logarithmic transformation has a distribution closer to the normal but more leptokurtic and with a longer tail than the normal.

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Figure 1a. The quantiles of Y/L distribution vs. the normal distribution.

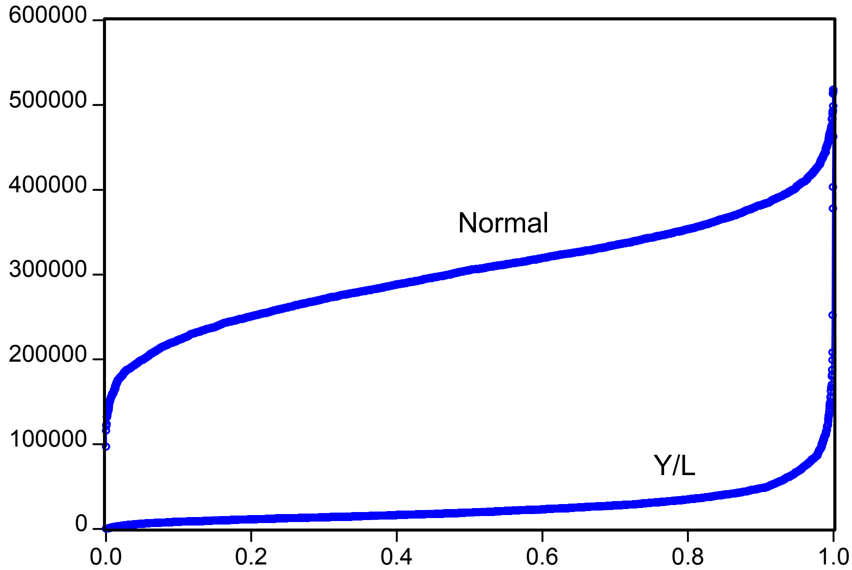

Figure 1b. The quantiles of the log(Y/L) distribution vs. the lognormal distribution.

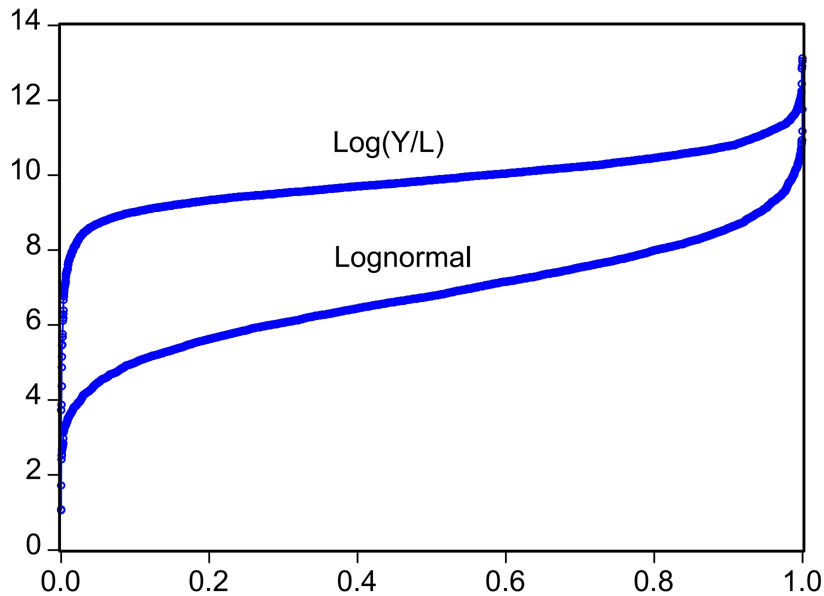

Table 1
Sample Statistics: Absolute values and shares

Sample	Domestic		Foreign		Majority		Minority	
Total: 4056	3840 (94.7%)		216 (5.33%)		118 (2.91%)		98 (2.42%)	
Variable	**Value**	**%**	**Value**	**%**	**Value**	**%**	**Value**	**%**
Sales (Y)[1]	6534443	73.76	2324714	26.24	1453047	16.40	871666	9.84
Labour (L)[2]	225049	83.15	45497	16.85	27396	10.15	18101	6.70
Capital (K)[1]	3078580	78.00	867771	22.00	522182	13.25	345588	8.75
Total Assets (S)[1]	7009972	75.00	2334647	25.00	1514355	16.20	820292	8.80

[1] In 000,000 GDR.
[2] Number of employees.

Table 2
Descriptive Statistics of variables by type of ownership

Sample	Domestic		Foreign		Majority		Minority	
Variable	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Sales (Y)[1]	1702	9806	10763	20202	12314	21854	8895	17947
Labour (L)[2]	59	136	211	300	202	261	221	342
Capital (K)[1]	802	6540	4017	10764	4425	12308	3526	8581
Total Assets (S)[1]	1826	9587	10809	31616	12834	39803	8370	17133
Leverage[3]	3.16	7.85	3.25	8.45	3.59	10.87	2.83	3.89
Liquidity[4]	0.64	0.22	0.66	0.20	0.67	0.20	0.64	0.21
Age	20.26	15.94	26.00	17.11	28.01	18.06	23.15	15.67
Capital-intensity (K/L)	10489	14373	40951	107919	44305	118220	36911	94480
Labour Productivity (Y/L)	24670	23044	45183	45043	48572	32891	41100	56225

[1] In 000.000 GDR.
[2] Number of employees.
[3] Leverage=ratio of short and long term debt to net worth.
[4] Liquidity=ratio of working capital to total assets.

Table 3
The relative position of foreign versus domestic firms

Ratio of the mean of the "foreign" variable to the mean of the corresponding "domestic" variable			
Variable	**Foreign**	**Majority**	**Minority**
Sales (Y)	6.32	7.24	5.23
Labour (L)	3.59	3.96	3.15
Capital (K)	5.01	5.52	4.40
Total Assets (S)	5.92	7.03	4.59
Leverage[1]	1.03	1.14	0.91
Liquidity[2]	1.03	1.05	1.00
Age	1.28	1.38	1.14
Capital-intensity (K/L)	3.90	4.22	3.52
Labour Productivity (Y/L)	1.83	1.97	1.67

[1] Leverage=ratio of short and long term debt to net worth.
[2] Liquidity=ratio of working capital to total assets.

Table 4
Estimation results of labour productivity on capital intensity, ownership, size and financial variables

Dependent variable: ln(Y/L)							
Variables	**OLS Estimates[1,2]**		**Quantile Regression Estimates[3]**				
	1	**2**	**0.10**	**0.25**	**0.50**	**0.75**	**0.90**
Constant	8.43*	5.83*	4.83*	5.49*	5.82*	6.16*	6.47*
	(74.7)	(45.7)	(29.40)	(39.13)	(76.21)	(45.96)	(29.80)
Ln(K/L)	0.16*	0.39*	0.49*	0.45*	0.41*	0.35*	0.30*
	(12.4)	(19.1)	(17.72)	(17.50)	(20.85)	(10.75)	(12.73)
Foreign	0.45*	-	-	-	-	-	-
	(6.9)						
Maj	-	0.25*	0.24	0.35*	0.31*	0.26*	0.11
		(4.4)	(1.51)	(6.69)	(9.25)	(4.05)	(1.40)
Min	-	0.01	0.01	0.01	0.07	-0.01	0.05
		(0.20)	(0.07)	(0.11)	(1.53)	(-0.14)	(0.36)
Size[4]	-	0.09*	0.07*	0.06*	0.08*	0.11*	0.13*
		(8.1)	(4.31)	(5.01)	(7.07)	(6.19)	(5.00)
Leverage[5]	-	0.09*	0.04**	0.08*	0.10*	0.11*	0.13*
		(8.4)	(1.84)	(6.75)	(8.22)	(8.66)	(6.48)
Liquidity[6]	-	1.06*	1.57*	1.25*	1.04*	0.85*	0.75*
		(14.4)	(15.38)	(16.6)	(16.63)	(16.96)	(21.72)
Adjusted R^2	0.09	0.42					
Pseudo-R^2	-	-	0.25	0.24	0.25	0.25	0.25
F-statistic	207.05*	472.9*					
No Observations[7] : 3969							

Notes:
[1]t-values in parentheses computed from White heteroskedasticity-consistent standard errors.
[2]The Jarque-Bera statistic of OLS regression 1 is 13157.5 with p=0.00, while for regression 2 it is 23355.6 with p=0.00, indicating that errors are not normally distributed.
[3]t-values in parentheses computed from bootstrapped standard errors to correct for heteroskedasticity.
[4]Size measured by the logarithm of total assets.
[5]Leverage=ratio of short and long term debt to net worth.
[6]Liquidity=ratio of working capital to total assets.
[7]The sample is smaller than the total (4056 firms) due to missing values in some of the variables.

*Statistically significant at less than 1%.
** Statistically significant at 5%.

Table 5
Tests of Coefficient Equality between Quantile Estimates of Table 4

	Marginal Significance Levels (p-values)[1]						
Quantile Groups Variables	**0.10 0.25**	**0.25 0.50**	**0.50 0.75**	**0.75 0.90**	**0.10 0.50**	**0.50 0.90**	**Joint**
ln (K/L)	0.05	0.04	0.01	0.02	0.01	0.00	0.01
Maj	0.42	0.41	0.35	0.07	0.60	0.02	0.00
Min	0.98	0.40	0.29	0.54	0.41	0.81	0.50
Size	0.17	0.23	0.01	0.19	0.96	0.02	0.10
Leverage	0.01	0.10	0.50	0.10	0.00	0.04	0.01
Liquidity	0.01	0.00	0.00	0.01	0.00	0.00	0.00

[1]P-values of F-tests evaluated using the variance-covariance matrix of the quantile coefficients estimated from the system of the relevant quantile regressions.

Table 6
Productivity spillovers and foreign ownership: OLS Estimates

	Dependent variable ln(Y/L) of domestic firms[1]					
	Sales		Employment		Fixed Capital	
Constant	6.08* (46.29)	6.12* (40.45)	6.03* (46.45)	3.99* (40.91)	6.05* (49.69)	6.05* (41.54)
Ln(K/L)	0.37* (17.54)	0.37* (16.86)	0.38* (17.85)	0.38* (17.35)	0.37* (17.55)	0.38* (16.98)
Foreign[2]	0.10* (3.33)	-	0.05** (1.75)	-	0.06* (2.68)	-
Maj[3]	-	0.04* (2.23)	-	0.01 (1.45)	-	0.01 (0.36)
Min[3]	-	0.08* (2.61)	-	0.06** (1.73)	-	0.06* (2.45)
Size	0.09* (7.17)	0.09* (6.92)	0.08* (7.07)	0.09* (6.91)	0.09* (7.12)	0.09* (6.88)
Leverage	0.09* (8.01)	0.09* (7.35)	0.09* (7.99)	0.09* (7.25)	0.10* (8.09)	0.09* (7.32)
Liquidity	1.02* (13.23)	1.04* (13.43)	1.02* (13.30)	1.05* (13.63)	1.02* (13.19)	1.04* (13.42)
Adjusted R^2	0.387	0.392	0.386	0.391	0.387	0.391
F-statistic	459.85*	347.59*	457.27*	345.46*	458.63*	346.61*
No Observations : 3627						

Notes:
[1] t- statistics in parentheses based on consistent standard errors.
[2] Sales, employment or fixed capital of foreign firms as a ratio of the respective industry values.
[3] Sales, employment or fixed capital of majority/minority owned foreign affiliates as a ratio of the respective industry values.

*Statistically significant at less than 1%.
**Statistically significant at 5%.

Table 7
Productivity spillovers and foreign ownership: Quantile Regression Estimates

Dependent Variable: ln (Y/L) of domestic firms					
	Quantile Regression Estimates[2]				
	0.10	**0.25**	**0.50**	**0.75**	**0.90**
Constant	5.19*	5.78*	6.05*	6.43*	6.88*
	(20.30)	(31.42)	(51.82)	(51.14)	(33.12)
Ln (K/L)	0.44*	0.42*	0.40*	0.34*	0.29*
	(12.61)	(16.47)	(26.5)	(12.55)	(9.73)
Maj[3]	-0.04	0.02	0.02	0.04*	0.07*
	(-0.98)	(0.63)	(1.45)	(1.99)	(2.61)
Min[3]	0.09*	0.03**	0.06*	0.05*	0.07*
	(2.63)	(1.68)	(3.13)	(2.29)	(1.91)
Size[4]	0.08*	0.06*	0.08*	0.11*	0.13*
	(3.98)	(3.46)	(7.23)	(6.72)	(6.97)
Leverage[5]	0.03	0.07*	0.10*	0.10*	0.13*
	(1.41)	(5.16)	(10.35)	(6.64)	(7.54)
Liquidity[6]	1.40*	1.15*	0.98*	0.85*	0.70*
	(12.96)	(18.13)	(22.6)	(17.05)	(10.03)
Pseudo R^2	0.24	0.22	0.23	0.23	0.22
No Observations : 3627					

Notes:
[1] t- statistics in parentheses based on consistent standard errors.
[2] t- statistics in parentheses based on bootstrapped standard errors to correct for heteroskedasticity.
[3] Fixed capital of majority/minority owned foreign affiliates as ratio of the industry's value.
[5] Size measured by the logarithm of total assets.
[5] Leverage = ratio of short and long term debt to net worth.
[6] Liquidity = ratio of working capital to total assets.

*Statistically significant at less than 1%.
** Statistically significant at 5%.

Table 8
Tests of Coefficient Equality between Quantile Estimates of Table 7

Quantile Groups / Variables	Marginal Significance Levels (p-values)[1]						
	0.10 0.25	**0.25 0.50**	**0.50 0.75**	**0.75 0.90**	**0.10 0.50**	**0.50 0.90**	**Joint**
Ln (K/L)	0.33	0.43	0.01	0.01	0.19	0.00	0.00
Maj	0.07	0.65	0.38	0.17	0.05	0.08	0.04
Min	0.15	0.28	0.50	0.17	0.50	0.65	0.37
Size	0.34	0.33	0.06	0.20	0.85	0.02	0.08
Leverage	0.02	0.01	0.85	0.05	0.00	0.05	0.01
Liquidity	0.01	0.01	0.00	0.00	0.00	0.00	0.00

[1]P-values of F-tests evaluated using the variance-covariance matrix of the quantile coefficients estimated from the system of the relevant quantile regressions.