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Trade and Technology Progress: An Analysis for Uruguay

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ABSTRACT

We examine technology spillovers to Uruguayan manufacturing firms through imports, foreign direct investment (FDI) and learning by exporting, for the period 1997-2001. This work provides evidence of the dynamic gains from trade openness for a small developing country, analysing simultaneously the various possible channels of international technology diffusion at the firm level. We find evidence of positive effects on production of imported intermediates and backward linkages with foreign firms. On the other hand there is evidence of negative effects of multinational presence at the industry level, while results for exporting are mixed. Finally, the results would indicate that absorptive capacity matters to take advantage of increased openness and FDI, so policies aimed to improve absorptive capacity such as investing in R&D and improving the skills of workers through training are likely to play a role in facilitating knowledge spillovers.

Keywords: Trade, Technology Spillovers, Foreign Direct Investment (FDI), Learning by Exporting, Technology Transfer.

JEL Classification: F1, F2, O3.

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RESUMEN

En este artículo se evalúan los "spillovers" tecnológicos hacia la industria manufacturera uruguaya por intermedio sus importaciones, inversión extranjera directa (IED) y "learning by exporting" para el período 1997-2007. Se presenta evidencia de las ganancias dinámicas derivadas de la apertura comercial para un país pequeño en desarrollo, analizando simultáneamente los canales alternativos de difusión tecnológica internacional a nivel de empresa. Se encuentra evidencia de efectos positivos en la producción de productos intermedios y en los vínculos hacia atrás con empresas extranjeras. Por otra parte, existe evidencia de efectos negativos de la presencia de multinacionales a nivel de industria, aunque los resultados son mixtos. Finalmente, los resultados indicarían que la capacidad de absorción es importante para poder aprovechar el aumento del grado de apertura y las IED, de manera que es posible que políticas dirigidas a mejorar la capacidad de absorción, tales como inversión en I+D y mejora en las habilidades de los trabajadores a través de la capacitación, jueguen un rol facilitando la difusión del conocimiento.

Palabras Clave: Comercio, Difusión Tecnológica, Inversión Extranjera Directa (IED), "Learning by Exporting", Transferencia de Tecnología.

Clasificación JEL: F1, F2, O3.

I. INTRODUCTION

The development of theories of endogenous growth has renewed the interest in the relationship between trade and growth. Recent theories of endogenous technological change (Grossman and Helpman, 1991; Aghion and Howitt, 1992) provide a rationale for examining international knowledge diffusion due to increased trade openness. While in the absence of trade, a country's productivity is determined by its own stock of knowledge, in a world with international trade in goods and services, foreign direct investment (FDI), and international exchange of information, a country's productivity will also depend on international technology transfer[1] produced by foreign countries.[2]

The role of trade policy on development has been the focus of considerable academic research. Nevertheless the empirical support is

1. We consider technology in a broad sense, so technology is equivalent to knowledge. Thus, we will refer to knowledge or technology indistinctly along the text.
2. Knowledge diffuses across national boundaries in many ways: imports, FDI, internet, technology licensing, scientific journals and personal contacts, among others.

mixed. One source of the weakness of the trade and growth results might be due to the omission of relevant mechanisms through which openness can promote growth. The liberalisation process is expected to increase not only trade but also foreign direct investment. Therefore if international flows of foreign direct investments are important, focusing only on trade as a proxy for openness may be misleading (Golberg and Klein, 1999; Kraay et al., 2001). In this regard most studies analyze only one source of spillovers and usually at the aggregate level. Furthermore Görg and Strobl (2000) argue that research design can crucially affect whether or not spillovers are found. They argue that panel studies using data on firm rather than on industry level appears to be more appropriate to determine the true extent of spillovers. We address these issues analyzing the various sources of knowledge spillovers working with micro level panel data.

Thus, the objective of this work is to analyze whether trade openness induces technology progress, and hence productivity gains, for a small country –Uruguay– that underwent a process of regional integration at the beginning of the 90s with the creation of the Southern Common Market (MERCOSUR). Nowadays there are on going negotiations aimed to form new Free Trade Areas (FTAs), between the MERCOSUR with the EU and NAFTA blocs. This raises concerns on the possible consequences of the integration between MERCOSUR, the European Union and NAFTA, namely for MERCOSUR's members, and particularly for the smaller ones. While there is mixed evidence of the impact on productivity and technology transfers from MERCOSUR creation for Argentina (Calfat et al., 2003; Yeats, 1998), there has been little empirical work on these effects.

As far as we know there are only two works which analyse simultaneously the various sources of technology spillovers at the micro level. These are the studies by Kraay et al. (2001) and Yasar et al. (2007). The work by Kraay et al. (2001) analyse what mechanisms transmit foreign technologies to LDCs at the plant level for Colombia, Mexico and Morocco. The mechanisms analysed are Foreign Direct Investment (FDI), learning by exporting and importing intermediates and capital goods. They find that activities tend to go together therefore studies that relate firms' performance to one international activity and ignore the others may generate very misleading conclusions. The work by Yasar and Morrison (2007) evaluate the relationship between productivity and FDI, exports, imports and licensing for Turkish manufacturing plants. These authors find that productivity is most closely related to foreign ownership, especially for larger plants and in combination with other forms of technology transfer, followed by exporting and then licensing.

Thus our work contributes to the literature by analysing the various possible sources of knowledge spillovers simultaneously at the firm level for a developing country, controlling for firms technological capabilities. Finally, our analysis is based on the estimation of a translog production function which captures firm heterogeneity through output-input relationships and scale effects.

In this regard the methodology to be used will follow the lines of previous works by Griliches (1979), Evenson and Singh (1997), followed also by Smarzynska (2002) and Griffith et al. (2004), examining the impact of imported intermediates, FDI and learning by exporting directly on output. The analysis is conducted on a panel of manufacturing Uruguayan firms for the period 1997- 2001. Availability of data on firms' expenditures in R&D and training of workers for the period allows the analysis of the effect of firms' technological capabilities as well as the complementarities between these activities and the different channels of knowledge spillovers.

We find evidence of positive effects on production of imported intermediates and backward linkages with foreign firms. On the other hand there is evidence of negative effects of multinational presence at the industry level, while results for exporting are mixed. Nevertheless for those firms that undertake own R&D and/or training of workers and hence have higher absorptive capacity, the positive impact of imported intermediates and backward linkages are greater than for those firms that do not perform R&D and/or training. These results would indicate that absorptive capacity matters to take advantage of increased openness and FDI, so policies aimed to improve absorptive capacity such as investing in R&D and improving the skills of workers through training are likely to play a role in facilitating knowledge spillovers.

The remainder of this work is as follows: section II presents briefly the theoretical arguments on the relation between trade openness and technology progress and reviews some previous empirical studies, section III describes the empirical strategy followed, while section IV presents the results, the main conclusions are summarized in section V.

II. TRADE AND TECHNOLOGY PROGRESS

As we have mentioned above, trade liberalisation is argued to have dynamic effects, most of which are related to knowledge diffusion and technology progress. The conceptual framework is based on models of endogenous growth in open economies, which recognizes that trade in goods and factors of production may open new sources of technological inputs (Grossman and Helpman, 1991, and Rivera-Batiz and Romer, 1991). In these models knowledge is not only contained within national boundaries, but it is transmitted through a variety of ways such as trade, foreign direct investment, and personal mobility among others. Knowledge diffuses across national boundaries and a country's knowledge may increase because its trading partners have accumulated knowledge.

In what follows we briefly review the theoretical basis of these channels and some of the empirical studies. Even thought, there is a growing number of studies on trade related spillovers, most of them are at the aggregate level, for developed countries and usually analyze only one source of knowledge spillovers. Nevertheless, most of the effects of learning on productivity are observable primarily at the sector and micro-level, since the potential for technical progress differs across industries and firms within industries. The literature has recently interested in studies for developing countries, based on industry and micro level data.

II.1. Imports of intermediate inputs and capital goods or R&D trade related spillovers

Ethier (1982) has shown that in the presence of firm-level scale economies and therefore imperfect competition, free trade in differentiated intermediate inputs is formally equivalent to technical progress. The reason is that imports of intermediates allow a better division of labour, which increases firms' efficiency. A similar reasoning applies to imports of differentiated capital goods. Moreover, through imports of intermediates and capital goods, domestic firms can benefit from foreign innovations embodied in these goods. This argument is particularly relevant for developing countries. Thus, technology transfers can increase with the removal of trade barriers.[3]

There are some works (e.g. Coe et al., 1997; Barba Navaretti and Soloaga, 2001; Falvey et al., 2002) that analyse the impact of technology transmission through trade from developed to less developed countries, finding positive effects on domestic country productivity at the aggregate level.

The work by Schiff et al. (2003) is the first to analyse North-South as well as South-South trade related technology diffusion at the industry

3. See Barba Navaretti and Tarr (2000) and Keller (2001) for two recent surveys of international trade and technology diffusion.

level, allowing the analysis of sectoral characteristics on international technology diffusion and TFP. The main finding is that R&D intensive industries learn mainly from trading with the North and low R&D intensive industries learn mainly from trading with the South.

II.2. Foreign direct investment

Foreign investment can generate several benefits for the host country. If foreign entrants possess a better technology, they can promote productivity improvements in the domestic industry either directly, by raising the productivity of the resources used in production, and indirectly through knowledge spillovers to local firms. In this regard, local firms can learn from foreign firms either by simply observing them, or through turnover of labour, as employees move from foreign to local firms. The theoretical literature on intra-industry spillovers provides a basis for spillovers through imitation, competition, transfers of skills through labour mobility and learning to export.[4]

There is a wide literature on the role of FDI as a source of technology spillovers for developed countries (Liu et al. 2000; Driffield, 2001; Girma et al., 2001; Girma and Wakelin, 2000, 2001; Harris and Robison, 2004; Görg and Hijzen, 2004). In particular, they find that spillovers are more pronounced in industries in which the technology gap between foreign and domestic firms is smaller, so domestic firms have a higher absorptive capacity.

For developing and transition countries the micro-level evidence suggests the absence of positive horizontal spillovers from FDI (Haddad and Harrison, 1994, Aitken and Harrison, 1999; and Harrison, 1996; Kathuria, 2000; Kugler, 2001), the only available micro-data evidence of positive horizontal spillovers effects comes from developed countries. Nevertheless there is a growing literature providing evidence of positive vertical spillovers from FDI. Smarzynska (2002) using firm level data for Lithuania, Blackock (2001) for Colombian firms, and Kugler (2000) for Indonesian firms, find evidence of positive vertical FDI spillovers through backward linkages. The reason is that, since multinationals have an incentive to prevent any kind of spillovers that would increase the productivity

4. For a survey on FDI and intra-industry spillovers see Görg and Greenaway (2001).

of their local competitors, but also want to transfer information to their local suppliers, FDI spillovers are more likely to be vertical than horizontal in nature.

For Uruguay, the study by Domingo and Bittencourt (2004), analyze Multinational Enterprises' (MNEs) spillovers using firm panel data for 1990-1996 and for the 1997-2000 periods find that for the period 1990-1996 there is a negative and significant impact of foreign presence on firms' output and labour productivity, nevertheless there is some evidence of positive inter-industry effects. While for the second period there is no evidence of significant intra-industry spillovers while the lack of information prevents the authors for proxying for inter-industry spillovers.

Although FDI spillovers are widely believed to be an important source of technology diffusion, particularly to developing countries, it has also its limitations. First, the issue of the "absorptive capacity": without a qualified workforce or investments in R&D, it is very unlikely that spillovers from FDI will occur. Further, the presence of foreign firms in the sector may reduce domestic productivity. There are two possible explanations for this negative effect. One is that foreign firms may reduce the market share of local firms reducing their capacity utilization moving them back down on their average cost curve. Another possibility is that foreign firms by paying higher wages attract the best workers, thereby reducing the productivity of local firms. Finally, the entry of large multinational firms in limited domestic markets raises the possibility of collusion and makes the results difficult to pin down.

II.3. Learning by exporting

It is often argued, that there are several channels through which domestic exporters can benefit from the technical expertise of foreign buyers. In particular, breaking into foreign markets allows firms to acquire knowledge of international best practice. Further, foreign buyers might provide their suppliers with technical assistance and product design in order to improve the quality of imported goods. It has also been noted that in some cases foreign buyers might transmit to their suppliers located in low-wage countries the tacit knowledge acquired from their other suppliers located in technologically advanced countries. Hence, exporting may foster learning and productivity growth.

The micro-level evidence shows a positive robust correlation between exporting and productivity. There are two possible explanations for this stylised fact. One is that, as shown by Melitz (2002), more efficient firms self-select into export markets. The other is the learning-by-exporting argument, according to which exporting cause efficiency gains. Bernard and Jensen (1999) for a panel of US manufacturing plants and Clerides et al. (1998) using plant level panel data for Colombia, Mexico and Morocco, find clear evidence that good firms become exporters, since performance is higher ex-ante for exporters relative to non-exporters. However, they do not find evidence that exporting improves performance, since productivity and wage growth are not higher ex-post for exporters relative to non-exporters. There are several reasons, however to be cautious in interpreting these results. In particular, since the time span covered by the data is very short, the econometric analysis can only pick up gains in efficiency, which materialise immediately (which is quite unlikely, given that learning is a gradual process), in the short-run they can be offset by the sunken entry cost associated with becoming an exporter. Indeed, sunken entry costs may contribute to explain the positive and significant correlation between exporting, and marginal costs found by the authors in some cases. Hence, this evidence simply suggests that becoming an exporter does not generate short-run efficiency gains.[5]

On the other hand, the studies by Kraay (1999) for China, Castellani (2001) for Italy, Bingsten et al. (2002), Girma et al. (2004) for UK, Alvarez and Lopez (2005) for Chile, Fernandes and Isgut (2006) for Colombia, Van Biesebroeck (2003), Blalock and Gertler (2004) for Indonesia, Baldwin an Gu (2004) for Canada, and De Loecker (2007) for Slovenia, find strong empirical support for the presence of learning by exporting.[6]

We should note that aside from these beneficial effects, trade liberalisation has also been argued to have potentially negative dynamic effects for developing countries. These negative effects can be thought of as the dynamic counterpart to the static gains from specialisation based on comparative advantages. For instance, as shown by Lucas (1988) and Young (1991), in the presence of sectoral asymmetries in the relevance of learning-by-doing, a developing country which in the free trade regime

5. Also, as noted by the authors, their approach does not allow detecting efficiency gains accruing to workers in the form of higher wages, but that leave average variable costs unchanged.

6. For a survey see Wagner (2005) and Greenaway and Kneller (2007).

switches its production mix toward technologically stagnant sectors may suffer a permanent reduction in its rate of productivity growth. Similarly, Grossman and Helpman (1991) have shown that trade liberalisation can adversely affect the rate of innovation and growth in a human capital-poor developing country by diverting its resources away from R&D. Further, Rodrik (1988) argues that if firms invest in superior technology to reduce their costs, then their incentive to invest depend positively on output. It follows that trade liberalisation may reduce the incentive to invest in new technology for firms belonging to the import competing sectors, since these sectors should contract after trade liberalisation.

Now we will turn to some works that analyses simultaneously the impact of various channels of spillovers.

II.4. Spillovers effects: various channels

As far as we know there are only two works which analyse simultaneously various channels at the micro level for developing countries at the micro level, the work by Kraay et al. (2001) and Yasar and Morrison (2007). The work by Kraay et al. (2001) analyse what mechanisms transmit foreign technologies to LDCs at the plant level. The countries studied are Colombia, Mexico and Morocco. The mechanisms analysed are Foreign Direct Investment (FDI), learning by exporting and importing intermediates and capital goods. They find that activities tend to go together therefore studies that relate firms' performance to one international activity and ignore the others may generate very misleading conclusions. Furthermore, the bundling of activities seems to mainly reflect unobserved plant characteristics like managerial philosophy, contacts, product niches and location. Once these are controlled for there is little evidence that by engaging in one international activity increases the probability that the others will occur in the future.

Yasar and Morrison (2007) evaluate the relationship between productivity and FDI, exports, imports and licensing for Turkish manufacturing plants for the period 1990-1996. These authors find that productivity is most closely related to foreign ownership, especially for larger plants and in combination with other forms of technology transfer, followed by exporting and then licensing.

III. METHODOLOGY

In this section we describe the procedure used for testing the impact of knowledge transfer from imports, FDI and learning by exporting on firms' production using a panel of Manufacturing Uruguayan firms for the period 1997-2001.

III.1. Empirical Specification

Most of the empirical studies examine the impact of knowledge spillovers on an index of total factor productivity (TFP) or total factor productivity growth. In this study we directly examine production relationships underlying input use and international technology transfer through production function regressions that allow a more structural analysis of firms' productive processes and performance. Moreover we include the various variables that can act as a conduit of knowledge transfer. When different variables account for knowledge transfer and only knowledge transfer from one source is analysed, then the coefficients on foreign knowledge spillovers might be overestimated. Including these other variables in the model gives us more confidence on capturing the true impact of the various channels of knowledge diffusion (Cuadros et al., 2001).

Further, the use of panel firm data avoids the limitations of cross section studies (Görg and Strobl, 2000).

Thus, our expected contributions are to analyse simultaneously the various possible sources of knowledge spillovers –imported intermediates, FDI and learning by exporting– at the firm level for a small developing country, for the period 1997-2001; availability of data on firms' R&D expenditures and training of workers for the period allow to control for firms' technological capabilities as well as to analyse the complementarities between domestic R&D and training and the various channels of technological progress; finally our analysis is based on the estimation of a translog production function which captures firm heterogeneity through output-inputs relationship and scale effects.

The model used here to test the various possible channels of knowledge diffusion is derived from a production function in which aside capital, labour and intermediates, a set of other explanatory variables are included. In the usual notation the production function can be written as:

$$Y=F(L, K, X), \qquad (1)$$

where:

Y is the value added at the firm level; *L* stands for labour at the firm level which can be further decomposed in skilled (*SL*) and unskilled labour (*UL*); *K* is the stock of capital of the firm; *X* is a set of variables that accounts for imports of intermediates, FDI and exports.

We assumed the production function to be a translogarithmic production function, which is more flexible than the commonly used augmented Cobb-Douglas function, since it allows the elasticity of scale to change with output and/or factor proportions:

$$\ln Y_{ijt} = \log \beta_0 + \sum_i \beta_1 \ln L_{ijt} + \sum_i \beta_2 \ln K_{ijt} + \frac{1}{2}\sum_i \sum_f \beta_3 \ln L_{ijt} \ln K_{ijt} + \frac{1}{2}\sum_i \sum_f \beta_4 \ln I_{ijt} \ln K_{ijt} + \beta_5 X^{\beta}_{ijt} + \varepsilon_{ijt} \quad (2)$$

Where *i* and *f* are the indexes for firms, *j* for sectors/industries, and *t* indexes time. β_0 will capture other factors not included in the model, and ε_{ijt} is a term with the following structure: $\varepsilon_{ijt} = \eta_i + \mu_{ijt}$, where η_i will be assumed to be a fixed or random effect, while μ_{ijt} is a disturbance term. Then our baseline equation to estimate when the dependent variable is value added is:

$$\begin{aligned} \ln y_{ijt} = {} & \beta_0 + \beta_1 \ln K_{ijt} + \beta_2 \ln UL_{ijt} + \beta_3 \ln SL_{ijt} + \beta_4 \ln K^2_{ijt} + \\ & \beta_5 \ln UL_{ijt} . \ln SL_{ijt} + \beta_6 \ln SL^2_{ijt} + \beta_7 \ln K_{ijt} . \ln UL_{ijt} + \beta_8 \ln K_{ijt} . \ln SL_{ijt} + \\ & \beta_9 \ln UL_{ijt} . \ln SL_{ijt} + \beta_{10} IIMP_{ijt} + \beta_{11} MNEP_{jt} + \beta_{12} \ln BACK_{jt} + \\ & \beta_{13} PEXPF_{ijt} + \beta_{14} ERD\_TE_{ijt} + \beta_{15} Dt + \varepsilon_{ijt} \end{aligned} \quad (3)$$

where:

Y_{ijt}: is deflated value added of firm *i* in industry *j* and year *t*. It is deflated using specific industry deflators with base year 1997.

L_{ijt} : stands for labour defined as the total number of workers at the firm level, which is further decomposed into skilled (*SL*) and unskilled labour (*UL*). Skilled labour is defined as the number of non-production workers, and unskilled labour as the number of production workers.

K_{ijt}: stands for deflated capital at the firm level.

$IIMP_{ijt}$: share of imported intermediates in relation to total intermediate inputs used by the firm.

$MNEP_{jt}$: MNEs' participation at the industry level. It is defined as the share of the sales by multinationals in relation to total sales at the sectoral level.

$BACK_{jt}$: is a proxy for the backwards linkages of the MNEs. The construction of this variable is explained below.

$PEXPF_{ijt}$: firm's export propensity defined as the share of exports in relation to total sales.

ERD_TE_{ijt}: expenditures in R&D in relation to total expenditures of the firm.

Dt: dummies by years.

The impact of knowledge transfer by imports is captured through the ratio of imported intermediates to total intermediates used by the firm. Many studies on trade related spillovers construct a variable of foreign knowledge stock. The construction of this measure has been object of debate, in particular regarding the weighting scheme that should be more appropriate (Keller, 1998; Lichtenberg et al., 1998; Falvey et. al., 2002). Usually the method employed by researchers involves the construction of the stock of knowledge from imports from the various countries by cumulating past R&D expenditures and then weighting this stock for some measure of the extent of trade between the donor and the recipient country, aggregating afterwards to obtain a measure of foreign R&D stock received through imports. In this work we will use a different approach using the share of imported intermediates used by the firm. Another way to measure trade related spillovers in previous studies is through measures of imports of capital goods, but lack of data does not allow including this latter variable in our model. Further it would be interesting to know the country of origin of intermediates[7] but also availability of data does not allow us to analyse this point.

7. It is not just whether the country trade that is likely to be important for knowledge related spillovers but also with which country it trades. In order to benefit from advanced technology and knowledge the country should trade with countries that are able to provide it with such knowledge. Here we also should note that there is also the issue of the technology gap, which remains an unsolved empirical question.

The impact of foreign direct investment is measured through two sector variables. Multinational presence ($MNEP_{jt}$) defined as the share of the sales by multinationals in relation to total sales at the industry level. This variable captures the extent of foreign presence in the sector, i.e. intra-industry spillovers. If foreign presence brings productivity gains we expect a positive and significant sign of this variable, meaning that MNEs presence in the sector enhances firms' production and productivity. To capture the extent of vertical spillovers we define a variable (*BACK*) that takes into account backward linkages of MNEs with local suppliers. The variable is a proxy for foreign presence in the industries that are being supplied by the sector at which the firm belongs and thus it is intended to capture the extent of potential contacts between domestic suppliers and multinational customers. It is defined as follows:

$$BACK_{jt} = \sum_{i \neq k} \alpha_{jk} MNEP_{kt}$$

where α_{jk} is the proportion of sector *j* output supplied to sector *k*, taken from the input-output matrix for the year 1997. This proportion is calculated excluding products for final consumption and imported intermediates (so considering only domestically produced intermediates). Further, inputs supplied within the sector are not included since this effect is captured by *MNEP* which measures the extent of horizontal spillovers from MNEs. Thus, the greater the foreign presence in sectors supplied by industry j and the larger the share of intermediates supplied to industries with multinational presence the higher the value of the variable.

The proxy for learning by exporting is the export propensity of the firm ($PEXPF_{ijt}$) as well as using its lagged value to proxy for past export experience.

The availability of data on firms' expenditures in R&D and training of workers for the period allows the analysis of the effect of firms' technological capabilities as well as the complementarities between these variables and the different channels of knowledge spillovers. It is well known that in developing countries, industries and firms that undertake R&D and training of workers expenditures are more likely to adopt, imitate and develop technological capabilities on the basis of transferred technology from technological leaders. The approach used in this work is to analyse the impact of expenditures of R&D in relation to total expenditures at the firm level instead of constructing the R&D capital stock. We should keep in mind that this measure is proxying the technological effort of the firm at a point in time, and usually expenditures in R&D, if successful will not be instantaneous, but operate with a time lag,[8] thus we also test for lagged R&D expenditures. Since only a small number of firms perform R&D and training we also define a dummy that takes the value of one if the firm undertakes expenditures in R&D and/or training of workers and takes the value of zero otherwise (named *TRD*), since it seems possible that these firms have higher technological capabilities and absorptive capacity. In order to analyze the complementarities between firms' technological capabilities and the various possible sources of knowledge spillovers, we interact this variable (*TRD*) with multinational participation at the sectoral level (*ET_TRD*), with vertical linkages (*BACK_TRD*), with the export propensity of the firm (*EXP_TRD*), and the share of imported intermediates used by the firm (*IM_TRD*).[9]

In addition, we test if the translog specification is preferred to the commonly used Cobb-Douglas function by means of a Wald test. To do so, we test if the second order coefficients are zero, i.e. $\beta_4=\beta_5=.....=\beta_8=\beta_9=0$ as well as unitary returns to scale, i.e. $\beta_1+\beta_2+\beta_3=1$.

Some econometric concerns need to be addressed. Griliches and Mairesse (1995) have argued that inputs should be considered endogenous since they are chosen by the firm based on its productivity, which is known by the producer but not for the econometrician. Further, there may exist firm, industry and time specific factors, unknown to the econometrician but known to the firm that may affect the correlation between production and the variables aimed to capture knowledge transfer (*IIMP, MNEP*, *BACK* and *PEXPF*), for instance, high quality management, or the productivity of some sector in particular. In other words, expenditure in R&D, firm's export propensity and the share of intermediate imports can all be affected by the level of output, or some other missing variable that affects these variables and the level of production. One way to address this problem is following Smarzynska (2002) and Haskel et al. (2002) and to use time differencing as well as fixed effects by industry and year. As these authors point out, in addition to removing any fixed firm effect, time differencing will also remove fixed industrial effects such as technological opportunity. Time and industry fixed effects will control for unobservable variables that may be driving changes in, for instance the attractiveness of FDI in a particular industry or the export propensity of firms in a particular

8. We should note that technology diffusion from the various channels is not instantaneous.

9. We should note that this specification it is not controlling for the simultaneity and selectivity bias that may be present (Griliches and Mairesse, 1995), and also causality could be an issue.

sector. Nevertheless, one cost of differencing is that it can aggravate measurement errors in the regressors and thereby introduce biases. In a multivariate setting the direction of the bias can not be signed. Longer time differences tend to attenuate the problem (Griliches and Hausman, 1986). If differencing and fixed effect are sufficient then the error term is left uncontaminated by omitted variables. This may not be the case however if there are important unobservable variables that vary both across plants and over time. For example, managerial talent may not be fixed over time within plants. Without measures of these firms-and-time varying factors, estimates from (1) may still be biased. Olley and Pakes (1996) show that these unobservable shocks can be proxied from investment behaviour, on the assumption that these shocks influence current investment, but since investment take time, not current output.

As Griliches and Mairesse discuss, the Olley and Pakes structural approach depends on a number of assumptions: e.g. firms can not undertake zero investment, other factors besides capital fully adjust to shocks each period, and markets are perfectly competitive. The sensitivity of this approach to violations of assumptions is an ongoing research question. For example, Levinshon and Petrin (2003) propose using intermediates inputs rather than investments to address the underlying omitted variable problem: For our purposes, we prefer not to assume perfect competition in the light of the emphasis in the literature on the competitive effects of foreign entrants.[10]

Other way to solve this problem is to use Instrumental Variable Methods; nevertheless the goodness of the instrument is crucial. Therefore we try to sort these problems by representing the production technology by a flexible (translog) functional form which explicitly captures differential productivity patterns for firms with different input composition. Moreover we use lagged values of the share of imported intermediates, export propensity, expenditures in R&D, and the measures of multinational presence and import penetration as explanatory variables which helps to alleviate the endogeneity problem. Further we control for industry and time specific effects.

Secondly, it is the issue of reverse causality, mainly between exports and growth. To tackle this point we perform additional regressions to shed light on the issue of reverse causality between productivity and exports, which are reported in Appendix 1.

10. Girma et al. (2001) and Smarzynska (2002) analyze productivity spillovers using both a specification similar to ours and the Olley-Pakes specification, and find that both approaches yields qualitatively identical results about spillovers.

Finally, another econometric concern was pointed out by Moulton (1990) who shows that in the case of regressions performed on micro-units yet including industry variables, the standard errors from OLS will be underestimate. If this is not taken into account it will result in a downward bias in the estimated errors leading to spurious findings of statistical significance for the aggregate variables of interest. To address this issue we have to correct the standard errors for a correlation between observations in the same industry in a given year (to cluster standard errors for all observations for the same industry and year).

The regressions are performed on an unbalanced sample of domestic firms.[11]

III. 2. Data Sources

The data sources for the panel of firms are from the Industrial Census for 1997 and the Annual Surveys from 1998 until 2001, carried out by the "Instituto Nacional de Estadísticas del Uruguay" (INE). Gross output, value added, intermediates and capital were deflated by specific price deflators that were constructed at the 3 or 4 ISIC digit level, with base year 1997. Data from imports are from the INTAL database.

VI. RESULTS

The estimation results when output is taken as the dependent variable are presented in Tables 1, 2 and 3. In order to determine whether the fixed or the random effect model was more appropriate Hausman's tests were performed for all the equations. In all the cases the fixed effect model seems to be more appropriate than the random effect model, thus we present the estimations for the fixed effect model with clustered standard errors by industry.

Further, we test if the translog specification is preferred to the commonly used Cobb-Douglas function by means of a Wald test. To do so, we test if the second order coefficients are zero, i.e. $\beta_4=\beta_5=......=\beta_8=\beta_9=0$ as well as unitary returns to scale, i.e. $\beta_1+\beta_2+\beta_3=1$. The Wald statistics allows us to reject the hypothesis of a Cobb-Douglas production function in favour of a translog functional form.

In Table 1, column (*i*) we present the model with current and lagged values. The lagged share of imported intermediates used by the

11. The sample selectivity problem may be important for panel data. If observations are not missing at random, estimates based on "clean" and "balanced" data sub-samples could be biased. In order to reduce this problem we choose not to "clean" our data, working with an unbalanced panel.

firms has a positive and significant effect on production while its current value does not; moreover these results are consistent across the various specifications. The current export propensity –which was used as a proxy for learning by exporting– also affects positively and significantly production, while its lagged value has a negative significant effect. This result is also consistent across specifications. One possible explanation for this unexpected result may be the presence of multicollinearity. In Appendix 2 we present the correlation matrix. Other possible explanation may be the exchange rate policy pursued by the Uruguayan government in this period. It consisted in a domestic currency appreciation in order to control for inflation. This made exporting less profitable than selling to the domestic market. Thus, the higher the past export share the lower the past profit, which could induce firms to reduce current production.

On the other hand there is no evidence that the share of R&D expenditures in relation to total expenditures has an impact on production. As noted above, we should keep in mind that this measure is proxying the technological effort of the firm at a point in time, and usually expenditures in R&D, if successful will not be instantaneous, but operate with a longer time lag that one period. Multinationals' participation at the sectoral level is negatively significant. This result is similar to some of the studies reviewed in the empirical literature: most of the works do not find support for positive intra-industry spillovers, and some report negative results at the aggregate level. The possible explanations for this results is that foreign firms in the industry reduce the market share of local firms, thereby reducing its capacity utilisation and forcing them back up on the average cost curve. Another possibility is that foreign firms, by paying higher wages, attract the best workers, thereby reducing the productivity of local firms. In Appendix 3 we report some features for MNEs and domestic firms.[12] Nevertheless some studies that use disaggregated data find some evidence for spillovers on firms that have a certain level of "absorptive capacity". This hypothesis is tested below. Further, backward linkages are positive and significant, in line with our expectations. Thus, those sectors that provide intermediate goods to MNEs are more likely to benefit from foreign presence. This result is consistent with the works of Smarzynska (2002) for Lithuania, Blalock (2001) for Colombia, and Kugler (2000) for Indonesia, working at the firm level.

12. MNEs have a higher size measured through production, number of employees and capital stock. They also show a higher export propensity, labour productivity, capital-labour ratio and share of imported inputs than domestic firms (See Appendix 2).

In Table 1, column (*ii*) we try only with lagged values of imported intermediates, multinational presence in the industry, backward linkages, export propensity and R&D expenditures in order to mitigate endogeneity. Moreover, in order to test if the previous results are driven by multicollinearity we try with only one of these variables at a time (column *iii* to column ix). We can observe from Table 1 that the results are robust across specifications, with a positive significant effect of imported intermediates and backward linkages and negative impact of multinational presence at the sector level.

Since only a small number of firms performs R&D and training of workers, we define a dummy which takes the value of one if the firm undertakes expenditures in R&D and/or training and zero otherwise (named TRD) to have a better insight of the impact of firms' technological capabilities on production. Results are presented in Table 2a and Table 2b.

From the results it can be observed that the fact of undertaking R&D and/or training of workers have a positive effect on production. The rest of the variables considered present a similar behaviour to those results presented in Table 1, with a positive and significant effect of lagged imported intermediates and current export propensity but an insignificant effect of lagged exports,[13] a negative significant effect of MNEs participation, and a positive significant effect of backward linkages on firms' output.

As mentioned above, it is recognised that in developing countries, industries and firms that undertake R&D and training efforts are more likely to take advantage of external knowledge. In order to analyze the complementarities between firms' technological capabilities and the various sources of spillovers we interact the variable TRD with multinational participation at the sectoral level (*ET_TRD*), and backward linkages (*BACK_TRD*), the export propensity of the firm (*EX_TRD*), and the share of imported intermediates used by the firm (*IM_TRD*). In order to avoid multi-collinearity problems we include them in separate regressions. In Table 3 we report the results for the fixed effect model since according to Hausman's test they would be the more appropriate. Nevertheless, we should take with care these results since the interactions terms may be endogenous.

We find that the interaction term that shows up as positive and significant is for imported intermediates, and in this equation the fact of

13. We tried the various specifications with current export propensity and it turns out to be positive and significant across specifications. Results are available upon request.

undertaking R&D and/or training of workers is not significant. The rest of the interactions terms are not significant while the fact of undertaking R&D and/or training of workers is positive and significant. The positive effect of the interaction between the share of imported intermediates and R&D and/or training could be reflecting that the higher the technological capability of the firm the more likely would be to take advantage of embodied technological knowledge. On the other hand the results are similar to the ones obtained previously for the rest of the variables analysed.

In order to have a better insight on how technological capabilities –or absorptive capacity– may affect the use of external knowledge by the firms, we split the sample according to the firm undertaking R&D and/or training or not. We perform the regressions on these two sub-samples and report the results in Table 4a and 4b. The specifications in Table 4a contains current and lagged variables of the technology variables while Table 4b considers only lagged values.

We recall that working for the whole sample of domestic firms (see Table 1) we find evidence of negative intra-industry spillovers and positive effects of backward linkages. Nevertheless, these effects appear to differ across the various types of firms (Table 4a). While firms that do not perform R&D or training of workers (*TRD*=0) show a negative significant impact of multinational presence in the industry for current and lagged values, this effect is not significant for the current value of this variable for firms with higher technological capability (*TRD*=1) but its lagged effect is negative and significant. Thus the negative effect of competition with MNEs appears to be stronger for firms with low levels of technological capability. On the other hand, backward linkages with multinationals, the share of imported intermediates, and export propensity have a higher positive and significant impact on output. These results are consistent with the ones obtained previously, and may indicate that technology capabilities of domestic firms plays a role in absorbing external knowledge.

In Table 4b we report the specifications with lagged values of the technology variables. We find a higher positive effect of imported intermediates and backward linkages for those firms that undertake R&D and/or training of workers. On the other hand export propensity is not significant and we observe a higher negative magnitude of multinational presence for firms with higher technological capabilities which reverse our previous results. One possible explanation is that possibly these specifications are more adequate since they should mitigate two problems: endogeneity and multicollinearity, and after all it could be expected that

MNEs compete more aggressively with their peers in the domestic market and they are good at preventing flows of knowledge to their competitors. Nevertheless, we find that investing in own R&D and training brings gains in terms of being able to take advantage of other forms of foreign knowledge.

V. CONCLUDING REMARKS

Since the return to the democratic regime in 1985, the Uruguayan economy underwent considerable policy reforms. Among them, one of the most salient and stable of these reforms was trade liberalisation and the increasing integration of the country with the region and the world economy. This increased trade liberalisation raised voices of concern regarding the likelihood of a negative impact on the Manufacturing Uruguayan industry, which has been developed in a framework of high protection. In this regard our work contributes to the debate to improve our understanding of the mechanisms through which trade liberalisation can enhance productivity gains for the manufacturing sector and provides useful suggestions for policy prescription.

The present paper is part of the literature that aims at disentangling the contribution of international trade to productivity through the diffusion of technology. It is usually argued that technology transfer through imports, exports and FDI may enhance productivity growth, particularly for small developing countries. However, most of the studies have concentrated around the experience of developed countries. The empirical evidence for developing areas, which has mostly focused at the country or industry level, presents results that are far from conclusive.

In this paper we examine the relationships between productivity and FDI, exports and imported intermediates, for a small developing country –Uruguay– using data at the firm level. Our analysis is based on the estimation of a trans-logarithmic production function which captures plant heterogeneity through output-input relationships underlying productivity and scale effects (i.e. it captures production structure and interrelationships). In addition, data availability allows the analysis of other relevant firm characteristics such as expenditures in R&D and training of workers.

We find evidence of technology spillovers through imports of intermediates and into a less extent from exports, being these results robust across specifications.

On the other hand when working with the whole sample of domestic firms we find a negative effect of multinational presence at the industry level. Thus, multinational presence seems to crowd out domestic firms and decrease its productivity. Nevertheless, there is evidence of positive effects of multinationals through backward linkages with domestic firms. These results are in line with the recent literature and empirical works for developing countries that point out that although MNEs have incentives to prevent any kind of spillovers that would increase productivity of their local competitors; they are also interested in transferring information spillovers to their local FDI suppliers, which are more likely to be vertical rather than horizontal. The studies by Smarzynska (2002), Blalock (2001), for Indonesian firms, and Kugler (2000) for Colombian firms, are in line with our results.

Endogenous firms' technical capability measured by a dummy that takes the value of one if the firm undertakes R&D activities and/or training of workers has a positive effect on productivity. Moreover, import competition has a positive effect on productivity, which indicates that the level of openness of the industry has a positive impact on firms' productivity for the whole sample of domestic firms in the period analysed.

Since it is expected that firms with higher levels of technical capability are more likely to take advantage of external knowledge we tested this hypothesis in two distinct ways: one by interacting our dummy for R&D and/or training with the four possible channels of knowledge spillovers –imports of intermediates, exports, multinational presence in the industry and backward linkages-. The other way to analyse the effect of technological capabilities is splitting the sample in two sub-samples: firms that undertake R&D and/or training and those that do not. Regarding the first procedure, the only interaction term that turns to affect positively productivity was the interaction between R&D and/or training and imported intermediates while the rest of the interactions terms do not evidence any effect. Thus, the higher the technological capability of the firm, the more likely to take advantage of embodied technical knowledge in the imported intermediates.

On the other hand, when we split the sample according to the proposition that the firms undertake R&D and/or training or not, we find that the impact of multinational presence appear to differ across these different types of firms. We find evidence that the sub set of firms with higher technological capabilities perform better in terms of taking advantage of external knowledge through imports and backward linkages, while results are not so clear cut for exporting and multinational presence at the sectoral level. While multinational presence appears to crowds out domestic firms it seems that domestic capabilities may not be enough to countervail this negative effect.

Nevertheless, these results would indicate that absorptive capacity matters to take advantage of increased openness from other sources of knowledge, so policies aimed to improve absorptive capacity such as domestic investment in R&D and improving the skills of workers through training are likely to play a role in minimizing the negative effects as well as in facilitating knowledge spillovers.

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Table 1

Determinants of firms' production (value added), Fixed Effects Model

	(i)		(ii)		(iii)	
Constant	11.617 ***	(0.321)	11.596***	(0.273)	11.699***	(0.221)
Ln K	-0.121***	(0.022)	-0.124***	(0.021)	-0.122***	(0.020)
Ln SL	0.853***	(0.163)	0.859***	(0.158)	0.850***	(0.147)
Ln UL	0.597***	(0.158)	0.594***	(0.157)	0.580***	(0.150)
(Ln K)ˆ2	0.012***	(0.002)	0.012***	(0.002)	0.012***	(0.002)
(Ln SL)ˆ2	0.051***	(0.014)	0.051***	(0.014)	0.046***	(0.015)
(Ln UL)ˆ2	0.046**	(0.02)	0.048**	(0.002)	0.055***	(0.018)
Ln K*Ln SL	-0.013	(0.013)	-0.012	(0.013)	-0.011	(0.012)
Lnk*Ln UL	-0.006	(0.007)	-0.006	(0.007)	-0.007	(0.007)
Ln SL*Ln UL	-0.139***	(0.039)	-0.140***	(0.039)	-0.139***	(0.039)
IIMP	0.143	(0.122)				
IIMP_1	0.276***	(0.087)	0.366***	(0.112)	0.375***	(0.118)
MNEP	-1.063***	(0.449)				
MNEP_1	-0.678***	(0.256)	-0.677**	(0.285)		
BACK1	5.327***	(2.012)				
BACK1_1	5.617*	(3.144)	5.337**	(1.968)		
PEXPF	0.549***	(0.139)				
PEXPF_1	-0.253*	(0.148)	0.211	(0.140)		
ERD_TE	-0.958	(1.837)				
ERD_TE_1	2.699	(3.152)	2.301	(3.667)		
Times Dummies	Yes		Yes		Yes	
Squared R	0.81		0.8		0.8	
F statistic	2,888		1487		1717	
No. Observations	1969		1969		1970	

Cst: intercept, Ln K: natural logarithm of capital, ln I: natural logarithm of intermediates inputs, ln UL: logarithm of unskilled workers, ln SL: logarithm of skilled workers, IIMP: share of imported intermediates in relation to total intermediates, IIMP_1: IIMP lagged one period, MNEP: current foreign participation at the sectoral level, MNEP_1: MNEP lagged one period, BACK1: backward linkages of MNEs, BACK1_1: BACK lagged one period, PEXPF: export propensity of the firm, PEXPF_1: PEXPF lagged one period, ERD_TE: expenditures in R&D in relation to total expenditures, ERD_TE_1: ERD_TE lagged one period. Numbers between brackets are standard errors.

* Significant at the 10 percent level; ** significant at the 5 percent level; *** significant at the 1 percent level.

Table 1

Determinants of firms' production (value added), Fixed Effects continued

	(iv)		(v)		(vi)	
Constant	11.850***	(0.201)	11.317***	(0.271)	11.633***	(0.229)
Ln K	-0.129***	(0.021)	-0.128***	(0.021)	-0.131***	(0.022)
Ln SL	0.899***	(0.151)	0.901***	(0.149)	0.912***	(0.158)
Ln UL	0.612***	(0.155)	0.613***	(0.154)	0.625***	(0.160)
(Ln K)ˆ2	0.013***	(0.002)	0.013***	(0.002)	0.013***	(0.002)
(Ln SL)ˆ2	0.042***	(0.016)	0.042***	(0.016)	0.047***	(0.015)
(Ln UL)ˆ2	0.048**	(0.019)	0.048**	(0.019)	0.042**	(0.002)
Ln K*Ln SL	-0.013	(0.012)	-0.013	(0.012)	-0.014	(0.013)
Lnk*Ln UL	-0.006	(0.007)	-0.007	(0.007)	0.005	(0.007)
Ln SL*Ln UL	-0136***	(0.040)	-0.136***	(0.040)	-0.137***	(0.040)
IIMP						
IIMP_1						
MNEP						
MNEP_1	-0.712**	(0.284)				
BACK1						
BACK1_1			6.474***	(1.897)		
PEXPF						
PEXPF_1					0.227	(0.137)
ERD_TE						
ERD_TE_1						
Times Dummies	Yes		Yes		Yes	
Squared R	0.8		0.8		0.8	
F statistic	1512		1699		1215	
No. Observations	1970		1971		1970	

Cst: intercept, Ln K: natural logarithm of capital, ln I: natural logarithm of intermediates inputs, ln UL: logarithm of unskilled workers, ln SL: logarithm of skilled workers, IIMP: share of imported intermediates in relation to total intermediates, IIMP_1: IIMP lagged one period, MNEP: current foreign participation at the sectoral level, MNEP_1: MNEP lagged one period, BACK1: backward linkages of MNEs, BACK1_1: BACK lagged one period, PEXPF: export propensity of the firm, PEXPF_1: PEXPF lagged one period, ERD_TE: expenditures in R&D in relation to total expenditures, ERD_TE_1: ERD_TE lagged one period. Numbers between brackets are standard errors.

* Significant at the 10 percent level; ** significant at the 5 percent level; *** significant at the 1 percent level.

Table 2a
Determinants of firms' production (value added) using Training and R&D as explanatory variable

	(i)	
Constant	11.214***	(0.310)
Ln K	-0.114***	(0.022)
Ln SL	0.864***	(0.159)
Ln UL	0.578***	(0.156)
(Ln K)^2	0.011***	(0.002)
(Ln SL)^2	0.054***	(0.013)
(Ln UL)^2	0.048**	(0.020)
Ln K*Ln SL	-0.015	(0.013)
Ln K*Ln UL	-0.005	(0.007)
Ln SL* Ln UL	-0.143***	(0.039)
IIMP	0.135	(0.120)
IIMP_1	0.268***	(0.087)
MNEP	-1.065**	(0.443)
MNEP_1	-0.674**	(0.254)
BACK	5.439***	(1.936)
BACK_1	6.062*	(3.024)
PEXPF	0.551***	(0.140)
PEXPF_1	-0.264*	(0.148)
TRD	0.192***	(0.055)
IP	0.678***	(0.159)
IP_1	0.141	(0.395)
Time Dummies	Yes	
Squared R	0.81	
F	2,189	
No. Observations	1,968	

Cst: intercept, Ln K: natural logarithm of capital, Ln I: natural logarithm of intermediates, Ln UL: logarithm of unskilled workers, Ln SL: logarithm of skilled workers, IIMP: share of imported intermediates in relation to total intermediates, IIMP_1: IIMP lagged one period, MNEP: current foreign participation at the sectoral level, MNEP_1: MNEP lagged one period, BACK: backward linkages of MNEs, BACK_1: BACK lagged one period, PEXPF: export propensity of the firm, PEXPF_1: PEXPF lagged one period, TRD: dummy that takes the value of one if the firm undertakes R&D activities and/or training of workers and zero otherwise, IP: import penetration at the sectoral level, IP_1: IP lagged one period. Numbers between brackets are standard errors. * Significant at the 10 percent level; ** significant at the 5 percent level; *** significant at the 1 percent level.

Table 2b

Determinants of firms' production (value added) using Training and R&D as explanatory variable

	(i)		(iii)	
Constant	11.572***	(0.247)	11.586***	(0.270)
Ln K	-0.122***	(0.021)	-0.116***	(0.021)
Ln SL	0.867***	(0.157)	0.871***	(0.153)
Ln UL	0.589***	(0.156)	0.574***	(0.155)
(Ln K)^2	0.012***	(0.002)	0.011***	(0.002)
(Ln SL)^2	0.052***	(0.014)	0.053***	(0.013)
(Ln UL)^2	0.048**	(0.020)	0.049**	(0.020)
Ln K*Ln SL	-0.013	(0.013)	-0.014	(0.013)
Ln K*Ln UL	-0.005	(0.007)	-0.005	(0.007)
Ln SL* Ln UL	-0.142***	(0.038)	-0.144***	(0.039)
IIMP				
IIMP_1_	0.360***	(0.113)	0.352***	(0.110)
MNEP				
MNEP_1	-0.664**	(0.283)	-0.682**	(0.275)
BACK1				
BACK1_1	5.587***	(1.902)	5.707***	(1.861)
PEXP				
PEXPF_1	0.215	(0.138)	0.2	(0.137)
ERD_TE	-----		-----	
ERD_TE_1	-----		-----	
RD	0.133	(0.111)	-----	
TRD	-----		0.194***	(0.055)
Time Dummies	Yes		Yes	
Squared R	0.8		0.8	
F statistic	139		138	
No. Observations	196		196	

Cst: intercept, Ln K: natural logarithm of capital, Ln I: natural logarithm of intermediates, Ln UL: logarithm of unskilled workers, Ln SL: logarithm of skilled workers, MNEP: current foreign participation at the sector level, MNEP_1: MNEP lagged one period, BACK: backward linkages of MNEs, BACK_1: BACK lagged one period, PEXPF: export propensity of the firm, PEXPF_1: PEXPF lagged one period, TRD: dummy that takes the value of one if the firm performs R&D and/or training of workers and zero otherwise. Numbers between brackets are standard errors.

* Significant at the 10 percent level; ** significant at the 5 percent level; *** significant at the 1 percent level.

Table 2b
Determinants of firms' production (value added) using Training and R&D as explanatory (continued)

	(i)		(iv)	
Constant	11.606***	(0.222)	11.623***	(0.221)
Ln K	-0.130***	(0.018)	-0.125***	(0.017)
Ln SL	0.930***	(0.148)	0.929***	(0.144)
Ln UL	0.609***	(0.15)	0.596***	(0.148)
(Ln K)^2	0.012***	(0.002)	0.012***	(0.002)
(Ln SL)^2	0.040***	(0.016)	0.042**	(0.016)
(Ln UL)^2	0.047***	(0.016)	0.048***	(0.016)
Ln K*Ln SL	-0.013	(0.013)	-0.014	(0.013)
Ln K*Ln UL	-0.004	(0.007)	-0.004	(0.007)
Ln SL* Ln UL	-0.144***	(0.040)	-0.147**	(0.040)
IIMP				
IIMP_1_				
MNEP				
MNEP_1				
BACK1				
BACK1_1				
PEXP				
PEXPF_1				
ERD_TE				
ERD_TE_1				
RD	0.157*	(0.093)		
TRD			0.202***	(0.045)
Time Dummies	Yes		Yes	
Squared R	0.8		0.8	
F statistic	127		125	
No. Observations	247		247	

Cst: intercept, Ln K: natural logarithm of capital, Ln I: natural logarithm of intermediates, Ln UL: logarithm of unskilled workers, Ln SL: logarithm of skilled workers, MNEP: current foreign participation at the sector level, MNEP_1: MNEP lagged one period, BACK: backward linkages of MNEs, BACK_1: BACK lagged one period, PEXPF: export propensity of the firm, PEXPF_1: PEXPF lagged one period, TRD: dummy that takes the value of one if the firm performs R&D and/or training of workers and zero otherwise.

Numbers between brackets are standard errors.

* Significant at the 10 percent level; ** significant at the 5 percent level; *** significant at the 1 percent level.

Table 3
Estimation results including interactive terms as explanatory variables

	(ii)		(iii)	
Constant	10.220***	(0.310)	11.214***	(0.310)
Ln K	-0.113***	(0.022)	-0.114***	(0.022)
Ln SL	0.865***	(0.159)	0.864***	(0.158)
Ln UL	0.574***	(0.156)	0.575***	(0,158)
(Ln K)^2	0.011***	(0.002)	0.011***	(0.002)
(Ln SL)^2	0.054***	(0.013)	0.053***	(0.013)
(Ln UL)^2	0.048**	(0.020)	0.048**	(0.020)
Ln K*Ln SL	-0.015	(0.013)	-0.015	(0.013)
Ln K*Ln UL	-0.005	(0.007)	-0.005	(0.007)
Ln SL* Ln UL	-0.143***	(0.039)	-0.143***	(0.039)
IIMP	0.135	(0.120)	0.134	(0.12)
IIMP_1	0.269***	(0.087)	0.268***	(0.086)
IM_TRD	---------	---------	---------	---------
MNEP		(0.439)	-1.064**	(0.443)
MNEP_1		(0.254)	-0.675**	(0.254)
TRD	0.164*	(0.087)	0.207***	(0.057)
ET_TRD	0.099	(0.229)	---------	---------
BACK	5.479***	(1.964)	5.545**	(2.082)
BACK_1	6.051*	(3.037)	6.045*	(3.01)
BACK_TRD	---------	---------	-0.302	(1.287)
PEXPF	0.550***	(0.140)	0.550***	(0.140)
PEXPF_1	-0.265*	(0.148)	-0.267*	(0.149)
EX_TRD	--------	--------	--------	---------
Time Dummies	Yes		Yes	
Squared R	0.8		0.8	
F statistic	2.98		2.05	
No. Observations	196		196	

Cst: intercept, Ln K: natural logarithm of capital, Ln I: natural logarithm of intermediates, Ln UL: logarithm of unskilled workers, Ln SL: logarithm of skilled workers, MNEP: current foreign participation at the sector level, MNEP_1: MNEP lagged one period, BACK: backward linkages of MNEs, BACK_1: BACK lagged one period, PEXPF: export propensity of the firm, PEXPF_1: PEXPF lagged one period, TRD: dummy that takes the value of one if the firm performs R&D and/or training of workers and zero otherwise, (TRD), IM_TRD: share of imported intermediates interacted by TRD, ET_TRD: multinational participation in the industry interacted by RD, BACK_TRD: backward MNEs linkages interacted by TRD, EX_TRD: export propensity interacted by the dummy that takes the value of one if the firm undertakes R&D expenditures and/or Training of workers and zero otherwise. Numbers between brackets are standard errors. * Significant at the 10 percent level; ** significant at the 5 percent level; *** significant at the 1 percent level.

Table 3
Estimation results including interactive terms as explanatory (continued)

	(iv)		(v)	
Constant	11.197***	(0.316)	10.182***	(0.326)
Ln K	-0.111***	(0.021)	-0.113***	(0.023)
Ln SL	0.889***	(0.159)	0.873***	(0.152)
Ln UL	0.582***	(0.158)	0.594***	(0.162)
(Ln K)^2	0.011***	(0.002)	0.011***	(0.002)
(Ln SL)^2	0.049***	(0.013)	0.054***	(0.013)
(Ln UL)^2	0.046**	(0.020)	0.046**	(0.020)
Ln K*Ln SL	-0.015	(0.013)	-0.014	(0,013)
Ln K*Ln UL	-0.005	(0.007)	-0.004	(0.007)
Ln SL* Ln UL	-0.141***	(0.038)	-0.147***	(0.039)
IIMP	0.001	(0.127)	0.135	(0.119)
IIMP_1	0.276***	(0.088)	0.266***	(0.088)
IM_TRD	0.292*	(0.153)	---------	---------
MNEP		(0.447)		(0.448)
MNEP_1		(0.265)		(0.248)
TRD	0.101	(0.085)	0.133*	(0.072)
ET_TRD	---------	---------	---------	---------
BACK	5.342*	(1.944)	5.392***	(1.922)
BACK_1	6.186*	(3.121)	6.026*	(3.091)
BACK_TRD	---------	---------	---------	---------
PEXPF	0.545***	(0.136)	0.418*	(0.161)
PEXPF_1	-0.258*	(0.148)	-0.235	(0.159)
EX_TRD	---------	--------	0.32	(0.254)
Time Dummies	Yes		Yes	
Squared R	0.8		0.8	
F statistic	3.62		2.39	
No. Observations	196		196	

Cst: intercept, Ln K: natural logarithm of capital, Ln I: natural logarithm of intermediates, Ln UL: logarithm of unskilled workers, Ln SL: logarithm of skilled workers, MNEP: current foreign participation at the sector level, MNEP_1: MNEP lagged one period, BACK: backward linkages of MNEs, BACK_1: BACK lagged one period, PEXPF: export propensity of the firm, PEXPF_1: PEXPF lagged one period, TRD: dummy that takes the value of one if the firm performs R&D and/or training of workers and zero otherwise, (TRD), IM_TRD: share of imported intermediates interacted by TRD, ET_TRD: multinational participation in the industry interacted by RD, BACK_TRD: backward MNEs linkages interacted by TRD, EX_TRD: export propensity interacted by the dummy that takes the value of one if the firm undertakes R&D expenditures and/or Training of workers and zero otherwise. Numbers between brackets are standard errors. * Significant at the 10 percent level; ** significant at the 5 percent level; *** significant at the 1 percent level.

Table 4 a
Determinants of production by technological capability of the firms

	TRD=0		TRD=1	
Constant	11.546***	(0.256)	11.503***	(0.784)
Ln K	-0.087***	(0.026)	-0.144*	(0.08)
Ln SL	0.911***	(0.169)	0.783**	(0.194)
Ln UL	0.557***	(0.152)	0.736***	(0.194)
(Ln K)^2	0.010***	(0.002)	0.012***	(0.003)
(Ln SL)^2	0.061***	(0.015)	0.039	(0.028)
(Ln UL)^2	0.040**	(0.021)	0.059*	(0.035)
Ln K*Ln SL	-0.019	(0.014)	0.000	
Ln K*Ln UL	-0.001	(0.007)	-0.011	(0.013)
Ln SL* Ln UL	-0.135***	(0.044)	-0.182***	(0.059)
IIMP	-0.013	(0.165)	0.378***	(0.129)
IIMP_1	0.235*	(0.165)	0.263**	(0.123)
MNEP	-1.166**	(0.451)	-0.198	(0.478)
MNEP_1	-0.547*	(0.300)	-0.585**	(0.276)
BACK1	4.442*	(2.209)	3.349	(2.614)
BACK1_1	5.550	(2.209)	8.872**	(3.212)
PEXPF	0.546**	(0.231)	0.644**	(0.277)
PEXPF_1	-0.357	(0.231)	-0.080	(0.312)
Time Dummies	Yes		Yes	
Squared R	0.76		0.76	
F statistic	480,56		378,56	
No. Observations	1348		662	

Cst: intercept, Ln K: natural logarithm of capital, Ln I: natural logarithm of intermediates, Ln UL: logarithm of unskilled workers, Ln SL: logarithm of skilled workers, MNEP: current foreign participation at the sector level, MNEP_1: MNEP lagged one period, BACK: backward linkages of MNEs, BACK_1: BACK lagged one period, PEXPF: export propensity of the firm, PEXPF_1: PEXPF lagged one period, TRD: dummy that takes the value of one if the firm performs R&D and/or Training of workers and zero otherwise. Numbers between brackets are standard errors.
* Significant at the 10 percent level; ** significant at the 5 percent level; *** significant at the 1 percent level.

Table 4b
Determinants of production by technological capability of the firms

	TRD=0		TRD=1	
Constant	11.558***	(0.267)	11.404***	(0.875)
Ln K	-0.085***	(0.025)	-0.134	(0.082)
Ln SL	0.918***	(0.159)	0.698***	(0.281)
Ln UL	0.547***	(0.153)	0.803***	(0.178)
(Ln K)^2	0.009***	(0.002)	0.013***	(0.004)
(Ln SL)^2	0.060***	(0.015)	0.046*	(0.027)
(Ln UL)^2	0.042**	(0.021)	0.075**	(0.034)
Ln K*Ln SL	0.020	(0.013)	0.007	(0.019)
Ln K*Ln UL	0.000	(0.007)	-0.020	(0.015)
Ln SL* Ln UL	-0.135***	(0.044)	-0.198***	(0.062)
IIMP	------		------	
IIMP_1	0.218*	(0.110)	0.495***	(0.171)
MNEP	------		------	
MNEP_1	-0.585*	(0.323)	-0.708*	(0.384)
BACK1	------		------	
BACK1_1	4.328	(2.861)	9.677***	(3.374)
PEXPF	------		------	
PEXPF_1	0.125	(0.105)	0.359	(0.367)
Time Dummies	Yes		Yes	
Squared R	0.76		0.74	
F statistic	505,87		342,51	
No. Observations	1348		662	

Cst: intercept, Ln K: natural logarithm of capital, Ln I: natural logarithm of intermediates, Ln UL: logarithm of unskilled workers, Ln SL: logarithm of skilled workers, MNEP: current foreign participation at the sector level, MNEP_1: MNEP lagged one period, BACK: backward linkages of MNEs, BACK_1: BACK lagged one period, PEXPF: export propensity of the firm, PEXPF_1: PEXPF lagged one period, TRD: dummy that takes the value of one if the firm performs R&D and/or Training of workers and zero otherwise. Numbers between brackets are standard errors. * Significant at the 10 percent level; ** significant at the 5 percent level; *** significant at the 1 percent level.

VII. APPENDIX 1

Effect of exporting on labour productivity and shipments

As stated by Bernard and Jensen (1999) perhaps one of the cleanest test of the effects of exporting on plant outcomes can be found by running a regression of the change in a performance measure x_{it} on initial export status and control for initial employment levels and other initial plant characteristics. Thus, we run the following regression:

$$\%\Delta x_{it} = 1/T\ (\ln x_{it} - \ln x_{io})$$

$$= \alpha + \beta\ \text{Export}_{io} + \gamma \text{Size}_{io} + \delta \text{Char}_{io} + \varepsilon_{it}$$

where x_{it} are performance measures such as labour productivity and shipments. $Export_{io}$ is the initial export status of the firm, $Size_{io}$ is measure through total employment, and $Char_{io}$ are control variables such as the ratio of skill workers to total employment and industry dummies. E_{it} is the disturbance term.

The coefficient β gives the increase in the average annual growth rate of the performance measure of exporters relative to non exporters in the same industry for an interval of length T.

Since our data is for the period 1997-2001, we consider two horizons: short term defined as a two year period (97-99 and 99-01) and medium run defined as the difference between 1997 and 2001. We present the results in the table below.

Results for labour productivity growth are significantly higher at exporter than non exporters. Taking into account the whole period (1997-2001) the rate of growth is lower -almost the half- than for the two year periods. On the other hand results for shipments also show evidence of a higher growth rate in shipments for exporters compared to non exporters. Also, the short run –two year periods- show a higher growth rate than the medium run period.

Changes in Labour Productivity

	dlp 099	dlp9997	dlp0197
Ex	0.63***	0.68***	0.34***
Size	-1,83***	-1.82***	-0.91***
R^2	0.57	0.57	0.57

dlp: changes in labour productivity, * :significant at the 10 %, **: significant at the 5 %, ***: significant at the 1%.

Changes in Shipments

	ds0199	ds9997	ds0197
Ex	0.61***	0.70***	0.35***
Size	-2.59***	-2.57***	-1.28***
R^2	0.58	0.58	0.58

dls: changes in shipments, *: significant at the 10 %, **: significant at the 5 %, ***: sig nificant at the 1%.

These direct tests of the benefits of exporting provide evidence that productivity and shipments are higher for initial exporters compared to non exporters.

Bernard and Jensen (1999) working for a sample of US firms do not find evidence that exporting helps to boost productivity. Similar results were obtained by Clerides et. al. (1996), working for on firms for Morocco, Mexico and Colombia and using a different empirical approach. Nevertheless, we should take into account the small size of the domestic Uruguayan market, which measure by population is of 3,431,923 inhabitants, while the population of the US is 299,491,873; the population of Mexico 106,202,903; the one of Colombia 43,593,035; and the Moroccan population is of 26,073,717 inhabitants.

Thus, for the Uruguayan case there is some evidence that exporting helps to boost labour productivity and shipments. This could be explained by the fact that exporting may bring not only knowlege spillovers, but also it provides expanded market opportunities that are far more important in the case of small domestic markets.

VIII. APPENDIX 2

Correlation matrix

	lva	lcap	lsl	lul	lcap_2	lsl_2	lul_2	lcap_lsl	lcap_lul	lsl_lul	im_itot	l1_im_ itot	x_vtas	l1_x_vt as	et_vtast l	1_etv- tast	back2	l1_back 2
lva	1																	
lcap	0.567	1																
lsl	0.738	0.467	1															
lul	0.792	0.513	0.579	1														
lcap_2	0.691	0.947	0.570	0.637	1													
lsl_2	0.692	0.427	0.956	0.560	0.540	1												
lul_2	0.763	0.483	0.599	0.957	0.624	0.608	1											
lcap_lsl	0.765	0.666	0.950	0.629	0.756	0.931	0.658	1										
lcap_lul	0.794	0.748	0.617	0.926	0.842	0.607	0.920	0.753	1									
lsl_lul	0.803	0.505	0.887	0.826	0.648	0.902	0.869	0.902	0.837	1								
im_itot	0.341	0.205	0.282	0.211	0.225	0.231	0.158	0.277	0.216	0.234	1							
l1_im_itot	0.329	0.189	0.262	0.196	0.206	0.214	0.143	0.256	0.197	0.216	0.821	1						
x_vtas	0.291	0.199	0.139	0.324	0.246	0.132	0.366	0.186	0.329	0.261	0.076	0.054	1					
l1_x_vtas	0.267	0.189	0.123	0.321	0.234	0.116	0.362	0.168	0.321	0.25	0.053	0.071	0.915	1				
et_vtast	0.002	-0.058	-0.009	-0.12	-0.084	-0.019	-0.129	-0.028	-0.117	-0.068	0.08	0.066	-0.128	-0.137	1			
l1_etv-tast	0.022	-0.036	-0.001	-0.109	-0.06	-0.013	-0.122	-0.016	-0.101	-0.06	0.089	0.075	-0.116	-0.124	0.956	1		
back2	0.091	0.156	0	0.205	0.198	0.002	0.224	0.051	0.226	0.118	-0.13	-0.116	0.051	0.044	-0.425	-0.417	1	
l1_back2	0.085	0.154	-0.002	0.202	0.194	0.001	0.221	0.049	0.223	0.116	-0.13	-0.1166	0.037	0.03	-0.409	-0.401	0.99	1

lva: natural logarithm of constant value added; lcap: natural logarithm of constant capital; lsl: natural logarithm of skilled workers; lul: natural logarithm of unskilled workers; lcap_2: natural logarithm of constant value added squared; lsl_2: natural logarithm of skilled workers squared; lul_2: natural logarithm of unskilled workers squared; lcap_lsl: interaction between lcap and lsl; lcap_lul: interaction between lcap and lul; lsl_lul: interaction between lsl and lul; im_itot: share of imported intermediates in relation to total intermediates; l1_im_itot: lagged im_itot; x_vtas: export propensity; l1_x_vtas: lagged export propensity; et_vtast: multinational presence at the sector level, l1_etvtast: lagged multinational presence; back2: backward linkages; l1_back2: lagged backward linkages.

IX. APPENDIX 3

Average value of some variables for MNEs and domestic enterprises

Variable	MNE			Domestic Firms		
	Obs	Mean	Std Dev	Obs	Mean	Std Dev
Gross output*	360	217,000,000	350,000,000	2610	73,000,000	322,000,000
Value added *	360	78,600,000	172,000,000	2610	17,500,000	36,000,000
Number of employees	360	145	144.09	2610	84	134.78
Capital*	360	65,300,000	137,000,000	2610	16,400,000	53,700,000
Export Propensity	360	0.38	0.39	2610	0.16	0.3
Share of impor-ted imputs	360	0.51	0.38	2610	0.25	0.34
Labour productivity*	360	511,797	465,214	2607	209,235	490,198
Capital-labour ratio*	360	425,688	813,039	2607	162,485	388,206

*Values are in constant pesos, base year 1997=100.

X. APPENDIX 4

Average value of some variables for firms that undertake R&D and/or training and those that do not undertake R&D and/or training

	Firms that undertake R&D and/or training			Firms that do not undertake R&D and/or Training		
Variabl	Obs	Mean	Std. Dev	Obs	Mean	Std. Dev.
Gross	844	146,000,00	545,000,00	1766	38,200,000	88,500,00
Value Added*	844	33,700,00	51,400,00	1766	9,785,752	21,600,00
Number of employees	844	136.25	190.89	1766	59.4	86.8
Capital	844	32,200,00	85,800,00	1766	8,896,860	23,900,00
Export propensity	844	0.2	0.3	1766	0.1	0.2
Share of imported inputs	844	0.3	0.3	1766	0.1	0.3
Labor productivity*	844	12.2	0.7	1761	11.6	0.7
Capital_labor ratio*	844	220,289	484,46	1763	134,81	328,98

*Values are in constant pesos, base year 1997=100.