Technology Transfer through Backward Linkages: The Case of the Spanish Manufacturing Industry.

Jean-Louis MUCCHIELLI*
Liza JABBOUR**

Abstract

The aim of this paper is the study of technology transfer through backward linkages between multinational enterprises and local suppliers. This issue is of a great interest for several reasons.

First of all, the new theory of economic growth suggests that technological innovations are becoming an increasingly important contributor to economic growth.

Secondly, an obvious policy issue for governments is whether incentives should be offered to multinational firms to attract them or not. In fact and despite the controversies surrounding the benefits and costs of foreign direct investment, many countries have now changed their policies from restricting foreign investment towards promoting it. One benefit often cited, in the literature on the gains from FDI, to justify this promotion is the new technology brought in by foreign affiliates.

The econometric analysis will be based on a firm level dataset from Spain for the period 1990-2000. We use the Olley and Pakes method to estimate the total factor productivity of the firms and measure the effect of downstream FDI on local firm productivity and find positive evidence on the existence of technology transfer through backward linkages.

* Professor of the University of Paris I Panthéon-Sorbonne, jlmuc@univ-paris1.fr
** PHD student at the University of Paris I Panthéon-Sorbonne and TEAM-CNRS, ljabbour@univ-paris1.fr

I-Introduction

Recently, the economic literature is focusing on the analysis of the technology transfer, especially the technology diffused through foreign direct investment (FDI).

The interest in the technology transfer finds its origin in the new theory of economic growth. In fact the theory of economic growth suggests that technological progress is the main contributor to the economic growth. Developing countries, which are in need of attaining high levels of economic growth so that they can be able to fill the development gap with the developed countries, lack the capacity to undertake research and development activities and to generate technological innovations; therefore they rely on foreign source of technological innovations in their growth process.

Technology can be diffused internationally through many channels such as international trade, FDI and the movement of factors and communication between agents. Two stylised facts make FDI deserve a deep analysis as a channel of international diffusion of technology. The first is the growing importance of FDI in the international economy (WIR 2000). The second is the fact that many countries, especially developing ones, are changing their policies from restricting toward promoting FDI despite the controversies surrounding the benefits and costs of foreign investment. One benefit often cited, in the literature on the gains from FDI, to justify this promotion is the new technology brought in by foreign affiliates.

The economic theory presents four essential mechanisms through which FDI diffuses technology in the host countries: demonstration effect, workers turnover, competition and vertical linkages.

The econometrical literature presents much diversified results. Earlier studies, such as those of Caves (1974) and Globerman (1979) are at the industry level and find a positive relation between the presence of foreign enterprises and the productivity of the local industry. However a positive correlation does not mean causality and this result may simply reflect the fact that multinationals invest in the most productive sectors of an economy or the fact that the entry of foreign firms pushes the less productive firms out of the market, raising the average productivity of the industry. The studies at the firm level, such as those of Haddad and Harrison (1993) and Aitken and Harrison (1999), overcome most of the problems faced by the industry level studies. Most of those studies are concerned with developing countries, and find negative or insignificant correlation between foreign presence and the productivity of local firms. The absence of technological spillovers is generally explained by the lack of absorptive capacity of the local firms. However all of those studies focus on the technology transfer between foreign affiliates and local enterprises belonging to the same sector, e.g. the horizontal technology transfer. One plausible explanation of the absence of this kind of technology transfer is that the diffusion of their technology and know-how to their local competitors it is not in the strategic interest of foreign affiliates, especially when the technological superiority of the foreign affiliates is the main element of their competitive advantage in the host market.

Considering this fact and the fact that foreign affiliates can be interested by the technological upgrading of their suppliers, vertical linkages between foreign affiliates and domestic suppliers may be the most effective channel through which FDI may transfer technology to the host economy. Moreover, and in the more optimistic cases where horizontal technology transfer exists, this transfer corresponds to indirect and involuntary technological externalities. We can suppose that in the presence of backward linkages with local suppliers, the foreign affiliates will engage in a direct and explicit transfer of technology.

The literature on the technology transfer through vertical linkages is relatively rare but we can cite the studies of Smarzynska (2002) on Lithuania, Blalock and Gertler (2003) on Indonesia and Schoors and Van der Tol (2001) on Hungary. In contrary to the studies analyzing horizontal technological transfer, these studies find significant proof on the existence of technology transfer between foreign enterprises and their local suppliers.

This paper analyses the case of the Spanish manufacturing industry and aims at verifying the existence of technological spillovers through backward linkages and examining which kind of foreign firms is the most favourable to the establishment of backward linkages with local suppliers and to the transfer of technology to those suppliers.

More precisely we distinguish between foreign affiliates serving essentially the local market and those using the local market as a base for exportation. We distinguish also between fully owned foreign affiliates and affiliates with some local participation. Those distinctions are important for the policy makers aiming to upgrade the technological capacities of their domestic enterprises by attracting multinationals.

We estimate the effect of backward linkages with foreign affiliates on the total factor productivity (TPF) of domestic firms in the upstream sectors and find positive and significant correlation. We also find negative and significant correlation between foreign presence and productivity of domestic firms in the same sectors. This result confirms the precedent results on the efficiency of backward linkages as a channel for technology transfer.

Moreover we find that export oriented and fully-owned ones are more efficient for the vertical technology transfer than home market-oriented affiliates and partially owned affiliates.

We estimate total factor productivity using the semiparametric estimation method proposed by Olley and Pakes (1996). This method accounts for the endogeneity of input demand and for the exit of firms improving the quality of the estimation.

Our data set results from the ESEE annual enterprise survey conducted by the Spanish ministry of science and technology and the “Fundación SEPI”. The survey covers the period 1999-2000.

The rest of the paper is structured as follow; in the second section, we present a brief survey of the literature on vertical linkage and technology transfer. In the third section, we present the data and the estimation methodology. In the fourth section we measure the effect of foreign presence and the effect of backward linkages with foreign affiliates on the productivity of domestically owned firms. Section five concludes the paper.

II-Vertical linkages and Industrial development

Foreign direct investment has many implications on the host economy. The entry of multinationals affects the labour market, the size of the market, the balance of payment and the industrial development. Those implications can be positive or negative, and the net effect of FDI on the host economy is generally hardly determined. In this paper we are particularly interested in the effect of FDI in industrial development through the creation of backward and forward linkages with the host economy.

The economic literature presents two main analyses of the relation between vertical linkages, FDI and industrial development.

On one hand, we have models, like those of Markusen and Venables (1999), Rodriguez-Clare (1995) and Saggi (2002), that treat the effect of FDI on industrial development through its effect on the intensity of vertical linkages.

The basic idea behind those models is that the intensity of backward and forward linkages within the sectors of an economy is an engine of industrial dynamism and development.

Foreign direct investment generates two opposite effects on the intensity of linkages. The entry of foreign firms creates a new source of demand for the suppliers of intermediate goods but it will increase the competition faced by local firms and forces some of them to exit the market or to cut back on their output. Thus the net effect of foreign firms will depend on the linkages they generate compared to the linkages that would be generated by local firms that will be displaced from the market.

Those models share two main hypotheses. First, the foreign firms are more technologically advanced than local ones. In fact, the theory of multinational firms supposes that multinationals rely on intangible assets such as technological advantages to be able to compete with local firms who are more familiar with the host country environment. The hypothesis of the technological superiority of multinationals is the basis that drives the analysis of the technology transfer through FDI.

The superior technology of multinationals is generally modelled as of lesser intensity in intermediate goods than the local firms. In other words, to produce one unit of output local firms need more units of intermediate goods than multinationals.

The second hypothesis is that intermediate goods must be locally sourced. This idea reflects the fact that intermediates are internationally tradable to different degrees and some of which, especially services, are usually viewed as non tradable goods.

In the model of Saggi (2002), there is a possibility for technology transfer between foreign firms and local ones. If this transfer is horizontal, it will generate an expansion of the size of the local industry thereby leading to an increase in the intensity of linkages. If the technology transfer is vertical, it will lower the marginal cost of production of the intermediate goods, thereby lowering the cost of production of the downstream industry.

An important implication of those models is that the net effect of the entry of multinationals on the host economy depends on the technological gap between the multinationals and the local firms. In the presence of a large technological gap the competition effect of the entry of foreign firms will be very important and the linkage effect will be too small to compensate the exit of local firms (the intermediate requirement of the foreign firms is too small relatively to that of the local firms)[1].

On the other hand, we have models, like those of Pack and Saggi (2001) and Matouschek (2000), that analysis the vertical transfer of technology more explicitly. The idea behind such analysis is that foreign firms are willing to transfer some of their

[1] This kind of analysis focuses mainly on the global amount of linkages in the host economy. The intermediates must be locally sourced but the nationality of the suppliers does not affect the result. In other words the supplier can be a national firm as well as a foreign firm investing in the upstream industry.

technology and know how to their suppliers in the purpose of guaranteeing the quality of their intermediate goods.
Case studies and interviews with managers of domestic suppliers show that foreign firms have high requirements concerning the design and the quality of the product and on-time delivery, that they often impose quality control and help the suppliers with upgrading their production process through the training and the turnover of workers, through visits to the supplier's plant by the technical stuff of the foreign buyer and through the provision of blueprints and information on the production techniques.

Moreover, backward linkages with domestic suppliers can benefit foreign firms especially by allowing them to increase their specialisation and flexibility and to adapt their product to the conditions of the local market (WIR 2001).

Another important hypothesis of the analysis of technology transfer through vertical linkages is that this form of transfer is suitable for a large diffusion of the technology in the upstream industry. In fact, the multinationals generally tend to diversify their suppliers in order to guarantee the security and the stability of the supply and to maintain the price competition between suppliers. However this hypothesis will not hold if the foreign firm and the supplier are vertically integrated (i.e. they are both affiliates of the same multinational).
Pack and Saggi (2001) show in their model that technology diffusion in the upstream industry benefits the foreign buyer by creating competition among suppliers and by lowering the price of the intermediate goods. Furthermore, the reduction of prices in the upstream market can induce the entry of other foreign firms and the emergence of local firms in the downstream market[2].

For this mechanism to be efficient for the development of the host country, there are two conditions to be met. The fist one is the existence of backward linkages between foreign firms and domestic suppliers. The second one is for the backward linkages to engender transfer of technology from foreign buyers to domestic suppliers. The host country will benefit from this transfer of technology only if the suppliers are national

[2] In the Pack and Saggi model we have a firm from a developed country (DC) that outsource the production of its product to a firm from a developing country and then import the product and sell it on the DC market, but the same logic and conclusion can be applied to the relation between a multinational and a domestic supplier from the host country.

firms, because we can suppose that the host country is interested by the technological upgrading of its own firms. If the local suppliers are foreign firms, the host country will benefit only from the existence of linkages between its industries.

The intensity of backward linkages between foreign firms and domestic suppliers and the extent to which those linkages will generate technology transfer depends on several elements, particularly the technological capacity of domestic suppliers, the nature of the product supplied, the entry mode of foreign firms and the nature of their activity.

In fact, we can suppose that the foreign firms will be more willing to share their know-how and their technology with their suppliers if the intermediate product supplied is specific to the production process of the foreign firms. The more the supplied product is specific and specialised, the higher the quality requirement of the foreign buyer will be and the more specialised and strategic the transferred technology will be. If the local supplier produces a "general" intermediate output, (not strategically related to the production process of the foreign buyer), its possibility of learning is weak and limited to general techniques of production. But if the intermediate good is too specialised, there is a risk that the technology transferred will be too specific to the foreign buyer in a way that prevents the local supplier to use it in order to expand its linkages to other firms in the downstream industry.

Thus the effect of FDI on the technological development of firms in the host country will not depend on the amount of backward linkages but on the quality of those linkages.

In the same time, the nature of backward linkages will depend on the technological capacities of the domestic suppliers. More precisely, if the technological gap between the foreign buyer and the domestic supplier is important, we can suppose that the foreign firms will be reticent to purchase specialised intermediates from domestic suppliers because, even in the presence of technology transfer, the suppliers will not have the capacity to absorb this technology and to develop the intermediate good. It is worth noting that countries studied in the empirical papers on technology spillovers through backward linkages, Lithuania, Indonesia and Hungary, are developing countries that had achieved a certain level of industrial and technological development.

The incentive of foreign affiliates to tie backward linkages with domestic firms depends on their mode of entry. It is argued that foreign affiliates that enter the host country through mergers and acquisitions (M&As) or joint ventures are more likely to engage in backward linkages with domestic firms than those who enter the host country through Greenfield projects (WIR 2001). In fact the former can benefit from the knowledge of their local partner concerning the conditions of the local market as well as from their established suppliers network. We can also suppose that with time the likelihood of backward linkages with domestic suppliers will increase as the foreign investors get a better knowledge about the quality of the local suppliers and the opportunities of linkages with them.

It is also suggested that foreign affiliates that serve the local market are more likely to have backward linkages with domestic suppliers than those who are export oriented [UNCTAD (2000), Altenburg (2000)]. When serving the local market, the foreign affiliates will need to adapt their production to the local conditions and tend to be more integrated in the local economy. However, export oriented affiliates are generally part of a global sourcing and distribution network managed by the parent company and have higher quality requirements which can be difficult for the local suppliers to meet but in the same time offer a greater opportunity for technology transfer.

The examination of those hypotheses and the determination of the characteristics of foreign projects that are more suitable to have backward linkages with local suppliers and to engage in a technology transfer with those suppliers have important policy implications. The knowledge of those characteristics will enable the governments of host countries seeking the technological upgrading of their local firms through FDI to elaborate targeted policies to attract the most effective foreign projects.

In what follows, and after a presentation of the data and of FDI in Spain, we will test those hypotheses, particularly the distinction, on one hand between Greenfield projects and M&As and joint ventures, and on the other hand between export-oriented projects and domestic-market-oriented projects.

III-Data description and Methodology

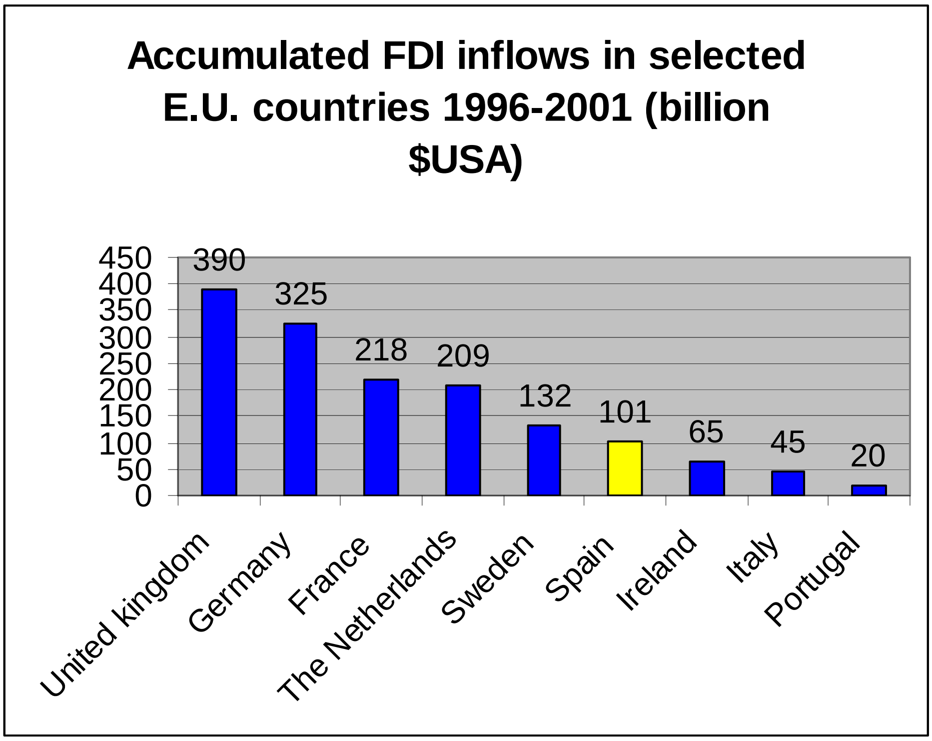
This study is based on a data set from the ESEE survey, the annual survey conducted by the Spanish ministry of science and technology and the "Fundación SEPI". The survey concerns manufacturing Spanish enterprises with more than 10 employees, it is not exhaustive and covers approximately 40% of the total employment in the manufacturing sectors included in the sample. The data set is an unbalanced panel that covers the period 1990-2000 with a number of firms per year varying from 2198 firms in 1990 to 3431 in 2000.

The annual survey is based on a questionnaire of approximately 100 questions. The survey is mainly interested in the strategies of the enterprises; especially the instruments of competition in the short term and in the long term and provide data on the property structure of the enterprise, the output, the capital stock, the number of employees, the investment, the research and development (R&D) activity and the international trade activity. The variables are deflated using sectoral price indices. The sectoral classification of enterprises is at the three digits CNAE-93 which is a derived version of the European NACE_REV1. This classification results in twenty manufacturing sectors[3].

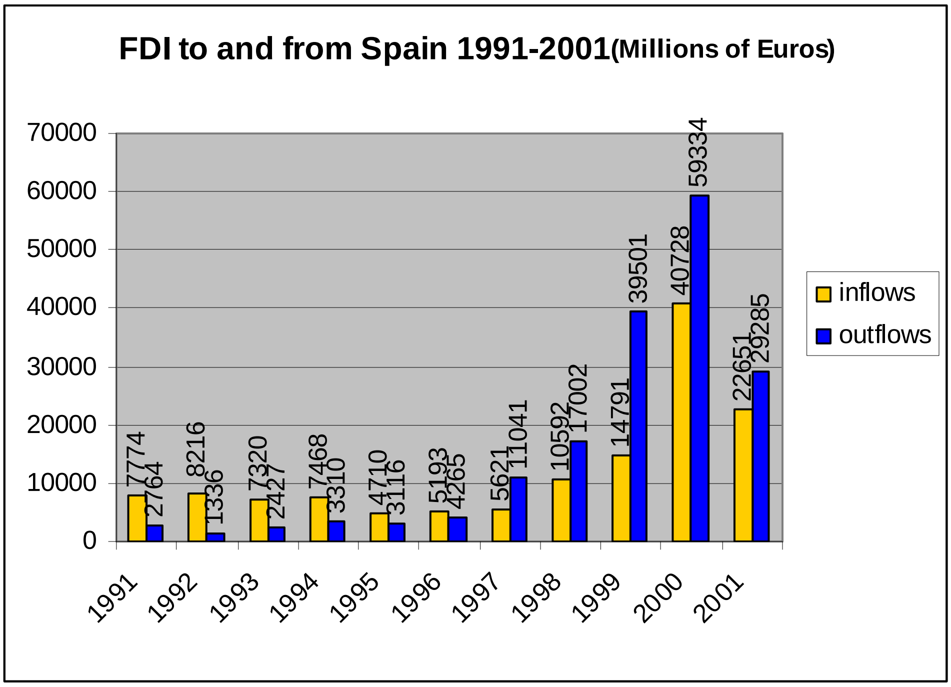
We mentioned earlier that the study of technology transfer is more interesting in the case of developing countries. The Spanish economy is not a developing one; on the contrary, it is the eighth economy in the world in terms of GDP (Spanish ministry of economy). However, the study of the technology transfer through FDI in the case of Spain presents several interesting aspects. First of all, Spain is a member of the European Union and is considered as a less developed member. Second the influx of FDI has increased significantly after the adhesion of Spain in the European Union and the application of the macroeconomic stability programs.

[3] Sector classification is presented in the appendix.

For example, for the period 1995-2000, Spain is ranked sixth among the members of the European Union in terms of influx of FDI and third in terms of number of foreign affiliates.



Source: World Investment Report 2001.



Source: Balance of Payments, Bank of Spain.

In Spain, FDI is mostly directed to the service sector (77% of FDI inflows between 1997 and 2000)[4], the rest (22.5%) goes to the industrial sector and more specifically to the chemicals, pharmaceutical, automobile, food and beverage and electronics subsectors.

The sectoral distribution of FDI in our sample reflects the general trend of FDI in the Spanish industrial sector, with 14.5% of foreign affiliates located in the food and beverage sector, 12.78% in the automobile sector, 8.30% in electronics and 8.10% in chemicals.

If the foreign affiliates transmit a part of their know-how and technology to their local suppliers, we can expect that this transfer of knowledge will enhance the productivity of the local partners. Thus to verify the existence of technology transfer through backward linkages, we test the effect of backward linkages with foreign affiliates on the productivity of domestic firms and interpret a positive effect as evidence on the existence of vertical technology transfer.

However a necessary condition for the transfer of technology through FDI is for the foreign affiliates to be more productive than the domestic firms. The technological gap between foreign affiliates and domestic firms needs to be moderate. When the technological gap is too small, the possibility for the domestic firms to learn from the foreign affiliates will be negligible, and when the gap is too large, the domestic firms will not have the capacity to absorb the technology brought in by the foreign affiliates.

Thus, before testing the existence of technology transfer we need to compare the technological capacity of the foreign affiliates to that of the domestic firms. There are several measures that can be used to represent the technological capacity of a firm or industry. Kokko (1994) proposes three measures; the different industries capital intensities, the amount of patent fees in different industries and the difference in labour productivity between foreign affiliates and domestic firms.

Since, in this analysis, we are interested in the effect of backward linkages on the productivity of firms, we use the productivity of labour as a proxy for the technological capacity and we consider foreign affiliates as firms with 10% or more

[4] Source: The Spanish ministry of Economy.

of foreign participation in their capital[5]. Ideally, and to obtain a precise evaluation of the technological gap, we have to compare the productivity of each foreign affiliates to that of each of her local supplier. But since we do not have data on the linkages between firms and since the backward linkages within a sector represent an important part of the total linkages of a sector[6], we will take the gap of technology between foreign affiliates and the domestic firms in the same sector as a proxy for the technological gap between the foreign affiliates and their domestic suppliers.

Table I shows that, on average, foreign affiliates are more productive than domestic firms. In some sectors, like the chemical industry and the motor vehicle industry, the difference is high, significant and increasing with time. However the difference in productivity may simply reflect the difference in size between foreign affiliates and domestic firms. In fact, foreign affiliates are, on average, of larger size than domestic firms.

To examine whether backward linkages with foreign affiliates affect the productivity of domestic suppliers, we follow the earlier literature and estimate the following equation:

$$\ln Y_{it} = \alpha + \beta_1 \ln L_{it} + \beta_2 \ln K_{it} + \beta_3 \ln M_{it} + \beta_4 \text{Horizontal}_{jt} + \beta_5 \text{Foreign-linkages}_{jt} + d_i + d_r + d_t + \varepsilon_{ijrt}. \quad \text{(Eq 1)}$$

Where i, j, r and t represent respectively firms, sectors, regions[7] and time.

Y_{it} represents real output of firm i at time t. Output is defined as the value of sales adjusted for changes in stock. L_{it} is employment and it is measured by the number of employers. K_{it} is the stock of capital, which is equal to the value of fixed assets. M_{it} stands for the use of intermediates and it is equal to the purchased value of intermediates adjusted for changes in stock.

Horizontal_{jt} is a sector specific variable that represents the foreign presence in sector j at time t and it is defined as the part of foreign firms in the total employment of the sector.

$$\text{Horizontal}_{jt} = \left(\sum_{i\in j} for_{it} * l_{it}\right) / \sum_{i\in j} l_{it}$$

Where for_{it} equals the foreign participation in the capital of firm i at time t.

[5] The 10% level is consistent with the definition of the OCDE and the IMF.

[6] The level of aggregation of the data generates large sectors composed of many subsectors with related activities. So it is normal to have an important amount of backward linkages within a sector.

[7] Firms are located in seventeen different regions, each one of them represents one of the 17 autonomous regions of Spain.

Table I: Comparison between labour productivity of foreign affiliates and that of domestic firms [ratios Foreign/local firms using unweighted means]

Sector	1999	2000
Production of Meat	1.448	1.218
Manufacture of Food and Tobacco	2.11*	2.628*
Manufacture of Beverages	1.151	1.315
Manufacture of Textile	1.131	1.514**
Manufacture of Leather	1.319	1.166
Manufacture of Wood	2.555*	1.565***
Manufacture of Paper	1.144	1.293
Publishing and Printing	1.752**	1.815*
Manufacture of Chemicals	1.284**	1.682*
Manufacture of Rubber and Plastic Products	1.225**	1.679*
Manufacture of Mineral (non Metallic) products	2.206*	1.387*
Manufacture of Metal	0.802	1.192
Manufacture of Fabricated Metal Products	1.3***	1.611*
Manufacture of Machinery and Equipment	1.466*	2.206
Manufacture of Office Machinery, Computers, Medical Precision and Optical Instrument	1.554***	3.101*
Manufacture of Electrical Machinery	1.339*	1.969*
Manufacture of Motor Vehicles	1.439*	2.48*
Manufacture of Other Transport Equipment	1.875*	1.995*
Manufacture of Furniture	2.133*	1.768*
Other Manufacturing Industries	1.631**	1.652

*,**, *** indicate difference in means is significant at the 1%, 5% and 10% level.

The variable $Horizontal_{jt}$ captures the effect of foreign affiliates on their local competitors. A positive coefficient on this variable reflects the existence of horizontal technology transfer.

$Foreign\text{-}linkages_{jt}$ is a sector specific variable that represents the extent of backward linkages between local suppliers and foreign affiliates. A positive coefficient on this variable signifies the presence of technology transfer between foreign affiliates and their suppliers.

$$\text{Foreign-linkages}_{jt} = \sum_k \alpha_{jk} * horizontal_{kt}$$

Where α_{jk} is equal to the proportion of sector j output that is supplied to sector k. The proportions are taken from the input-output matrix at the three digit level of the NACE. We only have input-output matrices for the period 1995-1998. Values of α_{jk} for the years 1990-1994 are from the 1995 input-output matrix and those for the years 1999-2000 are from the 1998 matrix.

The calculation of the α_{jk} proportion considers only the inputs supplied locally[8] and we include in the $Foreign\text{-}linkages_{jt}$ variable the backward linkages within a sector, e.g. the case where k=j. In fact because of the level of aggregation of the data an important proportion of the output is supplied within the sector. Thus if we exclude inputs supplied within the sector, the effect of linkages within the sector will be captured in the horizontal variable and the coefficient on this variable will be biased.

Finally d_j, d_r and d_t are respectively sector, region and year dummies.

However, when estimating the productivity, we face two important problems; a problem of simultaneity and a problem of selection. Simultaneity problem arises because productivity shocks are unobservable for the econometrician but are known to the firms when they choose their inputs [Marschak and Andrews (1944)]. The firms' knowledge of their productivity makes it more appropriate to consider inputs as endogenous variables [Griliches and Mairesse (1995)].

The estimation of productivity by ordinary least squares (OLS) consider labour, capital and other inputs as exogenous variables and may lead to biased estimated coefficient.

8 Imports of intermediate products are excluded.

The selection problem is related to the entry and exit of firms to and from the data. Firms decide whether to exit the market or to continue their activity after considering their expected productivity and profitability. Expectations of productivity are partially determined by current productivity. The result is that exit decision depends on the firms' perception of their productivity.

Traditionally, econometricians dealt with entry and exit of firms by reducing the data set to a "balanced" panel. Restricting the analysis to a "balanced" panel does not take account of the endogeneity of the exit decision and generate a selection bias.

The semiparametric estimation is based on a dynamic model of firm behaviour, suggested by Olley and Pakes (1996), that allows avoiding the selection and the simultaneity problems. To control for the selection bias the model generates an exit rule, and to correct for the simultaneity bias, the model uses investment as a proxy for productivity shocks. The model assumes that some inputs, like labour and intermediates, will adjust immediately to the productivity shocks while others, especially capital, will need a certain lag of time to adjust to the shocks. The model also assumes that investment is strictly increasing in the productivity shock [Pakes (1994)][9] and that the markets are perfectly competitive.

Levinsohn and Petrin (2000) propose an analogous methodology but they replace investment by intermediate inputs use, as a proxy for productivity shocks. They argue that intermediate inputs will respond to the entire productivity shock, while investment may only respond to the "non-forecastable" component of the productivity shock. The authors choose the electricity as a proxy for productivity because the inability to store electricity makes its use highly correlated with the current productivity.

The ESEE data set does not provide information on the use of electricity but provide data on the investment of the firms. So in our estimation, we consider investment as a proxy for the productivity. Moreover, when a firm exit the sample we can not determine if this exit means that the firm has exit the market or simply that she did not respond to the questionnaire. Thus, we do not control for firms exit in our estimation. Considering that some critiques can be applied to the assumption of the Olley and Pakes model, we also estimate Eq 1 with ordinary least squares.

[9] Details of the semiparametric estimation are presented in the appendix.

IV- Evidence on technology spillover

Horizontal and vertical technology spillover

Table II reports the results of the estimation of equation 1. The first three columns present the coefficients estimated with OLS and the forth, fifth and sixth columns present the coefficients estimated with the Olley and Pakes methodology. Both of the estimations concern the subsample of domestically owned firms[10]. The positive and significant coefficient on Foreign-linkage, in the first and third columns, implies that greater amount of backward linkages with foreign affiliates increase the total factor productivity of domestic firms in the Spanish industry. The positive effect of backward linkages on PTF can drive from the exchange of technology and know-how between foreign buyers and their suppliers but can also drive from the industrial dynamism generated by vertical linkages. If the later hypothesis holds, the positive coefficient on Foreign-linkage will be related to the amount of linkages and not to the relation with foreign affiliates. To verify if backward linkages are a channel of technology transfer, we introduce the total backward linkages[11] of a sector as an explanatory variable. If the positive effect of backward linkages reflects industrial dynamism, we expect the total-linkages variable to have a greater effect than Foreign-linkages on PTF. Columns two, three, five and six of table III report a negative and significant coefficient on Total-linkages, and columns three and six show that the coefficient on Foreign-linkages remains positive and significant in the presence of the Total-linkages variable.

---

[10] We estimated the model on the full sample (not reported) and found slightly greater coefficient on both Horizontal and Foreign linkages, which suggests that foreign affiliates have a greater effect on each other than on domestic firms.

[11] The variable Total-linkages measures the global amount of backward linkages of a sector with both kinds of firms (domestic and foreign) in upstream sectors. Thus Total-linkages = $\sum_k \alpha_{jk}$

Table II: Estimation of the effect of foreign presence on total factor productivity

	OLS[a]			Olley-Pakes[b]		
ln L	0.43173* (0.00427)	0.43197* (0.0043)	0.43158* (0.0043)			
ln K	0.10894* (0.0026)	0.10865* (0.0026)	0.10902* (0.0026)			
ln M	0.4578* (0.0024)	0.4759* (0.0024)	0.4757* (0.0024)			
Horizontal	**-0.17789*** **(0.0626)**	**-0.0444** **(0.0522)**	**-0.1938*** **(0.0627)**	**-0.19744*** **(0.0635)**	**-0.05897** **(0.0530)**	**-0.2145*** **(0.064)**
Foreign-linkages	**1.06043*** **(0.330)**		**1.5184*** **(0.353)**	**1.08926*** **(0.335)**		**1.5806*** **(0.358)**
Total-linkages		**-0.4501**** **(0.1965)**	**-0.7696*** **(0.2099)**		**-0.4936**** **(0.1994)**	**-0.8264*** **(0.213)**
Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes
Regional dummies	Yes	Yes	Yes	Yes	Yes	Yes
Adj R^2	0.9702	0.9702	0.9702	0.1619	0.1616	0.1626
No of observations	15387	15387	15387	15387	15387	15387

[a] The independent variable is log of real output

[b] The independent variable is TFP estimated with the Olley and Pakes methodology

* ** *** Denote significance at the 1, 5 and 10% level.

This result suggests that what matters for the productivity of domestic firms in the Spanish industry is the vertical relation with foreign buyers and, by consequence that backward linkages are an efficient mechanism to diffuse technology brought in by foreign firms in the local economy.

To verify that the coefficient on Foreign-linkages is not affected by the construction of the input-output data, we estimate equation 1 on a restricted sample for the years 1995-1998 for which the input-output data are original. The coefficient on Foreign-linkages (unreported) remains positive but loses some of its extent and significance.

The coefficient on Horizontal reflects the effect of foreign presence on firms within the same sectors. This coefficient is negative in all the estimations in table II. This negative effect is probably due to the competition between foreign affiliates and domestic firms. The entry of more competitive foreign affiliates reduces the market share of domestic firms and pushes them further up their average cost curve [Aitken and Harrison (1999)]. This result is consistent with earlier studies on FDI on Spain, like those of Barrios (2000) and of Castellani and Zanfei (2001).

The effect of geographical proximity

However, the variable Horizontal is calculated on the national level and does not take into account the geographical proximity between firms. In fact, several authors [Aitken and Harrison (1999), Sjöholm (1999), Harris and Robinson (2001)] suggest that technological diffusion is easier, faster and more probable between firms located near each other. On one hand, geographical proximity affects the mechanisms of technology diffusion. For example, workers mobility is generally locally concentrated especially in Europe, demonstration of new products or production techniques are more likely to be observed and copied by neighbouring firms and geographical proximity reduces transportation costs and facilitates the establishment of backward linkages. On the other hand, geographical proximity induces agglomeration spillovers that are location specific and are not related to the intra-industry and inter-industry channels of technology transfer [Audretsch and Feldman (1996)]. For example, domestic firms may benefit from the infrastructure installed by foreign affiliates located in the same region.

In table III, we introduce two variables that capture the proximity effect. The Sector-$local_{jrt}$ variable measures the presence of foreign firms in sector j located in region r.

This variable is calculated in the same way as $Horizontal_{jt}$ but controls for the regional location of firms. Thus $Sector\text{-}local_{jrt}$ captures the effect of geographical proximity on the intra-sector mechanism of technology transfer. If geographical proximity facilitates technology transfer and if foreign affiliates consider the local market as a whole, we expect the coefficient on Sector-local to be positive and the negative effect of competition to be captured by the variable Horizontal.

The second variable, $Local_{rt}$, measures the foreign presence in a region r at time t for all sectors j. This variable is calculated as the share of employment in region r employed by foreign firms and captures the agglomeration spillovers. Unfortunately we do not have input-output data on the regional level, so we are not able to test the effect of proximity on backward linkages.

The results in table III indicate that geographical proximity facilitates intra-sectoral technology transfer and that competition between foreign affiliates and local firms is exercised at the national level. However there is no significance evidence on the presence of agglomeration spillovers.

The effect of the technology gap

The absence of technology transfer from foreign affiliates to domestic firms is generally related to the technology gap between domestic firms and foreign ones. When the technology gap is negligible, the possibilities of learning are limited, and when the technology gap is large, the domestic firms lack the capacity to absorb the technology and know how of the foreign affiliates. But if this is the case, then why the lack of absorptive capacity affects only the horizontal technology transfer? One plausible explanation is that in the case of backward linkages, foreign buyers assist their suppliers to assimilate the technology transferred, while in the case of horizontal spillovers, domestic firms need to have a certain level of technological capacity and to invest in a learning process to absorb the modern technologies brought in by foreign investors.

Table III: Estimation of the effect of geographical proximity

	OLS		Olley-Pakes	
ln L	0.43196* (0.00427)	0.43198* (0.00427)		
ln K	0.1088* (0.0026)	0.1089* (0.0026)		
ln M	0.4759* (0.0024)	0.4758* (0.0024)		
Horizontal	**-0.1972* (0.063)**	**-0.1973* (0.063)**	**-0.2085* (0.064)**	**-0.2086* (0.066)**
Foreign-linkages	**1.064* (0.33)**	**1.065* (0.33)**	**1.0915* (0.335)**	**1.0922* (0.348)**
Sector-local	**0.0313** (0.0138)**	**0.0288** (0.0139)**	**0.01769 (0.014)**	**0.01556 (0.0141)**
Local		**0.066 (0.0452)**		**0.05757 (0.0459)**
Industry dummies	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes
Regional dummies	Yes	Yes	Yes	Yes
Adj R^2	0.9702	0.9702	0.1619	0.1619
No of observations	15383	15383	15383	15383

We explore this hypothesis by adding to equation 1 a proxy of the absorptive capacity of domestic firms. The proxy we use is the intensity in human capital[12] calculated as the ratio of technical employees on total employment.

We have data on technical employees only for the years 1990, 1994 and 1998. Thus for the period 1990-1993 we use the ratio calculated for 1990, for the period 1994-1997 the ratio calculated for 1994 and for the period 1998-2000 the ratio calculated for 1998.

We verify the effect of the absorptive capacity on technology transfer by interacting the human capital variable with that of the horizontal foreign presence. The results are reported in table IV, and as expected, the intensity in human capital enhances the capacity of domestic enterprises to adsorb the technology of foreign affiliates.

To explore more precisely the effect of technology gap we split the sample of domestic firms into three subsamples following the difference between the productivity of each firm and that of the average foreign firm in the sector.

$\text{Technology gap}_{ijt} = \text{Prod}^{d}_{ijt} - \text{Averageprod}^{f}_{jt}$

Prod^{d}_{ijt} is the labour productivity of firm i in sector j at time t and $\text{Averageprod}^{f}_{jt}$ is the mean of labour productivities of foreign affiliates in sector j at time t.

The first subsample contains domestic firms that are more productive than the average foreign affiliate (positive values of Technology $\text{gap}_{ijt)}$. This subsample is defined as the low gap subsample. To construct the other subsamples, we take the median of the remaining values of Technology gap_{ijt} (negative values) and consider firms above the median as firms with moderated gap and firms below the median as firms with large technology gap.

We estimate the model for the three subsamples and expect to obtain positive and significant coefficient only in the case of moderated technology gap.

As showed in table V, the size of the technology gap affects mostly the technology transfer through backward linkages. The coefficient on Foreign-linkages is only significant when the technology gap is moderate.

[12] We used also the intensity in R&D as a proxy for absorptive capacity. We calculated the intensity in R&D as the ratio of R&D expenditures on total employment. However this variable had a marginal effect on the technology transfer.

Table IV: effect of the technology gap

	OLS				Olley-Pakes			
	Full sample	Low gap	Moderate gap	Large gap	Full sample	Low gap	Moderate gap	Large gap
ln L	0.437* (0.0042)	0.429* (0.0104)	0.429* (0.0067)	0.451* (0.0066)				
ln K	0.107* (0.0026)	0.1003* (0.0060)	0.107* (0.0041)	0.1104* (0.0042)				
ln M	0.473* (0.0025)	0.486* (0.0059)	0.477* (0.0039)	0.461* (0.0038)				
Horizontal	-0.265* (0.063)	-0.363** (0.161)	-0.381* (0.099)	-0.158 (0.098)	-0.278* (0.064)	-0.429* (0.163)	-0.357* (0.101)	-0.166** (0.1003)
Foreign-linkages	1.112* (0.329)	0.105 (0.788)	1.893* (0.532)	0.789 (0.505)	1.146* (0.334)	0.409 (0.797)	1.831* (0.539)	0.779 (0.516)
Human - capital* Horizontal	0.2383* (0.196)	0.564* (0.093)	0.2778* (0.046)	0.2114* (0.022)	0.2153* (0.019)	0.5428* (0.09)	0.2712* (0.046)	0.179* (0.223)
Sector-local		0.059** (0.033)	0.039** (0.022)	0.0025 (0.021)		0.039 (0.033)	0.033 (0.022)	-0.011 (0.022)
Local		0.112 (0.104)	0.011 (0.073)	0.091 (0.069)		0.09 (0.105)	0.005 (0.074)	0.09 (0.0708)
Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Regional dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adj R^2	0.9703	0.9677	0.9710	0.9711	0.1682	0.1624	0.1722	0.1736
No of observations	15370	2755	6309	6302	15370	2755	6309	6302

This result is somehow normal since, in our model, backward linkages are the most efficient channel of technology transfer. The coefficient on Sector-local is negative or insignificant for the large gap subsample. This result confirms the hypothesis that large technology gaps affect negatively the technology transfer.

The effect of the nature of activity of foreign affiliates

When foreign affiliates serve essentially the host market, we expect them to have more intense backward linkages with local suppliers than export-oriented affiliates since the former need to adapt their product to local market conditions. We follow Smarzynska (2002) and define export-oriented affiliates as foreign affiliates that export more than half of their output and local market- oriented affiliates as affiliates that sell more than half of their output in the local market. To explore the effect of the activity of foreign affiliates we create a measure of backward linkages for export-oriented affiliates and one for local market-oriented affiliates and we expect to have a higher coefficient on the latter. Those measures are calculated analogously to Foreign-linkages, but for the former, we replace the variable Horizontal by a measure of the presence of export-oriented affiliates in sector j at time t and, for the latter, we replace it by a measure of the presence of local market-oriented affiliates.

The results presented in table V are contradictory to our expectations. In fact we find positive and significant coefficient on export oriented-linkages and insignificant coefficient on home market oriented-linkages. This result does not reject the hypothesis that home market-oriented affiliates are more likely to establish backward linkages with local suppliers. In our estimation, we do not verify the effect of the activity of foreign affiliates on the intensity of backward linkages but we associate a measure of backward linkages with a measure of the presence of foreign affiliates and test the effect on productivity. The result in table V means that established backward linkages with export oriented have a greater effect on the productivity of domestic firms than those established with home market-oriented affiliates. Export-oriented affiliates may have higher quality requirements than affiliates that serve the local market and thus will transmit newer technologies and know-how to their suppliers. This confirms our earlier hypothesis that what matters the most for technology transfer through backward linkages is their nature and quality and not their intensity, and is consistent with the conclusion of the UNCTAD report on “Enhancing the competitiveness of SMEs through linkages" that "***investors focused on export-oriented industries created relatively few linkages, but those linkages were more competitive and sustainable***"

Table V: estimation of the effect of the activity of foreign affiliates

	OLS	**Olley-Pakes**
ln L	0.43173* (0.00427)	
ln K	0.10894* (0.0026)	
ln M	0.4578* (0.0024)	
Horizontal	**-0.1766*** **(0.062)**	**-0.1965*** **(0.063)**
Export oriented-linkages	**1.3486*** **(0.335)**	**1.369*** **(0.34)**
Home market oriented-linkages	**0.1544** **(0.38)**	**0.2246** **(0.386)**
Industry dummies	Yes	Yes
Year dummies	Yes	Yes
Regional dummies	Yes	Yes
Adj R^2	0.9702	0.1633
No of observations	15387	15387

The effect of the entry mode of foreign affiliates

In table VI, we explore the effect of the entry mode of foreign affiliates on the technology transfer through backward linkages. We suppose that foreign affiliates that enter the host market through M&As or joint ventures will have a better knowledge of backward linkages opportunities with local suppliers than fully-owned foreign affiliates, thus, they are more likely to engage with local suppliers.

To verify this hypothesis, we create two measures of backward linkages, one for foreign affiliates with 100% foreign participation to their capital and one for the remaining foreign affiliates. For the former, we replace the variable Horizontal, in the formula of Foreign-linkages, by a measure of fully-owned affiliates presence in sector j at time t and for the latter we replace it by a measure of the presence of partially-owned affiliates.

The results in table VI show that, as in the case of export oriented affiliates, the technology transfer is more related to the quality of backward linkages. Backward linkages with partially-owned firms have a negative and significant effect on the productivity of domestic firms, whereas backward linkages with fully-owned affiliate have a positive effect.

One possible explanation for this result is that fully owned affiliates are more technologically advanced than partially owned ones. In fact, we can suppose that when multinationals enter the host market through M&As or joint-ventures, they will be reticent to transfer state-of-the-art technologies to their affiliates in order to prevent their leakage in the host economy [Either and Markusen (1996)]. In other words, when multinationals introduce their newest technologies to host countries they prefer, full control over their production in order to protect their know-how. Econometric analysis like those of Mansfield and Romeo (1980) and Smarzynska (1999) seem to confirm this hypothesis. Mansfield and Romeo (1980) find that, on average, the technologies transferred from multinationals to their affiliates established through M&As and joint ventures tend to be older than the technologies transferred to fully-owned affiliates. The study of Smarzynska (1999) shows that the intensity in R&D is negatively correlated with the probability of entry through joint venture and positively correlated with the probability of entry through Greenfield projects.

So if fully-owned affiliates posses more valuable technology and know how than partially-owned ones, they we will have a better influence on the productivity of their suppliers.

Table VI: Estimation of the effect of entry mode

	OLS	**Olley-Pakes**
ln L	0.4319* (0.00426)	
ln K	0.1089* (0.0026)	
ln M	0.4757* (0.0024)	
Horizontal	**-0.1158** (0.062)**	**-0.1321** (0.054)**
Fully owned-linkages	**0.5814** (0.293)**	**0.5986** (0.297)**
Partially owned-linkages	**-1.492* (0.388)**	**-1.387* (0.394)**
Industry dummies	Yes	Yes
Year dummies	Yes	Yes
Regional dummies	Yes	Yes
Adj R^2	0.9702	0.1633
No of observations	15387	15387

V- Conclusion

Whether foreign direct investment helps upgrading the technological capacities of firms in host countries or not is an important question for policy makers in these countries. And more important is the question of what are the most effective channels of technology transfer?

We try to answer these questions using a panel of Spanish manufacturing firms between 1990 and 2000. We distinguish two mechanisms of diffusion of the technology brought in by foreign affiliates, a horizontal one, between foreign affiliates and domestic firms within the same sector, and a vertical one, between foreign affiliates and their local suppliers. As a proxy for the horizontal presence of foreign affiliates, we use the share of employment in a sector employed by foreign affiliates, and for the backward linkages with foreign linkages we use the input-output matrix and associate backward linkages between two sectors with the foreign presence in the downstream sector. This methodology is subject to several limitations. The most important limitation is that the backward linkages variable that we use is a sector specific variable. The input-output matrix does not distinguish between suppliers and other firms in the sector, domestic suppliers and foreign ones investing in the host country, and between foreign buyers and domestic ones. A more precise methodology to study technology transfer through backward linkages will be to identify domestic suppliers of foreign affiliates. This will allow us to examine the characteristics of domestic suppliers and to comprehend the foreign affiliate's choice of their suppliers.

By identifying domestic, suppliers we can also compare their productivity trend before and after the vertical relation with the foreign affiliates. But this kind of data is difficult to collect for confidentiality reasons.

We find that potential technology transfer between foreign affiliates and their local competitors is more than offset by the competition induced by the entry of foreign affiliates. Thus the net effect of the horizontal presence of foreign affiliates on the productivity of domestic firms is negative. We also find that horizontal technology transfer is facilitated by the geographic proximity between firms.

An important finding of this study is that backward linkages with foreign affiliates increase sharply the productivity of domestic firms in upstream industries. A 1% raise of backward linkages associated with foreign affiliates lead to a 1.06% raise of total factor productivity of domestic firms. However this result is affected by the extent of the technology gap between foreign affiliates and domestic firms. The technology transfer exists only in the case where the technology gap is moderated.

The existence of technology transfer through backward linkages is also affected by the quality of those linkages. In fact, and while home market-oriented affiliates and partially-owned affiliates may have more intense backward linkages with local suppliers, the established linkages with export-oriented affiliates and with fully-owned ones offer greater opportunities for technology transfer to the suppliers.

Thus, host countries that aim to promote technology transfer to their domestic firms need to encourage the establishment of backward linkages between foreign investors and domestic suppliers, especially in the case of export-oriented affiliates and fully-owned ones.

Host countries can enhance technology transfer through backward linkages by creating a network of competitive suppliers. This can be achieved by subsidizing R&D activity and the formation of human capital. This will lead to a decrease in the technology gap and to an increase of the confidence of foreign investors in the capacities of domestic suppliers.

Certainly further research is necessary to provide a better understanding of the elements that affect the establishment of backward linkages with foreign affiliates and those that affect the vertical technology transfer.

Bibliography

- Aitken B and A Harrison (1999): “Do Domestic Firms Benefit from Direct Foreign Investment” *American Economic Review 89: 605-618*.
- Altenburg T (2000): “Linkages and Spillovers between Transnational Corporations and Small and Medium-Sized Enterprises: Opportunities and Best Policies” in *UNCTAD, TNC-SME Linkages for Development: Issues-Experiences-Best Practices*.
- Audretsch D.B and M.P Feldman (1996): “Innovation Clusters and the Industry life Cycle” *Review Industrial Organisation 11: 253-273*.
- Barrios S (2000): “Foreign Direct Investment and Productivity Spillovers: Evidence from Spanish Experience” *FEDEA Documento de Trabajo 2000-19*.
- Blalock G and P Gertler (2003): “Technology from Foreign Direct Investment and Welfare Gains through the Supply Chain” *mimeo, Cornell University*.
- Castellani D and A Zanfei (2001): “Productivity Gaps, Inward Investment and the Productivity of European Firms” *Economics Working Paper Archive at Wustl: 0107001*.
- Caves R (1974): “Multinational Firms, Competition and Productivity in Host-Country Markets” *Economica 41: 176-193*.
- Either W and J Markusen (1996): “Multinational Firms, Technology Diffusion and Trade” *Journal of International Economics 41: 1-28*.
- Globerman S (1979): “Foreign Direct Investment and Spillovers Efficiency Benefits in Canada Manufacturing Industries” *Canadian Journal of Economics*, *Feb*.
- Griliches Z and J Mairesse (1995): “Production Functions: the Search for Identification” *NBER Working Paper 5067*.

- Haddad M and A Harrison (1993): "Are there Positive Spillovers from Direct Foreign Investment? Evidence from Panel Data for Morocco" *Journal of Development Economics 42: 51-74*.
- Harris R and C Robinson (2001): "Spillovers from Foreign Ownership in the United Kingdom: Estimates for UK Manufacturing Using the ARD" *mimeo, University of Durham*.
- Kokko A (1994): "Productivity Spillovers from Competition between Local Firms and Foreign Affiliates" *Journal of International Development 8(4).*
- Kugler M (2000): "The Diffusion of Externalities from Foreign Direct Investment: Theory ahead of Measurement" *Discussion Papers in Economics and Econometrics, University of Southampton, U.K.*
- Levinsohn J and A Petrin (2000): "Estimating Production Functions Using Inputs to Control For Unobservables" *NBER Working Papers: 7819*.
- Mansfield E and A Romeo (1980): "Technology Transfer to Overseas Subsidiaries by U.S-Based Firms" *Quarterly Journal of Economics 95: 735-750*.
- Markusen J and A Venables (1999): "Foreign Direct Investment as a Catalyst for Industrial Development" *European Economic Review 43: 335-356*.
- Marschak J and W.H Andrews (1944): "Random Simultaneous Equations and the Theory of Production" *Econometrica 12: 143-205.*
- Moran T (2001): "Parental Supervision: the New Paradigm for Foreign direct Investment and Development" *Institute for International Economics, Washington D.C.*
- Matouschek N (2000): "Foreign Direct Investment and Spillovers through Backward Linkages" *CEPR Working Paper: 2283*.
- Olley S and A Pakes (1996): "The Dynamics of Productivity in the Telecommunications Equipment Industry" *Econometrica 64 (6): 1263-1297*.
- Pack H and K Saggi (2001): "Vertical Technology Transfer via International Outsourcing" *Journal of Development Economics 46: 389-415*.
- Pakes A (1994): "Dynamic Structural Models, Problems and Prospects Part II: Mixed Continuous-Discrete Control Problems, and Market Interactions" *In Advances in Economics, ed. By C. Sims. Cambridge: Cambridge University Press.*

- Rodriguez-Clare A (1995): “Multinationals, Linkages and Economic Development” *American Economic Review 86: 852-873*.
- Saggi K (2002): “Backward Linkages under Foreign Direct Investment” *mimeo, Southern Methodist University*.
- Schoors K and B Van der Tol (2001): “The Productivity Effect of Foreign Ownership on Domestic Firms in Hungary” *mimeo, University Of Gent*.
- Sjöholm F (1999): “Productivity Growth in Indonesia: the Role of Regional Characteristics and Direct Foreign Investment” *Economic Development and Cultural Change 47: 559-584*.
- Smarzynska B (1999): “Technological Leadership and the Choice of Entry Mode by Foreign Investors: Evidence from Transition Economies” World Bank Working Paper: 2314.
- Smarzynska B (2002): “Does Foreign Direct Investment Increase the Productivity of Domestic Firms? In Search of Spillovers through Backward Linkages” *World Bank Policy Research Working Paper 2923*.
- UNCTAD World Investment Report (2000): “Cross-Border Mergers and Acquisitions and Development”.
- UNCTAD (2000): “The Competitiveness Challenge: Transnational Corporations and Industrial Restructuring in Developing Countries”.
- UNCTAD World Investment Report (2001): “Promoting Linkages”.

Appendix

The Olley-Pakes Semiparamatric Estimation

Olley and Pakes (1996) propose a model of firm behaviour to control for the selection and the simultaneity problems.

At the beginning of every period, a firm has to decide whether to exit the market or continue in operation. If it decides to continue, it chooses variable inputs (labour and intermediates) and a level of investment. The investment and the current capital value determine the capital stock at the beginning of the next period.

$K_{t+1}= (1- \delta) K_{t} + I_t$. (1)

Where δ represents the rate of depreciation of capital, K represents capital and I represents investment.

Firms will exit the market if the expected value of continuing operation is less than the sell of value of the assets. The expected value of continuing operation depends, among other things, on firm's own state variables. State variables consist of capital stock K and productivity ω. Olley and Pakes (1996) show that firms will continue in operation if the productivity exceeds a threshold level $\varpi_t (k_t)$.

$X_t= 1$ if $\omega_t \geq \varpi_t (k_t)$ and 0 otherwise. (2)

We assume the following production function:

$Y_{it} = \alpha + \beta_L L_{it} + \beta_K K_{it} + \beta_M M_{it} + \omega_{it} + \eta_{it}$. (3)

Where Y_{it} is the log of output of firm i at time t, L_{it} the log of its labour input, K_{it} the log of its capital input and M_{it} the log of its materials input. ω_{it} represents productivity and η_{it} is either a measurement error or a shock to productivity. Labour and materials represent variable factors and their choice is affected by the current level of productivity. Capital is a fixed factor and it is only affected by the distribution of productivity conditional on information at time t-1 and passed values of‘ω.

Pakes (1994, theorem 27) shows that investment is strictly increasing in ω for each K, thus investment can be used as a proxy for the shock conditional on fixed variables.

As a consequence, the investment function, $I_t = I_t(\omega_t, K_t)$, can be inverted to

$\omega_t = h_t(I_t, K_t)$. (4)

The estimation process consist of three stages; in the first stage, we estimate the coefficient on the variable inputs (labour and materials), in the second stage we use a probit model to control for the selection bias and in the third stage we estimate the coefficient on fixed factors (capital) conditional on the prior period’s shock and the probability of exit.

Stage 1:

Substituting (4) in (3), we have:

$Y_{it} = \beta_L L_{it} + \beta_M M_{it} + \phi_t(K_{it}, I_{it}) + \eta_{it}$. (5)

Where $\phi_t(K_{it}, I_{it}) = \alpha + \beta_K K_{it} + h_t(I_t, K_t)$.

To estimate the partially linear model in (5), we regress Y_{it} on labour, materials and a third order polynomial in (K_{it}, I_{it}) [with a full set of interaction]. Since the error term η_{it} is not correlated with the variable inputs, the estimation of equation (3) gives unbiased coefficient on labour and materials.

Stage 2:

In this stage we estimate the survival probabilities:

$$\Pr\{X_{it+1} = 1 \mid \varpi_{it+1}(k_{it+1})\}$$
$$= \Pr\{\omega_{it+1} \geq \varpi_{it+1}(k_{it+1}) \mid \varpi_{it+1}(k_{it+1}), \omega_{it+1}\}$$
$$= \rho_{it}\{\varpi_{it+1}(k_{it+1}), \omega_{it+1}\}$$
$$= \rho_{it}(k_{it}, I_{it})$$
$$= P_{it}.$$

The third equality follows from equations (1) and (3). The survival probability P_{it} is estimated using a prodit regression of X_{it+1} on a third order polynomial expansion of k_{it} and I_{it}.

Stage 3:

To obtain estimation of the coefficient on k_{it} we consider the expectation of $Y_{it+1} - \beta_L L_{it+1} - \beta_M M_{it+1}$, conditional on capital and the probability of survival.

$E [Y_{it+1} - \beta_L L_{it+1} - \beta_M M_{it+1} | k_{it+1}, X_{it+1} = 1]$

$= \alpha + \beta_K K_{it+1} + E [\omega_{it+1} | \omega_{it}, X_{it+1} = 1]$ (6)

We assume that ω_{it+1} is serially correlated and thus we rewrite ω_{it+1} as a function of ω_{it} and we consider ξ_{t+1} as the innovation in ω_{it+1}, we rewrite (6) as a function of K_{it} and I_{it}:

$Y_{it+1} - \beta_L L_{it+1} - \beta_M M_{it+1} = \beta_K K_{it+1} + g (P_t, \phi_t - \beta_K K_{it}) + \xi_{t+1} + \eta_{it+1}$ (7)

Where g is a third order polynomial in P_t, and $(\phi_t - \beta_K K_{it})$. Since the variable capital at time t+1 respond only to the lagged productivity shock ω_{it}, the error terms in equation (7) are mean independent of K_{it+1}. Thus the estimation of equation (7), using non-linear least squares, will provide unbiased coefficient on capital.

However, in our dataset we can not distinguish, when a firm exits the sample if it exits the market. For this reason we do not estimate the survival probability in stage two and we determine the coefficient on capital by estimating the following variant of equation (7):

$Y_{it+1} - \beta_L L_{it+1} - \beta_M M_{it+1} = \beta_K K_{it+1} + g (\phi_t - \beta_K K_{it}) + \xi_{t+1} + \eta_{it+1}$.

Table VII: Sectoral Classification

Sector	CNAE-93
Production of Meat	151
Manufacture of Food and Tobacco	152-158 +160
Manufacture of Beverages	159
Manufacture of Textile	171-177 & 181-183
Manufacture of Leather	191-193
Manufacture of Wood	201-205
Manufacture of Paper	211-212
Publishing and Printing	221-223
Manufacture of Chemicals	241-247
Manufacture of Rubber and Plastic Products	251-252
Manufacture of Mineral (non Metallic) products	261-268
Manufacture of Metal	271-275
Manufacture of Fabricated Metal Products	281-287
Manufacture of Machinery and Equipment	291-297
Manufacture of Office Machinery, Computers, Medical Precision and Optical Instrument	300 &331-335
Manufacture of Electrical Machinery	311-316 & 321-323
Manufacture of Motor Vehicles	341-343
Manufacture of Other Transport Equipment	351-355
Manufacture of Furniture	361
Other Manufacturing Industries	361-366 & 371-372

Table VIII: Foreign presence at the sectoral level

Sector	1990	2000
Production of Meat	0.165198	0.08608
Manufacture of Food and Tobacco	0.385025	0.461925
Manufacture of Beverages	0.349315	0.290988
Manufacture of Textile	0.168554	0.167023
Manufacture of Leather	0.054314	0.098184
Manufacture of Wood	0.060114	0.099241
Manufacture of Paper	0.232285	0.470856
Publishing and Printing	0.082149	0.219519
Manufacture of Chemicals	0.47316	0.63268
Manufacture of Rubber and Plastic Products	0.568037	0.710365
Manufacture of Mineral (non Metallic) products	0.285474	0.301013
Manufacture of Metal	0.116006	0.352172
Manufacture of Fabricated Metal Products	0.153288	0.290792
Manufacture of Machinery and Equipment	0.419184	0.400264
Manufacture of Office Machinery, Computers, Medical Precision and Optical Instrument	0.611924	0.324561
Manufacture of Electrical Machinery	0.525796	0.733057
Manufacture of Motor Vehicles	0.74014	0.843893
Manufacture of Other Transport Equipment	0.086417	0.368875
Manufacture of Furniture	0.116672	0.272698
Other Manufacturing Industries	0.199919	0.406134

Table IX: Foreign presence at the regional level

Region	1990	2000
Andalusia	0.27626920	0.38900055
Aragon	0.36440209	0.68426955
Asturias	0.22504867	0.27273033
Balearic Islands	0.00000000	0.24910209
Canary Islands	0.21254203	0.09698162
Cantabria	0.23652843	0.53546442
Castile-La Mancha	0.33860565	0.42037011
Castile and Leon	0.54173095	0.75123384
Catalonia	0.53240734	0.57539188
Valencian Community	0.38118841	0.43102188
Extramadura	0.21351330	0.41345489
Galicia	0.10923865	0.42973323
Madrid	0.44833308	0.55263848
Murcia	0.08613835	0.12976159
Navarre	0.62271226	0.47277050
Basque Country	0.20532879	0.33077300
La Rioja	0.25306005	0.56764352