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Abstract

In this study we estimated Stochastic Frontier Production Functions for different sub-samples of panel data of Uruguayan manufacturing firms, to evaluate the spillover effect of the presence of foreign affiliates and international competition on technical efficiency in locally-owned firms. The results suggest that the presence of FDI has a positive effect on the level of technical efficiency in local firms. Furthermore, we found that average technical efficiency in locally-owned firms in industries where foreign affiliates are present is higher than those of firms in industries with no foreign presence. We also found that significant spillover effects on technical efficiency arise when technology gap between local and foreign firms is moderate, and when the foreign affiliate's sales are mainly oriented to the local market. Moreover, our results suggest that when foreign firms are present in an industry their positive impact on the technical efficiency of local firms seems to be greater than the impact of competition from imported goods.

Key words: Foreign direct investment, Spillovers, Technical efficiency, Productivity, Stochastic Frontier Production Functions

JEL Classification: C23-D24-F23-L60-O13-O33

Resumen

Mediante la estimación de Funciones de Producción de Frontera se evalúan los efectos de la IED sobre la productividad y la eficiencia técnica de las empresas de la industria manufacturera uruguaya. Se constata la existencia de distinto niveles de eficiencia técnica en las empresas según la propiedad del capital y su participación en ramas con o sin presencia de firmas extranjeras, observándose una tendencia creciente de la ineficiencia técnica. La presencia de empresas extranjeras tiene un efecto positivo sobre la eficiencia técnica de las empresas domésticas, lo que parece estar ligado a la competencia en el mercado interno. Asimismo, se constata la existencia de efectos de derrame en empresas nacionales cuando la brecha tecnológica entre nacionales y extranjeras es moderada, y cuando las empresas extranjeras se orientan principalmente al mercado local. Es mas, los resultados sugieren que cuando se registra la presencia de empresas extranjeras en la rama su competencia en el mercado local es más relevante para elevar la eficiencia técnica que la competencia de bienes importados.

Palabras claves: Inversión Extranjera Directa, Spillovers, Eficiencia Técnica, Productividad, Función de Producción de Frontera.

1. Introduction

Various studies of Foreign Direct Investment (FDI) suggest that it has a positive impact on productivity and efficiency in local firms in a way similar to opening to international trade because it brings in new modern technologies in processes and products and increases competition in local markets, besides its contribution to raise the capital stock of the host countries. In particular these studies stress that the entry of FDI into a market forces local enterprises to operate more efficiently and accelerates the process of incorporating new technologies.

It is asserted that FDI generates various externalities or spillovers that contribute to "improving productivity and efficiency in local enterprises in the host country" (Blomström, Kokko and Zeján, 2000). Other positive externalities from FDI that have been suggested in different empirical studies arise from technical assistance for domestic supplier and from the training of workers and managers who will eventually be employed by domestic firms. Consequently externalities or spillovers from the entry of foreign firms may lead to the introduction of new technologies in products and processes, or/and they may give rise to intangible effects like that the mere fact that a foreign firm establishes in the country may be taken as a sign that competition in that market will intensify in the near future.

These considerations suggest that FDI should be regard not just as a transfer of capital to the host country but as a "complex package" that includes other components as well as financial investment, and it is these that determine the multinational corporations' (MNC) capacity to compete at the local and international levels, and may generate spillovers or spur domestic firms to perform better in order to survive. In this context we can mention various channels whereby firms in the host country can benefit from FDI, which will be analyzed in the first section of this article.

According to economic theory trade opening, defined as the reduction or elimination of trade restrictions, would have similar effects to the entry of FDI since it would contribute to improving resource allocation and raising production efficiency. In addition, foreign competition, or just the threat of competition, would limit how far local enterprises could exercise market power, which would be a contribution to improve social welfare.

In this study we evaluate the impact of FDI in the manufacturing firms in Uruguay, in particular the intra-industry spillover from FDI on productivity and technical efficiency, by estimating Stochastic Frontier Production Functions, or Best Practices, of Uruguayan firms. These results in various technical efficiency estimations which allow evaluation of the hypothesis that FDI generate spillovers that have an impact on the productivity and efficiency of domestic firms.

The first aim is to explore whether the technology employed in industries where foreign firms are present is different from that employed in those industries where there are no foreign presence. Secondly, we shall evaluate whether there are differences between the technology employed by foreign and local firms in the same industry, and in particular we shall analyze whether the technology gap between foreign and domestic firms, and their market orientation, affects this spillover process, if any. Lastly, we shall evaluate whether the technical efficiency of local firms has increased linked to the presence of foreign firms in the industry. This last point is particularly important when we take in consideration that different authors suggest that the entry of foreign firms promotes efficiency in that industry, in spite of technological differences with local firms. For this purpose we estimate Stochastic Frontier Production Functions for different sub-samples in the manufacturing sector in Uruguay so as to evaluate the hypothesis outlined above.

In the next section we discuss theoretical aspects and empirical results from previous studies. In section three we give a brief overview of the industrial sector in Uruguay and look at some key aspects of economic policy so as to orient the reader. In section four we present our estimation methodology and the panel data base we used in this study. In the fourth section we present our econometric estimations and results, and at the end we draw some conclusions.

2. Background

When foreign firms establish in an economy is generally linked to their having some specific advantage that enables them to compete successfully with local firms in the host country (Dunning, 1993). This advantage may be technological or that the foreign firms may have processes or products that are not available for local firms. Alternatively, the foreign firm might have intangible assets like management capabilities or access to markets for products or finance that domestic firms do not have access to. Whatever the advantage may be, the entry of foreign firms into a market will alter the existing equilibrium and force incumbent firms to become more competitive to maintain their market share, which is under threat of the new entrance. In particular, if we take in consideration that the specific advantage that the foreign firm has is some technology that is unavailable to local firms of Less Developed Countries (LDC), this could force the local competitors to make more efficient use of the technology they have or accelerate the process of acquiring new technologies so as to maintain their market share.

MNC entry into LDCs have at least two important consequences. First, the country's production or average productivity may increase thanks to the foreign firm introducing new technologies, which are usually more productive and efficient than those available to local firms. Second, local firms may make more efficient use of their resources to cope with pressures from the new competitor and try to maintain themselves in the market. The combination of these two effects will tend to raise productivity in the industry in question as long as the local firms continue to operate even though there is technological heterogeneity in that industry. Moreover, it may be that the entry of MNCs results in different technologies operating side by side in that industry. This would make for increased productivity and greater efficiency not just on industry average but also among local enterprises.

These effects are recognized in economics literature, and different kinds of spillovers that raise productivity in local firms have been analyzed. According to Blömstrom and Kokko (1996), spillovers occur when the foreign firms are unable to internalize all the benefits they derive from their specific advantages and thus there are positive spillovers to local firms. These may take various forms, (i) knowledge spillovers that increase the stock of human capital in host countries; (ii) technological spillovers, when local enterprises have links with the MNCs as supplier and/or customers, and can benefit from the superior technologies and better business practices these firms have (these spillovers may have a negative sign if the subsidiaries replace local with international supplier); and (iii) spillovers through competition, whereby competition from MNCs in the domestic market stimulates local firms to raise their productivity, improve the quality of their products and/or introduce innovations. Besides, spillovers in market access may occur when the MNC's export activity reduces the cost for local firms to export to a given market. But as Grossman and Helpman (1991) suggest, the presence of MNCs results in positive spillovers when local firms can internalize the information created by others without having to pay for it in a market transaction.

One of the main reasons why developing countries have sought to attract FDI is that it is related with the transfer of technology and the introduction of new knowledge, administrative skills and market technologies, that is to say it allows these countries access to modern technologies they could not develop for themselves. This view point have stimulated countries to implement policies to attract foreign capital. In line with this, in recent years there have been a series of empirical micro-econometric studies to analyze the benefits of FDI for host countries. One of the spillover effects that have been studied most is the impact of the presence of foreign firms on local competitors (horizontal effect) and thus on competitiveness in the industrial sector receiving the FDI. However, these empirical studies of whether or not there are spillover effects and what their signs may be have generated contradictory results. The first analyses of intra-industrial spillovers, such as that by Caves (1974) in Australia, Globerman (1979) in Canada and Blomström and Persson (1983) in Mexico, conclude that there are indeed spillovers and they are positive and significant at the aggregate level, but there is no explanation as to how these spillovers take place.

Other study that have produced similar results is that of Nadiri (1991), who found that FDI from US firms led to significant positive effects on productivity levels and on growth rates in manufacturing in France, Germany, Japan and Great Britain. Likewise Blomström and Wolff (1994) found that the presence of MNCs in the Mexican economy had a significant positive impact on domestic firms' total factor productivity growth rates which helped to bring them closer to productivity levels in the United States. Similarly, Blomström and Sjöholm (1998) found a positive correlation between the labor productivity of local firms in Indonesia and the presence of foreign firms.

However, other studies did not find positive spillover effects of FDI on productivity of domestic firms. In a study for Morocco, Hadad and Harrison (1993) did not find evidence that foreign presence has positive effects on the labor productivity of local firms, but they did report that MNCs competition seems to push local firms towards using best practices technologies, particularly in sectors that have low or moderate levels of technological development, which coincides with Blomström's (1986) findings for Mexico. In Venezuela Aitken and Harrison (1991) did not find evidence of positive effects for cross section analysis, however they found that local firms have higher productivity in sectors where foreign investment is more concentrated.

In a study of the impact of US firms in Europe, Cantwell (1989) found that there were sizeable differences between different sectors and firms, and concluded that the crucial factor in how successfully European firms respond to the challenge from US firms is their technology level and their market position. Kokko (1994) argued that spillover effects should not be seen as an automatic consequence of FDI because these effects depend on how the MNC is inserted into the local market and its relation to the economic activity of the host country. In a cross section study of the manufacturing sector in Mexico he concluded that positive spillovers are less likely in industries where a MNC has considerable market power and very superior technologies to those of local firms; that is to say in sectors that are "enclaves". Kokko, Tansini and Zeján (1996) found similar results for the manufacturing sector in Uruguay.

These and other similar authors suggest we should see local conditions in the host countries as a key factor in the extent and scope of spillovers. Furthermore, it is argued that for spillover effects to be positive local firms must have capacity to absorb them. This depends on a number of factors including local firms' technical skills and the extent and nature of their R&D activities. In other words, the crucial factor is how far local firms can internalize the knowledge the MNC generates and adapt it to their own conditions, processes and specific applications.

One crucial aspect of the above analysis is the extent of the technology gap between local and foreign firms that enter the market. Kokko (1994) emphasizes that if the gap is very large local firms will only be able to obtain limited benefits from the presence of foreign firms. According to Wang and Blomström (1992), the wider the technological gap the lower the spillover effect from MNCs. Furthermore, if there is a moderate technology gap, domestic firms will be able to become more efficient by imitating foreign technologies, but the gap should not be too large or else local enterprises will not be able to absorb the technological advantages the MNC brings to the country (Kokko et al., 1996). These authors also make the point that the level of competition in the market in question is important. When foreign affiliates are faced with more intense competition they will have to use more sophisticated technologies from the parent firm to maintain or increase their market share, and this will enable local firms to obtain greater spillover benefits and become more competitive, thus generating a virtuous circle.

However the empirical results are not conclusive. Cantwell (1989) found spillovers from US firms to be significant when technology gap between foreign and local firms was narrower. That is to say, the extent of the gap will affect the degree and the speed at which local enterprises adopt the new technologies brought in by the foreign firms. In a study of enterprises in Spain, France and Italy, Castellani and Zanfei (2003) found that the combination of a large gap in total factor productivity and high productivity levels in the foreign firms will generate greater positive spillovers from FDI, "while absorptive capacity does not seem to have a significant effect". However, in a study of English firms Girma, Greenaway and Wakelin (2000) found a contrary effect in that domestic firms benefit from the presence of MNCs when the total factor productivity gap is moderate, and that the effect is negative if the gap is large. Haskel, Pereira and Slaughter (2002), working with another panel of English firms, found that when the gap is large there is a greater likelihood of positive spillovers. In a study of manufacturing enterprises in Argentina, Marin and Bell (2003) found that the local firms' absorption capacity is not a significant variable for spillover effects of FDI, but they found significant positive spillovers for local firms in sectors where MNCs are "technologically active".

Most studies of these kinds take labor productivity as the variable to be explained, but in recent years there have been some empirical studies based on the frontier production function that also estimate how technically efficient firms are. An interesting study of this type was that by Sabiriana, Svejnar and Terrell (2004), who analyzed enterprises in two ex-members of the Soviet bloc, the Czech Republic and Russia. They found that in both countries local firms have diverged from the best practice established by foreign firms and have not succeeded in closing this gap. Furthermore, these authors suggest that a larger presence of MNCs in a sector has a negative effect on efficiency in local firms, and they conclude that "firms need to be more technologically advanced and open to competition in order to be able to gain from foreign presence".

Nourzad (2007) estimated a translogarithmic frontier production function on panel data for 46 countries, and concluded that increased FDI rises potential output in developing as well as developed countries, although the effect is greater in developed countries. This author also noted that FDI reduces technical inefficiencies the more open is the economy, but this effect only occurs in developed economies. These results might support the "Bhagwati hypothesis" whereby the effects of increased efficiency from FDI depend not only on trade opening but also on the degree of development of the host country.

Lastly, Suyanto, Salim and Bloch (2009) estimated productivity spillovers from FDI in two sectors, chemicals and pharmaceuticals, in Indonesia in the period 1988 to 2000, using a Stochastic Frontier approach, and they concluded that spillovers from FDI do make a significant contribution to technological progress, but their contribution to technical and scale efficiency are not significant. These authors also noted that firms that invest in R&D show greater technical progress and tend to gain more from technological spillovers. They also conclude that higher competition associates with larger spillovers.

There have been previous studies of productivity spillovers in manufacturing in Uruguay. Kokko, Tansini, and Zeján (1996) and Tansini and Zeján (1998) studied cross sections of plant level information from the 1988 Economic Industrial Census. In the first of these studies, on firms with more than 100 employees, no evidence of spillovers in the Uruguayan manufacturing sector was found, but they found significant spillovers in four-digit industries where there is a small technology gap between local and foreign firms. The authors suggest, moreover, that it is not just the characteristics of an industry that determine whether or not spillover effects occur but factors to do with the local firms themselves. In the second study the authors expanded their analysis to include all private manufacturing firms in the 1988 census to four-digit industries where there were MNCs. Again, when the sample is divided in agreement with technology gap and/or differences in organizational complexity between local and foreign firms, the authors found evidence of spillovers that are positive and significant only when the difference in organizational complexity is moderate and when technological differences are moderate.

Bittencourt and Domingo (2004) on two panels of Uruguayan industrial firms for two periods (1990-1996 and 1997-2000) found that in both periods the MNCs showed a significantly greater productivity than local firms, but the authors did not identify significant spillovers. However, when they take into consideration some measure of technological absorption capacity they concluded that the share of skilled worked in local firms improved their productivity through training and took advantage of the innovations introduced by MNCs in their industry.

3. The Uruguayan manufacturing sector: 1988-1994

The Uruguayan manufacturing sector developed in a framework of strong trade protection. Its firms are small, particularly when compared to the country's big neighbors, they lack international dimension, they are highly concentrated and they engage in very little R&D activities. The industrial structure, which was shaped in the context of an import substitution regime, is very diversified into different sectors with some firms that are basically small scale and oriented to the domestic market and others that are closely linked to processing the country's raw materials for export. However, starting in the mid 1970s, in a context of increasing external opening and structural adjustment policies, the sector has undergone important changes.

In 1974 the country's economic policy turned towards insertion in international markets. In trade policy, import licenses and quotas were abolished, tariffs were lowered, the currency market was deregulated and there was an important effort to diversify and promote non-traditional exports. The Government implemented a package of measures including tax reform, the liberalization of capital markets, reduction of public spending and stricter controls over operation of public utilities.

By the 1990s Uruguay joined the MERCOSUR and trade policy reforms continued with additional simplifications and reductions in tariffs in accordance with the requirements of the “convergence rules”. The top economic policy priorities in that decade were to stabilize the economy by implementing economic reforms, liberalizing trade and integrating into the MERCOSUR, which led to a big recovery in the economy driven by demand from Argentina and Brazil. As a consequence, up to 1994 Uruguay had moderate GDP growth rates supported by accelerated growth in volumes traded not only in response to demand from the MERCOSUR but also with the rest of the world, thanks to a certain extent to the country’s unilateral trade opening.

Manufacturing firms increased their average investments during the period, but most of this went on activities connected to production processes while investment in quality control and R&D came to account for a smaller share of the investment in the sector. Most of this new investment was made by the large exporting firms. Investment in the manufacturing sector has traditionally been quite low: in 1994 only 11% of the enterprises invested more than 5% of their sales. However, in that period the share of firms that invested increased because smaller firms with low levels of investment were going out of business. This made for a greater average level of investment per firm and to increased average investment per employee.

At the beginning of the 1990s FDI was concentrated in manufacturing (in pharmaceuticals, foodstuffs and beverages, textiles and clothing) and in the financial sector. In that decade manufacturing stopped being the main sector receiving foreign investment and its share in investment fell even more. Foreign affiliates were investing much more and spending more on R&D than local firms, and in the 1990 to 1994 period their productivity increased more.

The information we use in this study comes from the Annual Surveys of Manufacturing (Encuestas Anuales Industriales) of the National Institute of Statistics (Instituto Nacional de Estadísticas) for the 1988 to 1994 period, and two Surveys of the manufacturing sector collected by the Department of Economics at the University of the Republic for 1988-1990 and for 1994. The sample is made up of 540 firms that were active during those seven years. These enterprises employed more than 40% of all manufacturing sector workers in the average of the seven years under consideration, and they generated more than half of the gross value added in that period.

4. Methodology

There is abundant literature about estimating Stochastic Frontier Production Functions (SFPF) or Best Practices Technology, starting with the pioneer work by Farrell (1957), and various different estimation methodologies have been developed since then. The definition of frontier functions, or best practices, is based on the assumption that there are non-stochastic differences in efficiency between the productive units in an economic sector. Estimating the SFPF makes it possible to identify the dispersion of efficiency, as the estimation is based on the combination of the most efficient units. Therefore inefficiency is defined as the distance between the productive unit and the technology of reference, that is to say the relation between the utilization of resources and the output of an observed unit on the one hand and the reference technology on the other. This can be defined based on a cost, production or profit function. In the last ten years a wide range of models and methods to estimate these functions have been developed (Kumbhakar and Lovell, 2000).

Our main concern is on technical efficiency, therefore we opted for a translogarithmic specification of the of the frontier functions, so the specification we estimated is as follows:

$$\ln Y_{it} = \alpha + \beta_K \ln K_{it} + \beta_L \ln L_{it} + \frac{1}{2}\beta_{KK}\left(\ln K_{it}\right)^2 + \frac{1}{2}\beta_{LL}\left(\ln L_{it}\right)^2 + \frac{1}{2}\beta_{KL}\ln K_{it}\ \ln L_{it}$$

$$+\beta_t t + \frac{1}{2}\beta_{tt} t^2 + \beta_{Kt}\ln K_{it} * t + \beta_{Lt}\ln L_{it} * t + \beta_F F + (v_{it} - u_{it})$$

Where:

$\boldsymbol{Y_{it}}$ = Gross Value Added of firm i in the year t

$\boldsymbol{lnL_{it}}$ = log of employment in firm ***i*** in the year ***t***

$\boldsymbol{lnK_{it}}$ = log of capital stock in firm ***i*** in the year ***t***

$\boldsymbol{\beta}$ = parameters to be estimated

F = binary variable that takes the value 1 when the enterprise is foreign-owned and zero otherwise. [1]

$\boldsymbol{v_{it}}$ = random variables that we assume are ***iid*** $N(0, \sigma_u^2)$ and independent of $\boldsymbol{u_{it}}$

$\boldsymbol{u_{it}}$ = non-negative random variable that captures technical inefficiency in production. We assume it has a normal truncated distribution $N(\mu, \sigma_v^2)$

The output of the firm is defined as gross value added at constant price of 1988. Employment (***L***) is the average number of employees in the firm each year. Capital (***K***) includes machinery and buildings and is estimated based on information about capital stock declared by the firm in 1988, updated by the criterion of perpetual inventory, at constant price of 1988. It was possible to carry out this procedure because we had information about each firm's annual capital stock depreciation and investments over the period.

As regards the distribution of the second stochastic term, $\boldsymbol{u_{it}}$, which we assume is asymmetrical and non-negative, it includes a series of unobservable effects that we define as ***"inefficiency".*** To identify these, independently of the interception, we have to make an assumption about their distribution. In this case we assume that inefficiency has a normal truncated distribution with a truncation point that is not negative, so we can express it as:

$$v_{it} \approx N(0, \sigma_u^2) \qquad and \quad u_{it} \approx TN(\mu, \sigma_v^2)$$

Where ***TN*** stand for "*Normal truncated distribution*". It is particularly important to evaluate the null hypothesis:

$\boldsymbol{H_0 : \mu = 0}$

as the suitable distribution could be equal to or greater than zero. For this we estimate this parameter by maximum likelihood with the rest of the parameters in the model. The

[1] A foreign firm is defined to be any enterprise in which more than 10% of the integrated capital is owned by physical or legal persons not resident in the country.

evaluation of the assumption about distribution is made by the Maximum Likelihood Ratio test.

As suggested by Aigner, Lovell and Schmidt (1977), the variance parameters are replaced by $\sigma = \sigma_v^2 + \sigma_u^2$ and $\lambda = (\sigma_u / \sigma)$ for their estimation, and the latter is replaced by $\lambda = \gamma = (\sigma_u^2 / \sigma^2)$ so γ will take values between zero and one (Battese and Corra, 1977). Battese and Coelli (1993) suggest a time varying model for inefficiency effects, which are assumed to be expressed as:

$$u_{it} = \{exp[-\eta(t-T)]\} u_{it} \qquad i = 1,...,n; \quad t = 1,...,T$$

Where u_{it} are assumed to be ***i.i.d.*** non-negative error term following a truncated-normal distribution and η is an unknown parameter to be estimated. Thus technical inefficiency either increases at a decreasing rate, when $\eta > 0$, or decreases at an increasing rate when $\eta < 0$. If $\eta = 0$ the time invariant model is obtained.
To evaluate the impact of enterprise characteristics on inefficiency Battese and Coelli (1995) suggested that the technical inefficiency effects, u_{it}, could be replaced by a linear function of explanatory variables of firm-specific characteristics. In this way, every firm in the sample faces its own frontier, given the current state of technology and its endowments, and not a sample norm. The technical inefficiency effects are assumed to be independent, non-negative truncation of normal distributions with unknown variance and mean.

$$u_{it} = \delta_0 + \delta_1 z_{1it} \ldots\ldots + \delta_n z_{nit} + \omega_{it}$$

Where z_{nit} are the firm and time specific explanatory variables associated with technical inefficiencies; δ are parameters to be estimated and ω_{it} is a random variable with zero mean and variance σ^2. Based on this formulation, we included into the specification of the Best Practice function, the following firm and industry specific variables:

- ***Spillover:*** share of foreign enterprises in the sales of the four-digit industry

- ***Opening to imports***: share of imports in the sales of final goods of the four-digits industry
- ***LQ*****:** share of white collar personnel in total employment in the firm
- ***Percentage R&D***: share of professional in R&D activities in the professional staff of the firm
- ***Share of exports*** in total sales of the firm
- ***GAP GAV_L:*** ratio of labor productivity local-foreign firms

If all the parameters of these variables are zero, the model will reduce to one whose error term will have a normal truncated distribution, where δ_0 would correspond to the parameter μ specified by Stevenson (1980), and to the modeling of the stochastic frontier for the panel data of Aigner, Lovell and Schmidt (1977). But if all the parameters, the random as well as the deterministic, are equal to zero ($\gamma = \delta_0 = \dots = \delta_n = 0$) u_{it} is superfluous in the modeling. In this case we could estimate the traditional average function, which would mean the enterprises are technically efficient. The parameters of the production function and inefficiency effects model can be consistently estimated by Maximum Likelihood method. The simultaneous estimation of this formulation allows identifying consistently the factors affecting technical efficiency in a single stage.

In order to evaluate the hypotheses outlined above, we divided the sample into various sub-samples. One of these is the group of local firms, another are of local firms in four-digit industries where there are MNCs, and the other include the rest of the local enterprises. This classification is compatible with the hypothesis to be evaluated: whether the presence of foreign affiliates has an impact on the performance of local firms through spillover effects and other externalities that may be positive or negative. If this effect exists, we can expect it will have an impact on the local enterprises that operate in the immediate environment of the foreign affiliates, in other words in the industry or market that is common to both. Consequently we would expect that if this effect exists the structure of the parameters of the model should be significantly different in the two sub-samples (local firms belonging to industries with foreign presence and without foreign presence), which would denote that the two groups of local enterprises are employing different technologies, and we can analyze this by evaluating if the parameters are different.

We then focus the analysis of technological differences only on local firms in industries with foreign presence taking account of the technology gap between local and foreign firms. We define the technology gap as the ratio of the average labor productivity of foreign-owned firms in the relevant four-digit industry to the locally-owned plant's own labor productivity (*Gap GAV_L*). This variable is equal to one if the locally-owned firm operates at the same labor productivity as its foreign-owned competitors, and increases with the difference in labor productivity. According to Kokko et al. (1996) we can expect that the existence of spillovers to local firms will be associated with a narrower technological gap with respect to foreign firms. To evaluate this hypothesis we included this variable in the explanation of inefficiency in the SFPF for the sub-sample of local firms in industries where foreign firms are present. Then we divided the sample of local firms belonging to industries with foreign presence in two sub-samples, one defined as with "moderate technology gap", when the variable *GAP VAB_L* is less than 2.17, and other as with "large technology gap", when this variable is greater than 2.17.[2]

After the SFPF estimations for the whole sample and for each sub-sample, we carried out various tests to evaluate the existence of differences between the sub-samples. This approach enabled us to refine the null hypothesis and was aimed at identifying differences in technology use by local and foreign firms. With respect to the tests of the hypothesis we carried out, we considered that when evaluating differences in individual parameters between two sub-samples the standard t-test is suitable, under the assumption that the parameters related to the same variable in the two sub-samples will have a normal and independent distribution.

Note that we carried out the estimation for the whole sample introducing a dummy variable that identifies the foreign firms so as to evaluate whether there was significant difference at the frontier with local firms, for the 540 enterprises over the seven years.

[2] This value was proposed by Kokko, et al. (1996), as this value generates similar size sub-samples of domestic enterprises in branches where there are foreign firms.

5. Econometric estimations and results

A crucial aspect of the SFPF estimation is the functional form that it takes, which requires the evaluation of a series of underlying assumptions in the translogarithmic specification not only for all the firms but also for each sub-sample. For the evaluation of the null hypothesis in the different specifications of the SFPF we employ the Generalized Likelihood Ratio test, which has a distribution χ^2 with degrees of freedom equal to the number of parameters involved in the restrictions to be evaluated. The Generalized Likelihood Ratio test is defined as:

$$LRT = -2\left[\ln(L(H_0)) - \ln(L(H_1))\right] = \lambda$$

Where:

L(H$_0$) = log-likelihood value of the SFPF estimated with the restrictions, Null Hypothesis,

L(H$_1$) = log-likelihood value of the FPF estimated in accordance with the proposed model, without restrictions. In the case of ***H_0: γ=0*** of no inefficiency effects it has approximately a mixed χ^2 distribution of $\frac{1}{2}\chi_0^2 + \frac{1}{2}\chi_1^2$. The results of the various tests of the hypothesis are given in Table 1.

According to the evaluation of the hypothesis the Cobb-Douglas formulation is rejected at 1% of significance ($\beta_{KK}= \beta_{LL}= \beta_{LK}= \beta_t= \beta_{tt}= \beta_{Lt}= \beta_{Kt}=0$), as is the inexistence of technical progress ($\beta_{Kt}= \beta_{Lt}= \beta_{tt}= \beta_t= 0$), the Hicks-Neutral formulation ($\beta_{tK}=\beta_{tL}=0$) and the inexistence of inefficiency ($\gamma=\delta_1=\ldots=\delta_n=0$). We can also reject the hypothesis that the dummy variable which identifies the foreign firm is not suitable for the specification of the SFPF. This very last result constitutes a first indication that there are technology differences in the SFPF, between local and foreign firms.

Table 1: Test of Hypothesis about the Frontier Production Function (FPF)

	All		All local		Local with foreign		χ^2 Critical Value at 1%
Test of Hypothesis	**λ**	H_0	**λ**	H_0	**λ**	H_0	
Cobb-Douglas	8926.26	Rejected	7984.52	Rejected	4544.10	Rejected	18.48
No technological progress	8731.49	Rejected	7833.14	Rejected	4406.75	Rejected	13.28
Hicks Neutral	21.35	Rejected	25.51	Rejected	22.19	Rejected	9.21
No inefficiency	355.96	Rejected	332.92	Rejected	200.24	Rejected	16.07[3]
$\mu=0$	127.33	Rejected	104.37	Rejected	66.97	Rejected	6.64
No effect of foreign firms on the FPF (F)	141.33	Rejected	---	---	---	---	10.83

The null hypothesis, H_0: $\gamma=0$, makes it possible to evaluate not only whether the distribution is semi-normal, but also whether it meets the requirements to represent technical inefficiency, and consequently its rejection will suggest that the distribution of technical inefficiency is normal truncated, and with the truncation significantly greater than zero. Note that the null hypotheses are evaluated in the different sub-samples (see in Table 1) and in all cases the results are coincident.

Table 2 shows the estimated parameters of the SFPF, without explaining inefficiency, for all firms and for each sub-sample: all domestic firms; domestic firms in industries where MNCs are not present; and those in industries where MNCs are present. The last column (5) gives the SFPF parameters estimation for MNCs. The estimations suggest that the specification allowing for different levels of technical efficiency of the firms ($\gamma\neq0$) makes possible a better estimation than that made with average production functions. In all SFPF estimations the variance in technical efficiency of the firms is between 36% and 59% of the variance of the error in the estimation. In other words, if the estimation were carried out by average production functions we would be treating as random errors differences that in fact correspond to different levels of firm's technical efficiency.

It can be seen that the parameter η of the time trend in technical efficiency, turns out to be highly significant and negative, which indicates there is a decreasing trend in technical inefficiency. Note that similar results were found in n the different sub-samples. However, that parameter is more than 50% smaller in the sub-sample of local firms belonging to

[3] Critical value is taken from Table 1 of Kodde and Palm (1986).

industries with MNC presence than in the sub-sample of industries where foreign firms are not present. This result suggests that the Best Practice technology shifted over time in such a way that the level of output with given inputs increased. This is confirmed by the positive sign and significance of the time trend in the SFPF (β_t).

To evaluate whether the difference in ownership of the firms is significant for frontier technology in the sample we included in the specification of the SFPF a dummy variable (***F***) that takes the value 1 if the firm is foreign, and zero otherwise. As can be seen in Table 2, this parameter (β_F) turns out to be highly significant in the specification that includes an efficiency time structure (Battese & Coelli, 1993), and it also turns out to be significant when we include the explanatory variables of inefficiency (see Table 3). The evaluation of technical progress in the SFPF shows the existence of a significant positive change close to 2% (β_t) although it should noted that the one corresponding to time squared (β_{tt}) is negative and significant, which suggests that technological change is decreasing over time.

Table 2: Maximum Likelihood Estimation of the Frontier Production Function

	All enterprises	All Domestics	Domestics without MNCs in the industry	Domestics with MNCs in the industry	MNCs
Intercept	5.462***	5.647***	6.445***	5.533***	7.683***
	(17.18)	(17.18)	(12.61)	(11.73)	(7.76)
β_K	0.075**	0.046	-0.063	-0.004	-0.487
	(2.01)	(1.12)	(-1.09)	(-0.05)	(-0.92)
β_L	1.203***	1.129***	0.992***	1.449***	2.179***
	(12.45)	(11.19)	(6.15)	(8.31)	(4.28)
β_{KK}	0.008***	0.007***	0.009***	0.020***	0.055***
	(8.54)	(7.53)	(8.02)	(3.50)	(3.13)
β_{LL}	-0.051***	-0.044***	-0.061***	-0.006	-0.012
	(-3.94)	(-3.07)	(-3.36)	(-0.27)	(-0.25)
β_{KL}	0.0001	0.009	0.033**	-0.050**	-0.124***
	(0.01)	(0.91)	(2.32)	(-2.40)	(-2.47)
β_t	0.019***	0.019***	0.019***	0.020***	0.021***
	(56.49)	(54.57)	(37.50)	(40.97)	(13.78)
β_{tt}	-0.001***	-0.001***	-0.001***	-0.001***	-0.001***
	(-26.65)	(-26.62)	(-16.67)	(-22.36)	(-7.90)
β_{Lt}	-0.00005	-0.0001**	-0.0003***	0.0001	0.0005**
	(-0.82)	(-2.05)	(-3.05)	(0.56)	(2.10)
β_{Kt}	-0.0001***	-0.0001**	0.00003	-0.0002***	-0.0004***
	(-2.72)	(-2.15)	(-0.55)	(-3.73)	(-2.89)
β_F	0.738***	---	---	---	---
	(8.71)	---	---	---	---
σ^2	1.051***	0.885***	1.103***	0.742***	1.653***
	(17.27)	(10.39)	(13.45)	(13.94)	(9.27)
γ	0.701***	0.648***	0.723***	0.613***	0.798***

	(59.77)	(32.15)	(45.73)	(33.88)	(41.74)
γ Corrected [4]	***0.460***	***0.401***	***0.487***	***0.366***	***0.590***
μ	1.716*** (15.57)	1.514*** (15.41)	1.787*** (14.29)	1.349*** (11.01)	2.298*** (10.62)
η	-0.092*** (-11.82)	-0.079*** (-7.79)	-0.101*** (-7.34)	-0.043*** (-3.08)	-0.125*** (-5.89)
Obs.	3780	3297	1407	1890	483
Log-likelihood	-3826.7	-3292.818	-1394.017	-1892.149	-507.936
LR Test	1609.3	1315.513	652.450	595.608	289.919

t statistic in brackets:=significant at 10%. **=significant at 5%, ***=significant at 1%*

In general there are no important differences when we compare the results for all the firms and for the different sub-samples, but it is noteworthy that in the sample of local firms in industries where MNCs are present the parameter of the time variable interactive with capital stock (β_{Kt}) is negative and significant, which suggests that there is a capital saving trend on the best practice technology. Something similar happens with the sub-sample of foreign firms.

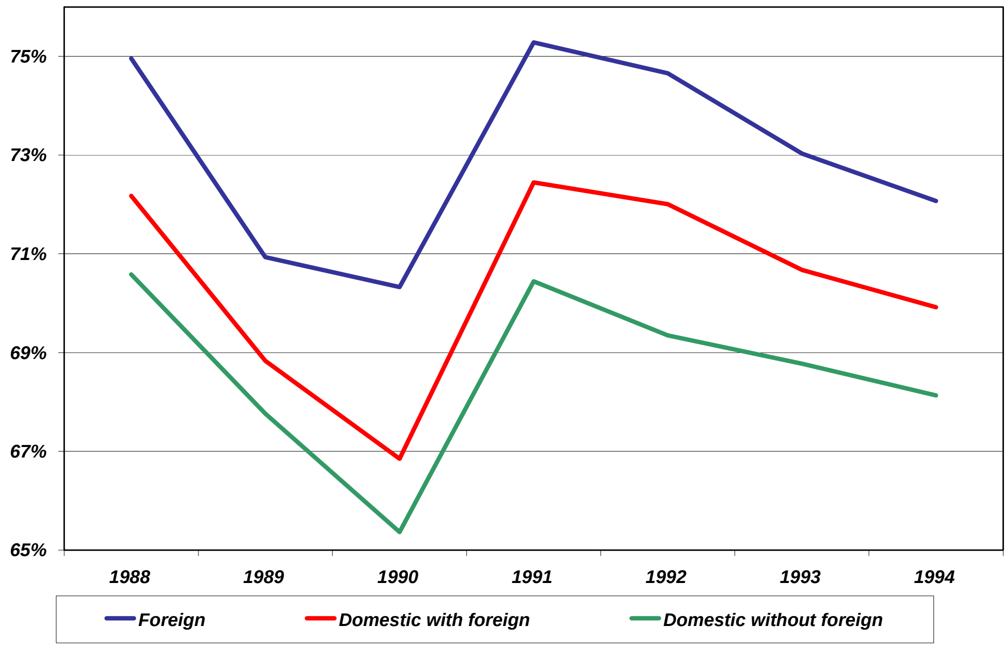
The capital stock parameter is positive and significant at 5% in the estimation for the whole sample, and then it loses significance when we look at the sub-samples. However, it has to be noted that the parameters of the squared variable of capital (β_{KK}) is positive and highly significant in all the sub-samples, which suggests the existence of increasing returns to this factor. Note, too, that this parameter is larger in the sub-sample of local firms in industries with MNCs, and even larger when we look at the sub-sample of foreign firms. The labor variable (β_L) emerges as positive and highly significant; although the parameters of the squared variable of labor (β_{LL}) suggest decreasing returns. It seems interesting that the value of this parameter is nearly 50% larger in the sub-sample of local firms in industries with foreign firms than in the sub-sample with no foreign presence. In the sub-sample just of foreign firms this parameter is even larger.

This evaluation suggests that in the sample of 540 enterprises in the seven years analyzed the levels of technical efficiency in enterprises in industries with or without foreign presence were different. The foreign firms use capital saving technologies and with increasing returns to this factor, while labor shows decreasing returns. Domestic firms in industries where MNCs operated had technology that is more like that of the foreign

[4] Given that the variance of v_i is equal to $[(\pi - 2)/\pi]\,\sigma^2$, the contribution of technical efficiency to total variance will be equal to $\gamma/[\gamma + (1-\gamma)\,\pi/(\pi - 2)]$ (see Battese and Coelli (1995) and Green (1993))

enterprises than that of other local enterprises. It also emerges that there is technological change in the frontier technology, which was positive but decreasing over time, and there are significant differences in terms of technology between local and foreign firms. Figure 1 shows the average technical efficiency for the different sub-groups of firms resulting from the estimation.

Figure 1: Average Technical Efficiency by Ownership: 1988-1994



It can be seen that over the period there is a rather constant difference between the average technical efficiency of MNCs and that of local firms, with foreign firms clearly more efficient. It can also be seen that among local firms, those operating in industries with foreign presence are more efficient. The efficiency of all firms increased over the period analyzed.

When we look at the evolution of technological progress, in line with the specification of Coelli, Prasada Rao and Battese (1998), as can be seen in Table 3, the rates are positive but they decreased over the period. The differences between the firms by ownership are not very important, but the foreign firms always have slightly higher rates than those of local firms, and local firms in industries with foreign presence show the lowest rates of technological progress over the period.

Table 3: Technological Progress of Firms by Ownership (SFPF)

	Domestics in industries with foreign presence	*Foreign enterprises*	*Domestics in industries without foreign presence*
1988-1989	1.6%	1.7%	1.7%
1989-1990	1.6%	1.7%	1.6%
1990-1991	1.5%	1.6%	1.5%
1991-1992	1.4%	1.5%	1.4%
1992-1993	1.3%	1.4%	1.4%
1993-1994	1.2%	1.3%	1.3%

The other hypothesis to be tested is if the presence of foreign firms has any effect at all on the level of technical efficiency in local firms. To evaluate this hypothesis we constructed a sub-sample with 471 domestic firms and evaluated the effect of firm-specific variables to explain technical inefficiency. In particular we evaluated whether or not the fact that a local firm operates in a four-digit industry with foreign presence affected its level of technical inefficiency.

Table 4 gives the maximum likelihood estimations of the SFPFs with explanation of inefficiency for all the firms and for the two sub-samples of local firms according to whether they belong to a four-digit industry in which MNCs are present. As mentioned above, the Generalized Likelihood Ratio test allows us to reject the null hypothesis that the explanatory parameters are equal to zero (see table 1).

It can be seen that for all the firms the inclusion of the variables that explain inefficiency reduce the magnitude of the variance of technical inefficiency of firms with respect to the variance in the error of the estimation ***(γ corrected)***. That is to say, the inclusion, among others, of a variable accounting for the presence of foreign firms in the industry the local firm belongs to, significantly reduces the errors in the estimation and confirms that it is relevant in the explanation of the local firms' performance in terms of technical efficiency. The presence of MNCs in the industry (***Spillover***) is highly significant for the explanation of the technical inefficiency of the local firms. The negative coefficient of ***Spillover*** variable implies a positive efficiency spillover, suggesting that the higher share in sales of foreign firms in the industry results in more efficient local firms, which leads to productivity gains.

The opening to imports of the industry that the firm operates in is significant for reducing inefficiency for local firm in sectors where there is no foreign affiliate presence. These results suggest that imported goods competition in domestic markets would lead local firms to improve their technical efficiency. But the fact that opening to imports does not turn out to be significant for technical inefficiency in the case of local firms that operate in industries where there are foreign firms, suggests that their presence would be a more important factor in improving efficiency of local firms than competition from imports in the local market.

It also emerges that the propensity to export of firms does not contribute to reducing technical inefficiency, and this result is similar in all the sub-samples. Apparently firms that have a larger propensity to export would not experience relevant competitive pressures on efficiency because they base their competitiveness on some comparative advantage the country has (agro-exporters) rather than on improved efficiency.

Table 4: Maximum Likelihood Estimation of the SFPF (different sub-samples)

	All enterprises	Local	Local without Foreign	Local with Foreign
Intercept	5.049*** (20.78)	5.247*** (21.03)	5.193*** (13.42)	5.273*** (15.33)
β_K	0.008*** (0.23)	-0.037 (-1.08)	-0.079*** (-0.56)	-0.209 (-0.09)
β_L	1.241*** (17.84)	1.230*** (17.40)	1.133*** (10.70)	1.722*** (14.26)
β_{KK}	0.007*** (8.81)	0.006*** (7.89)	0.008*** (9.32)	0.032*** (6.36)
β_{LL}	-0.067*** (-6.34)	-0.076*** (-7.08)	-0.087*** (-6.34)	-0.012 (-0.64)
β_{KL}	0.020*** (2.86)	0.033*** (4.68)	0.045*** (4.56)	-0.062*** (-3.75)
β_t	0.018*** (42.07)	0.018*** (41.37)	0.018*** (25.46)	0.018*** (32.64)
β_{tt}	-0.001*** (-22.50)	-0.001*** (-21.63)	-0.001*** (-13.68)	-0.001*** (-17.07)
β_{Lt}	0.00003 (-0.36)	-0.0001 (-1.20)	-0.0002** (-1.98)	0.0001 (1.14)
β_{Kt}	-0.0001* (-1.85)	-0.0001* (-1.64)	-0.00004 (-0.55)	-0.0002*** (-2.79)
β_F	0.651*** (15.51)	--- ---	--- ---	--- ---
Spillover	-0.710*** (-2.91)	-0.695*** (-2.95)	--- ---	-0.736*** (-2.59)
Opening to imports	-0.520*** (-2.57)	-0.797*** (-3.61)	-0.797*** (-8.45)	0.119 (0.48)
LQ	-0.804***	-0.335	-0.157***	-2.375***

	(-2.73)	(-1.38)	(-6.57)	(-3.40)
Personnel in R&D	-26.001*** (-3.39)	-24.985*** (-3.48)	-1.507*** (-4.93)	-29.211*** (-2.65)
Percentage of exports	1.679*** (16.70)	1.601*** (13.53)	1.137*** (13.77)	1.420*** (7.99)
Gap GAV/L	--- ---	--- ---	--- ---	0.124*** (2.39)
σ^2	0.855*** (14.60)	0.759*** (14.36)	0.605*** (29.21)	0.878*** (9.98)
γ	0.387*** (6.26)	0.344*** (4.88)	0.127*** (4.27)	0.571*** (10.48)
γ Corrected	***0.187***	***0.160***	***0.050***	***0.326***
Obs	3780	3297	1407	1890
Log-likelihood	-4453.381	-3784.113	-1640.285	-2043.463
LR	355.958	332.923	159.913	200.243

t statistic in brackets:=significant at 10%. **=significant at 5%, ***=significant at 1%*

The variables that stand for local firms' technology absorption capacity (share of white collar in total employment and percentage of technicians and professionals in R&D activities) turn out to be significant and negative in all sub-samples, suggesting that they have inefficiency reducing effects. The explanation for this could be that more skilled personnel available would increase local enterprises' technical and absorption capacity, having a positive impact on technical efficiency.

When we include the variable measuring technology gap between local and foreign firms in the same industry (***GapVAB_L***) it results positive, which suggests that when the technological gap is larger local firms have higher levels of technical inefficiency.

Lastly, Table 5 shows the results of the estimation only for local firms that operate in industries where MNCs are present, and they have been re-grouped in function of two characteristics. The first rearrange is in function of the existing technology gap between the local and foreign firms. The sub-sample of local firms with moderate technology gap includes those whose ratio is less than 2.17, while those with a larger technology gap are those whose ratio is greater than this value. The second grouping of local firms is in function of the export propensity of foreign firms in their industry (greater or less than 40% of sales), and the aim is to evaluate if the market orientation of MNCs, and hence the level of competition in the local market, has any impact on the spillover effects that has been identified in firms of industries with foreign firms. We present the estimated parameters of the SFPF for the four sub-samples of local firms belonging to industries with foreign presence.

When we compare the estimations for the sub-samples of local firms by the technology gap we can discard (by the t-test) the hypothesis that the parameters of the SFPF in the two sub-samples are the same. These results suggest that the best practice technologies in the two sub-samples are significantly different. The spillover effect parameter only turns out to be significant, and with the expected sign, where the technology gap is moderate. However, in local firms in industries where there is a larger technology gap the parameter turns out to be positive and with a level of significance within conventional limits, which could be interpreted as an indication that the technological distance allows two groups of firms to exist in the same industry, local firms alongside foreign ones that behaves in a way similar to an “enclave”.

Where there are local firms with large technology gap with respect to foreign ones, the share of white collar personnel in total employment turns out to be highly significant and has the expected sign (negative). Moreover, the participation of personnel in R&D is also significant and negative in both estimations, but it is three times larger when the gap is larger. These results suggest that in local firms with moderate technology gap the impact on technical efficiency of white collar personnel in total employment and the number of people engaged in R&D is higher than in local firms where the gap is larger. Probably this is a consequence of the technology difference between local and foreign firms, which reduces competitive pressures and the necessity to boost productivity. In any case, we can conclude that when the share of white collar employees and of personnel engaged in R&D is greater, even in firms that further behind the foreign firms in terms of technology, they contributes to reducing inefficiency in local firms.

When we evaluate the sub-sample of local enterprises in industries where the MNCs are mainly exporters, again we find that there are significant technological differences in the two groupings of local firms. Furthermore, in the estimation in the last two columns of Table 5 the evaluation of the two sets of parameters shows that we cannot reject the hypothesis that the parameters of capital and labor are equal while for the rest they are significantly different, which shows that there are different technologies in these groupings of local firms.

In this case the spillover variable is negative and significant only in the group of local firms in industries where more than 60% of foreign affiliate sales are aimed to the local market, but it is not significant for those in industries where foreign firms export most of their production. Similarly, the variable that identifies the technology gap (***Gap GAV_L***) turns out to be highly significant and positive for local firms in industries where the sales of foreign firms are mostly in the domestic market, and it is not significant among local firms where most foreign sales are exports. These results suggest that when MNCs export a large share of their production they put less competitive pressure on the local market, which reduces the spillover effect on technical efficiency in local firms. This would seem to be supported by the fact that the parameter of the technology gap (***Gap GAV_L***) does not turn out to be significant. We should remember that large exporters usually base their operations on the comparative advantages that the country has, and in the case of Uruguay they mainly engage in processing products of agricultural origin, which are generally commodities.

Table 5: Maximum Likelihood Estimation of the SFPF (local firms in industries with foreign presence)

	Local with MNCs	**Technological GAP**		**MNCs in the industry export:**	
		Moderate	**Large**	**Less than 40%**	**More than 40%**
Intercept	5.273*** (15.33)	5.671*** (13.07)	5.093*** (9.58)	5.422*** (14.61)	6.108*** (9.38)
β_K	-0.209 (-0.09)	-0.118 (-1.38)	-0.324 (-1.03)	-0.204 (-0.92)	-0.245 (-0.20)
β_L	1.722*** (14.26)	1.214*** (7.33)	2.077*** (11.72)	1.519*** (9.41)	1.519*** (8.41)
β_{KK}	0.032 (6.36)***	0.022*** (3.34)	0.047*** (6.24)	0.031*** (5.86)	0.020*** (2.57)
β_{LL}	-0.012 (-0.64)	-0.005 (-0.17)	0.012 (0.49)	0.017 (0.73)	-0.082*** (-2.74)
β_{KL}	-0.062*** (-3.75)	-0.025 (-1.08)	-0.114*** (-4.97)	-0.063*** (-3.19)	0.005 (0.19)
β_t	0.018*** (32.64)	0.017*** (22.85)	0.020*** (25.68)	0.018*** (26.82)	0.019*** (21.68)
β_{tt}	-0.001*** (-17.07)	-0.001*** (-10.84)	-0.001*** (-14.14)	-0.001*** (-14.20)	-0.001*** (-13.25)
β_{Lt}	0.0001 (1.14)	0.0003* (1.79)	0.0001 (0.37)	0.0001 (0.74)	0.0003* (1.73)
β_{Kt}	-0.0002*** (-2.79)	-0.0002** (-2.24)	-0.0002*** (-2.95)	-0.0001 (-1.18)	-0.0003*** (-3.00)
Spillover	-0.736***	-4.046***	0.618**	-0.469***	0.379

	(-2.59)	(-4.55)	(2.02)	(-3.13)	(0.79)
Opening to imports	0.119	0.319	-0.566	0.034	-0.655
	(0.48)	(0.77)	(-1.19)	(0.27)	(-1.00)
LQ	-2.375***	-0.592	-3.335***	-0.551***	-1.893*
	(-3.40)	(-0.96)	(-4.13)	(-2.96)	(-1.80)
Personnel in R&D	-29.211***	-23.640*	-75.311***	-4.426	-48.665***
	(-2.65)	(-1.71)	(-2.74)	(-1.59)	(-2.76)
Percentage of exports	1.420***	2.575***	1.053***	0.011	1.405***
	(7.99)	(9.79)	(4.85)	(0.15)	(5.87)
Gap GAV/L	0.124***	---	---	0.258***	-0.112***
	(2.39)	---	---	(6.85)	(-1.51)
σ^2	0.878***	0.761***	1.083***	0.474***	1.105***
	(9.98)	(7.82)	(10.15)	(27.10)	(8.91)
γ	0.571***	0.439***	0.742***	0.406	0.788***
	(10.48)	(4.65)	(17.88)	(1.21)	(21.48)
γ Corrected	***0.326***	***0.221***	***0.512***	***0.199***	***0.575***
Obs	1890	980	910	1064	819
Log-likelihood	-2043.463	-1042.794	-943.215	-1093.849	-864.339
LR	200.243	174.687	100.771	54.673	104.128

t statistic in brackets:=significant at 10%. **=significant at 5%, ***=significant at 1%*

5. Conclusions

In this study we evaluate whether there were intra-industry spillover effects from foreign firms on technical efficiency in local firms in the manufacturing in Uruguay, using panel data of 540 firms over seven years (1988-1994). To do this we estimated Stochastic Frontier Production Functions. The first point to note is that the estimation for the whole sample shows that the firms have different levels of technical efficiency, which suggests that average production function estimations would not be a suitable estimation method because what we would be identifying as random errors would in fact be differences in technical efficiency.

We found that there are differences in best practices technology between local and foreign firms, and our evaluation of the parameters suggest that there are significant differences between the sub-sample of local firms in industries with and without foreign presence, and both are different to the sub-sample of MNCs.

Our analysis of the whole sample of manufacturing firms also reveals that the foreign firms had higher average technical efficiency levels in the seven years, nearly four percentage points higher than that of locals, and that local firms in industries with foreign presence registered higher average technical efficiency (three percentage points) than those in industries where there were no foreign firms.

The estimations also suggest that the presence of foreign firms, measured by their share of sales in the industry, has a positive and significant spillover effect on technical efficiency in local firms, and that competition from imported goods, measured by the share of imported goods in the market of final products of the industry, is also associated with higher levels of technical efficiency, but in local firms in industries without foreign presence. Furthermore, we found that this variable loses significance in the sub-group of firms of industries where foreign firms are present, which suggests that the effect of the presence of foreign firms operates as direct external competition.

The share of white collar employees and of professional and technicians working on R&D is also associated with higher efficiency levels in local firms (negative and significative parameters). Furthermore, the parameter estimates for these variables for local firms in industries with foreign presence were very much larger than that for firms in industries without foreign presence.

The evaluation of the magnitude of the technology gap between local and foreign firms in the same industry suggests that a larger technology gap is associated with higher levels of technical inefficiency in local firms. What is more, when we evaluated the spillover effects in two sub-samples, one with moderate technology gap and the other with large gap, we found that the impact of the presence of MNCs is associated with increasing levels of technical efficiency when the gap is “moderate”, while in the sub-sample of local firms in industries with a “large” gap the presence has a negative impact on technical efficiency.

These results suggest that although there are significant spillover effects on technical efficiency from MNCs on local firms, these depends upon absorption capacity of local firms, linked to R&D activities and to the magnitude of the technology gap between local and foreign firms. Moreover, we can conclude that the spillover effect from the presence of foreign firms in an industry on local firms is only significantive when technology gap between them and local firms is moderate, and when the foreign firms in the industry are mainly geared to the domestic market These last results suggest that the spillover effects of foreign firms on technical efficiency would occur when the foreign firms are a direct competition for domestic firms, not just because of the foreign firms' presence.

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