# Regional Integration and Technology Diffusion: The case of Uruguay

*Adriana Peluffo**

## Abstract

In this paper we examine the impact of trade related R&D spillovers on total factor productivity (TFP) for the Uruguayan case at the industry level. Total Factor Productivity is estimated using plant level data and after aggregating at the industry level. Measures of foreign R&D are constructed for the MERCOSUR, European Union, NAFTA, and the rest of the world, based on industry specific R&D, Uruguayan trade patterns and input-output relations in Uruguay.

Although several papers have addressed the effect of FDI spillovers for Uruguay, no studies have been undertaken on specific trade related spillovers. This paper provides the first application on the trade and technology diffusion link for Uruguay. The main contribution of this paper to the stock of empirical literature is based on the assessment of the impact of trade related spillovers of MERCOSUR's partners as well as Northern countries (EU, NAFTA), and the rest of the world.

Thus, we will try to find out: 1) the impact of trade related spillovers from MERCOSUR partners on Uruguayan TFP, and 2) the impact of trade related spillovers from developed countries (Northern countries) on Uruguayan TFP discriminating the impact of trade related spillovers from EU and the NAFTA blocs, as well as the rest of the world (ROW) on Uruguayan TFP, at the industry level, for the period 1988-1995.

This paper builds up on the methodology developed by Lumenga-Neso, Olarreaga and Schiff (2001), Olarreaga, Schiff and Wang (2002) and Schiff and Wang (2003), based on extensions of previous works by Coe and Helpman (1995). We use more refined estimates of TFP at the plant level which are further aggregated at the 2 and 3 ISIC level. A further contribution is the use of data on domestic R&D of Uruguay, which allows analysing the impact of domestic R&D on TFP.

The results suggest that there is evidence of trade related technology diffusion from MERCOSUR's partners. Thus it seems that even in the case of South-South integration as the MERCOSUR one, it could enhance the productivity of a small country. Furthermore, there is a positive impact of positive trade related technology diffusion from knowledge from NAFTA and the EU on high R&D intensive sectors. Thus, by decreasing tariffs to imports from NAFTA and the EU could increase even more Uruguayan Manufacturing productivity on high R&D intensive sectors.

*Phd Programme, University of Antwerp, Universidad de la Republica, Uruguay
apeluffo@csic.edu.uy, silvia.peluffogeronazzo@ua.ac.be

We gratefully acknowledge the financial support from the European Union, Alfa Programme, AML/B7-311-97/0666/II-0058-FA, Eulalia. We want to thank specially to Gabriela Fachola for her help, as well to Marcelo Olarreaga, Maurice Schiff and Marcel Vaillant for his comments on further extensions to this work. The usual disclaimer applies.

## 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 (Romer, 1986; Grossman and Helpman, 1991; and Aghion and Howitt, 1992) provide a rationale for examining international knowledge spillovers through trade. 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 of knowledge produced by foreign countries[1].

The objective of this work is to analyze the existence of trade related spillovers 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 (FTA) between the MERCOSUR with the EU and NAFTA blocs[2]. This raises the concern on the possible consequences of the integration between MERCOSUR, the European Union and NAFTA, namely for MERCOSUR's countries, and particularly for the smaller ones. While there is prima facie evidence of positive effects arising from potential increase in productivity and technology transfers from MERCOSUR creation for Argentina (Calfat et al., 2003), there has been little empirical work on these effects. Among the negative effects, possible reductions in employment and higher wage dispersion are pointed out, though some studies do not seem to corroborate these predictions[3]. On the other hand, some of the new geography models predict catastrophic agglomeration in developed countries and de-industrialization in the less developed ones when developed and developing countries integrate. Nevertheless, these effects depend on the way and intensity of the integration process, as well as the implementation of specific policies aimed to reduce the negative effects[4], such as those that promote technology spillovers would reduce the negative impacts on the less developed countries (Baldwin et al, 2003).

The creation of new FTAs between MERCOSUR and NAFTA and EU can be considered as an increase in trade openness[5]. There are three main conventional arguments to link trade liberalisation and economic performance[6].

One is the well known 'resource reallocation effect', in the presence of perfectly competitive markets, trade liberalisation will change the set of relative prices in line with world prices, and the producers will respond to this new set of prices reallocating resources according to the comparative advantage of the countries. This is the standard gain associated with a move towards free trade.

---

[1] Knowledge diffuses across national boundaries in many ways: imports, FDI, internet, technology licensing, scientific journals and personal contacts, among others.

[2] In La Cumbre in La Plata, Argentina, 2005, the MERCOSUR states not to sign a FTA with the NAFTA for the time being, while in Uruguay there are on going discussions on the benefits of signing an unilateral FTA with the NAFTA.

[3] For a survey see Epifani P. (2003).

[4] Roughly speaking an increase in the mobility in goods and labour would foster agglomeration in the more developed countries while mobility of capital and knowledge will foster dispersion, i.e. convergence among economies. On the other hand, policies aimed to promote the diffusion of technology spillovers and to diminish congestion would be first best (Baldwin et al, 2003).

[5] Though RIAs have some differences with unilateral trade liberalisation since it can also generate trade diversion.

[6] Pack (1988) surveyed the mechanisms through which trade liberalisation may improve performance.

In the presence of imperfectly competitive markets increased openness may bring additional gains. The potential or actual competition of imports will stimulate producers to lower their x-inefficiency, and promote gains in economies of scale. Even more, when competitive discipline is absent producers will enjoy monopoly power, which in turn may allow inefficient firms to survive.

Finally, liberalisation is expected to induce a higher long run rate of growth through greater technical change either through imports, foreign direct investments and learning by exporting. These dynamic effects are associated with a higher growth path and so with cumulative improvements over time. Thus, technology progress would be the source of long run growth, therefore the importance of studying technology transmission due to increased openness.

Though there are some studies on FDI spillovers for the Uruguayan case (Kokko et al., 1994; Kokko et al., 1996; Tansini and Zejan, 1998; Domingo and Bittencourt, 2004), as far as we know there are no case studies on trade related spillovers for Uruguay. The exception is the work by Coe, Helpman and Hoffmaister (1997) and Falvey et al. (2001) which includes Uruguay among the 77 and 52 countries analysed respectively.

The methodology to be used will follow the lines of the works by Schiff et al. (2002) and Schiff and Wang (2003), using the concepts of trade-related spillovers, constructing specific measures of Southern knowledge (knowledge from MERCOSUR's partners, $SRD^{M}$), Northern total knowledge ($NRD^{t}$), and distinguishing between knowledge from NAFTA ($NRD^{N}$), the EU countries ($NRD^{EU}$) and the rest of the world ($RD^{ROW}$). The analysis will be conducted at the two and three digit ISIC level, classifying industries according to its R&D intensity. Measures of TFP estimated at the firm level and aggregated, afterwards, at the 2 or 3 digit level were provided by Casacuberta et al. (2003). Furthermore, the availability of data on domestic R&D for the Uruguay allows analyzing the impact of domestic R&D and R&D from trade with the various countries and blocs. The final aim is to assess some policy implication regarding the possible effects of the creation of new FTAs between MERCOSUR, NAFTA and EU, on TFP of the various manufacturing industries of a small southern country at the sectoral level.

Summing up, the importance of technology development for long run economic growth, the little empirical research conducted on this issue (trade related spillovers) for developing small economies at a more desegregated level, and the need to assess the possible impacts of further integration at the sectoral level, are the central concern of this study.

The remainder of this work structures as follows: section II presents the conceptual framework, section III reviews briefly some previous empirical studies, section IV describes the empirical strategy followed, while section V presents the results and finally the main conclusions.

## II. Conceptual Framework

The empirical studies are rooted on models of endogenous growth in open economies, which recognizes two main mechanisms of knowledge accumulation. The first is that trade may change a country's pattern of specialization. Learning is faster if a country specializes in goods with higher learning potential (Krugman 1987; Lucas 1993; Stokey 1988, 1991; and Young 1991). The second mechanism is 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). Thus, we can identify two groups of models, one in which learning is mainly a domestic affair and other group in which knowledge is imported from abroad[7].

In the first group we can identify the works of Young (1991) and Stokey (1991). In these works productivity growth is attributed to learning process in increasingly sophisticated products and the associated knowledge spillovers is limited to the country in which learning takes place.

In the second group of 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 this group of models we can identify the works of Rivera-Batiz and Romer (1991) which extends on previous works by Ethier (1982) and Dixit and Stiglitz (1977). While Rivera-Batiz and Romer focus on symmetric countries, Grossman and Helpman (1991) extend this framework to the case of asymmetric countries and to the case in which there is more than one final good. An open country can use world R&D experience: if spillovers are global, foreign R&D would have a similar effect on productivity as domestic R&D.

Grossman and Helpman make one prediction analogous to that of Young (1991): industrial economies with relative abundance of human capital will undertake more research and grow faster than developing economies. But by engaging in international trade with industrial countries, developing countries can obtain a greater variety of intermediate inputs, and therefore grow faster. Although growth rates do not converge, openness does raise the growth rates of developing countries.

Thus, according to the endogenous growth literature, the impact of trade on the growth of developing countries depends crucially on the international scope of knowledge diffusion and on the mechanisms through which knowledge is transmitted. One way to test these predictions is to analyze how inflows of knowledge affect productivity in the importing countries, i.e. to analyze the impact of trade related spillovers on TFP.

## III. The empirical evidence

In this section we review briefly some empirical studies and main findings on trade related spillovers.

Coe and Helpman (1995) – CH hereafter - made the first most widely quoted attempt to establish an empirical connection between international R&D spillovers and economic growth. These authors studied the extent to which a country's total factor productivity (TFP) depends upon both domestic and foreign knowledge stock, where cumulative R&D expenditures are used

[7] For a survey see Grossman and Helpman (1995), and Aghion and Howitt (1998).

as a proxy for the knowledge stock of a country. The foreign knowledge stock is constructed using the weighted sum of trade partner's cumulative R&D spending. The weights used are the bilateral import shares, since it is assumed that a country's imports are a mechanism of transfer for knowledge spillovers.
They used three different specifications. The simplest one [8] includes domestic and foreign R&D plus a country specific constant. To capture the role of openness[9] a specification which includes the interaction between the ratio of imports to GDP and foreign R&D was tried. The sample consisted of 21 OECD countries plus Israel during the period 1971-1990. Furthermore, since the impact of domestic R&D may be different for the largest seven economies (G7 countries[10]) they used also a specification which interacts the domestic R&D stock with a dummy variable that takes the value of one for the seven largest economies and zero otherwise.
The main finding is that productivity of a given country depends not only on its domestic R&D but also on R&D produced by its trade partners. Foreign R&D may have a stronger effect on domestic productivity the more open the economy is to international trade. Whereas in large countries (G7 countries) the impact of domestic R&D capital stocks on TFP is larger than the effect of foreign R&D, the opposite holds in small countries. Smaller countries tend to be more open and benefit more from foreign knowledge than larger countries. Therefore, foreign R&D may have a stronger effect on domestic productivity the more open the economy to international trade. These findings allow to conclude that trade is an important mechanism through which knowledge is transferred across OECD countries.

Keller (1998), using Coe and Helpman data develops alternative concepts of foreign R&D:1) estimates of foreign R&D using random trade shares rather than the observed ones; 2) estimates using the simple sum of R&D produced in the rest of the world. Working with the same specifications as Coe and Helpman and with alternative concepts of foreign R&D, he finds that his results were as good as or even better than those of Coe and Helpman. Thus, his results cast doubts on the relevance of trade as a transmission mechanism for foreign knowledge.
Previous results are in a way tied to the degree of aggregation chosen. To circumvent this limitation, Keller (2000) employs industry level data for the G7 countries plus Sweden. The author finds once again, that "random" imports shares perform as well as actual imports ones.
The fact that Keller's results are better than those of Cohen and Helpman leads to the conclusion that a country's specific trade pattern may not be relevant for its access to foreign R&D. Thus, his results confirm the doubts about the relevance of trade as a mechanism for foreign knowledge transfer.

Lumenga-Neso, Olarreaga and Schiff (2001) – LOS hereafter- extend the CH analysis by incorporating the concept of 'indirect' trade-related R&D spillovers, to capture flows of available foreign knowledge. This concept enables to reconcile the results of CH and Keller, and shows that doubts concerning the relevance of trade as a knowledge transmission mechanism vanishes once "indirect" trade-related R&D spillovers are included in the analysis.
The concept of "indirect" trade-related spillovers relies on the idea that the available stock of knowledge of a country is greater than its domestically produced knowledge, and it is this available stock that could be transmitted through trade. The concept can be explained by the

---

[8] $\log F_i = \alpha_i^o + \alpha_i^d \log S_i^d + \alpha_i^f \log S_i^f$ , where $F_i$ total factor productivity of country *i*, $\alpha_i$ country specific variable, $S_i^d$ domestic R&D stock, and $S_i^f$ foreign R&D.

[9] The impact of foreign R&D in an importing country is expected to be higher the more the importing country buys from the foreign country undertaking the R&D.

[10] These are: Canada, France, Germany, Italy, Japan, United Kingdom, and United States.

following example. Suppose a 3 country world (A, B, C), assume that country B imports only from C, and A imports only from B. When B imports from C it will obtain spillovers from C, and the available stock of knowledge to B will be greater than its domestically produced R&D. Then, if A trades with B, A will obtain a level of R&D spillovers from B that is related to the available level of R&D in B and not only to its domestically produced R&D. Thus, A could benefit from R&D spillovers from C even if it does not trade with C. Thus, the available stock of knowledge gives 'total' stock of foreign R&D, which can be decomposed into 'direct' - domestically produced R&D or CH definition - and 'indirect' trade related foreign R&D. Indirect foreign R&D is computed as the difference between total and direct foreign R&D.

In table 1 the various concepts of foreign R&D are presented.

Table 1: Concepts and definition of foreign R&D

| CONCEPT | DENOMINATION | DEFINITION |
|---|---|---|
| **Direct-Trade related Foreign R&D (CH definition))** | $S_{CH}^{f}$ | Weighted average of foreign produced R&D<br>Weights: bilateral import shares. |
| **Keller's definition of Foreign R&D** | $S_{K}^{f}$ | Simple sum of the rest of the world R&D. |
| **Total R&D available in each country**<br><br>**Total Foreign R&D (LOS)** | $S^{t}$<br><br>$S_{T}^{f} = S_{CH}^{f} + S_{I}^{f}$ | Sum of domestically produced R&D and the import weighted sum of foreign R&D available in each trading partner.<br><br>Can be decomposed into "direct" and "indirect" trade related R&D. |

The authors find that for a sample of 22 countries in the period 1970-1990 the average ratio of "indirect" foreign to "direct" R&D is almost three times larger. Also, as expected, "total" foreign R&D flows are significantly more stable across countries than "direct" R&D flows, while Keller' s R&D flows are the most stable.

They use three empirical specifications[11] which are similar to those of CH as well as the same data set, and run regressions with the various definitions of foreign R&D (direct foreign R&D, Keller's definition of foreign R&D, total foreign R&D -the sum of both direct and indirect foreign R&D - and direct and indirect R&D separately in the same equation[12]). The results show that all foreign knowledge stocks enter in all regressions with the expected positive sign and are statistically significant.

Thus the main finding is that the introduction of indirect R&D improves the estimation results and re-establishes the importance of trade as a channel for the transmission of foreign knowledge, and the effect of indirect foreign knowledge is found to be dominant. This leads to the conclusion that there is a weaker dependence of a country's foreign R&D flows on its specific trade pattern, and that trade matters for the international transmission of R&D.

Keller (2002) has investigated whether knowledge spillovers are global or local by examining whether the distance between countries affects the magnitude of productivity gains from each others' R&D spending. Working with data on manufacturing industries in 14 OECD

[11] 1) $\log F_{c,t} = \alpha_c + \beta^d \log S_{c,t}^d + \beta^f \log S_{c,t}^f + \varepsilon_{c,t}$ ; 2) $\log F_{c,t} = \alpha_c + \beta^d \log S_{c,t}^d + \beta^G (G_7) \log S_{c,t}^d + \beta^f \log S_{c,t}^f + \varepsilon_{c,t}$
3) $\log F_{c,t} = \alpha_c + \beta^d \log S_{c,t}^d + \beta^G (G_7) \log S_{c,t}^d + \beta^f \log\left[T_{c,t} S_{c,t}^f\right] + \varepsilon_{c,t}$ ; where $F_{c,t}$ stands for total factor productivity; $\alpha_c$ country specific variable; $G_7$ dummy; for the larger countries**;** $T_{c,t}$ ratio of total imports to GDP for country c in time t; $S_{c,t}^f$ foreign R&D: $S^t = S_{CH}^f$ **,** $S^t = S_K^f$ **,** $S^t = S_{CH}^f + S_I^f$ **.**

[12] This was done to test if the effect of "direct" foreign R&D is significantly different from "indirect" foreign R&D since the latter can depreciate as it goes through the indirect channels.

countries[13] for the years 1970-1995, he examined if the magnitude of the productivity effects from G-5 countries[14] (more advanced countries) depends on the bilateral geographic distance between technology sender and recipient country. Recognising their dominant position, the G-5 countries were treated as the only sources of foreign technology, and the author focuses on the productivity effects of the G-5 countries R&D on the other nine countries. Also, using data on language skills, he analyses the extent to which technology diffusion results from the direct transmission of information between economic agents. Finally, he analyses if the localisation effects –in case of their existence- have become stronger or weaker over time
The main findings are that productivity is positively related to domestic as well as foreign R&D and that the effectiveness of foreign R&D is negatively related to the distance between sender and recipient countries[15]. He finds also that the localisation of technology diffusion has significantly decline over the sample period pointing out, a strong trend towards globalisation of technology. On the other hand, speaking the same language strongly facilitates the diffusion of technology. Though Keller does not analyse the determinants of localisation, one possible explanation for localised technology diffusion could be in part due to localised trade in high technology goods. Nevertheless, the reduction of localisation over time shows that the importance of foreign R&D has further increased relative to domestic in R&D in accounting for productivity differences.

These studies have focused on knowledge diffusion among OEDC countries and use aggregate data to measure the impact of knowledge diffusion through trade flows. 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. Recently, studies based on industry and micro level data for developing countries have started to arise.

Coe, Helpman and Hoffmaister (1997) examine the extent to which developing countries benefit from R&D performed in industrial countries. Working with a sample of 77 developing countries for the period 1971-1990, they find that spillovers from industrial countries in the North to the developing countries in the South are substantial. A developing country has a higher productivity the greater is its foreign R&D capital stock, the more open to trade with industrial countries, and the more educated its labour force.

Falvey, Foster and Greenaway (2002), analyse the links between growth and knowledge spillovers from five donor countries[16] to 52 developing countries for the period 1970-1990. They construct different measures of foreign spillovers taking into account whether knowledge is a public or private good in the donor and recipient countries and include these measures in a dynamic panel model of growth. The results obtained indicate that there do exist significant growth promoting foreign knowledge spillovers from the donors' countries, but results are sensitive to the weighting scheme used in the construction of the foreign knowledge variable. They found that it matters little whether knowledge is treated as a public or private good in the donor, but spillovers, if they exist, act as a public good in the recipient. They also find that the level of trade is important in facilitating knowledge transfer from donors to recipients.

---

[13] Australia, Canada, Denmark, Finland, France, West Germany, Italy, Japan, the Netherlands, Norway, Spain, Sweden, the United Kingdom and the United States.
[14] These countries are: France, Germany, Japan, UK and USA, and they account for the 92.6 % of the total R&D in the sample.
[15] The estimated magnitude of this effect varies across specifications.
[16] The five donors countries are the United States; United Kingdom; Japan; Germany; and France. These countries account for the 90 % of real R&D expenditures of the 15 OECD countries.

The works by CHH (1997) and by Falvey et al. (2002) on North-South trade related technology diffusion have been undertaken at the aggregate level. In this regard, the work by Schiff, Wang, Olarreaga (SWO, 2002) is the first to analyse North-South as well as South-South trade related technology diffusion at the industry level for 25 developing countries for the period 1976-1998. The use of industry level data level data permits to solve out one of the limitations of previous studies: it enables to analyse the impact of sectoral characteristic on international technology diffusion and TFP. The main contributions of their work are the followings: 1) it is the first paper to examine the impact on TFP of North-South and South-South trade-related R&D spillovers at the industry level for developing countries. (2) Previous studies have used R&D stocks from OECD countries to construct trade weighted foreign R&D stocks (called North-foreign R&D stocks by the authors). They construct also an R&D stock which measures the "indirect" technology spillovers arising from trade among developing countries. This is referred as "South-foreign R&D stock". (3) The use of industry level data enables to examine the impact of sectoral characteristics on international technology diffusion and TFP. One of the characteristic analysed is R&D intensity of the various industries. Splitting the sample into high and low R&D intensive industries the authors find that North-South R&D spillovers raise TFP mainly in R&D intensive industries, while South-South spillovers raise TFP mainly in low intensive industries. Thus, R&D intensive industries learn mainly from trading with the North and low R&D intensive industries learn mainly from trading with the South. According to the authors these findings are consistent with a situation of comparative advantage in the North in R&D intensive industries, and with comparative advantage in the different R&D intensity industries in the South varying by country. The authors conclude that South-South RIA's would tend to favour the development of low R&D intensive industries and are likely to retard the economic transformation of member countries to a high R&D economy by reducing technology spillovers from the North.

Schiff and Wang (SW, 2003) examines the impact of NAFTA of trade-related foreign R&D on total factor productivity (TFP) in Mexico for the period 1981-1998, and it is the first attempt to examine the effect of regional integration on technology diffusion and productivity at the industry level. The measures of foreign R&D are constructed based on industry-specific R&D in OECD countries, OECD-Mexico trade patterns, and input-output relations in Mexico. The stock of foreign R&D obtained by the importing country incorporates the production structure of the economy through the input-output relationships. The main findings are that trade with Mexico's NAFTA partners has a large and significant impact on Mexico's TFP while trade with the rest of the OECD does not. The authors conclude that NAFTA creation has led to a permanent increase in TFP in Mexico's manufacturing sector and to some convergence to the economies of US and Canada.

Schiff and Wang (2004) distinguish two components of knowledge accumulation: new knowledge (an increase in quality) and greater access to existing knowledge (an increase in quantity). New knowledge is proxied by the R&D content of trade while an increase in its quantity is proxied by openness. The measure of foreign R&D used in the literature imposes equal contribution to TFP of openness and R&D content of trade. The paper investigates whether openness (quantity) and the R&D content of trade (quality) enter symmetrically in the TFP equation for North-North trade (OECD countries) and North-South trade (between OECD and developing countries). For analysing North-North trade they use the same aggregated data at the country level as Coe and Helpman (1995), while for North-South trade use is made of a data set at the industry level used by Schiff et al (2002). The main findings are that the R&D component has a greater impact than openness on TFP for North-North RIAs, while for North-South RIAs openness has a greater impact than R&D. These results imply that the impact of openness in developing countries is larger than previously obtained in the literature.

Schiff and Wang (2004) in other related work examines the impact on TFP of North-South trade related technology diffusion incorporating the role of education and governance. The sample covers 25 countries, comprising 9 Latin American Countries (LAC countries) and 16 industries over a 23 year period. The main finding is that the direct impact of the North's R&D on TFP is much smaller in LAC countries, but the effect of education and governance is several times larger than in non-LAC countries. Education and governance raise the level of TFP directly and education and governance also raise TFP through their interaction with foreign R&D in R&D intensive industries for LAC countries. These results imply that the potential virtuous growth cycles exist both in the level and in the growth of TFP, and the level of these virtuous growth rises with the degree of openness of the economy. Therefore, taking into account the interaction between trade, education and governance, leads to the conclusion that by reforming the policies simultaneously would have a greater impact on TFP. One possible explanation of the higher elasticity of TFP with respect to education and governance in LAC countries may be that both are smaller in those countries.

Schiff and Wang (2004) examine the impact of trade with Japan, North America and the EU on technology diffusion and TFP in Korea, Mexico and Poland. Using industry-level data they find that technology diffusion and productivity gains tend to be regional: Korea benefits mainly from trade with Japan, while Mexico benefits mainly from trade with the US, and the result are not so clear cut for Poland.

Kraay, Soloaga and Tybout (2001) analyse what mechanisms transmit foreign technologies to LDC 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.

In Table 2 we present a synthesis of the main works reviewed.

Table 2: Empirical works reviewed

| Study | Objective | Methodology | Level of Analysis | Sample | Main Finding | Conclusion |
|---|---|---|---|---|---|---|
| Coe and Helpman, 1995 | Analyze the impact of domestic and foreign stock of R&D on TFP. | TFP explained by domestic and foreign R&D. Foreign stock of knowledge constructed using the weighted sum of trade partners R&D. | Country level analysis. | 21 OECD countries plus Israel, 1971-1990 | Domestic and foreign knowledge have a positive impact on TFP. Stronger effect of foreign R&D in smaller and more open economies. | Trade as a channel of technology transfer. |
| Keller, 1998 | Analyze the impact of domestic and foreign stock of R&D on TFP. | Same specification as CH but different concepts of foreign R&D: a) random trade shares; b) simple sum of R&D produced in the ROW. | Country level analysis. | 21 OECD countries plus Israel, 1971-1990 | Results as good or even better than CH's results. | Doubts on the relevance of trade patterns for accessing foreign R&D. |
| Keller, 2000 | Analyze if previous results were affected by the level of aggregation. | Input output relations. | Industry level data. | G7 countries plus Sweden, 13 manufacturing industries | Random import shares perform as well as actual shares. | Doubts on the relevance of trade for accessing foreign R&D. |
| Lumenga-Neso, Olarreaga, Schiff, 2001 | Analyse the impact of various definitions of foreign R&D on TFP. | Introduction of the concept of trade related spillover: available foreign knowledge by imports. CH's empirical specification. | Country level analysis. | 22 OECD countries plus Israel, 1970-1990 | The introduction of indirect R&D improves the estimation results and re-establishes the importance of trade as a channel of knowledge diffusion. | Trade matters for knowledge transmission. |
| Keller, 2002 | Examines whether distance between countries affects the magnitude of productivity gains from each other's R&D spending. | Effects of R&D of G5 countries on the productivity of the other 9 countries. Intermediate imports. | Industry level analysis. | Data at the industry level for 14 OECD countries, 1970-1995. | TFP positively related to domestic and foreign R&D. Effectiveness of R&D decreases with distance. Decrease importance of localisation over time. | Magnitude of technology diffusion declines with distance. Over time knowledge has become more global. |

| | | | | | | |
|---|---|---|---|---|---|---|
| Falvey, Foster and Greenaway, 2002 | Impact of five donors R&D countries on 52 developing countries | Static and dynamic panel specification relating output growth to various measures of foreign knowledge and other control variables. | Country level analysis. | 52 developing countries. | Results sensitive to the weighting scheme of the foreign knowledge variable. | If knowledge spillovers act as a public good in the recipient country. The level of trade is important in facilitating spillovers. |
| Coe, Helpman and Hoffmaister, 1997 | Analyse whether developing countries benefit from R&D performed in industrial countries. | Equation relating TFP to foreign R&D stock, import share in GDP, and secondary school enrolment rate. | Country level analysis. | 77 developing countries, 1971-1990. | The higher the foreign R&D stock, openness and the more educated the labour force the higher TFP. | R&D spillovers from industrial countries to developing countries are important. |
| Schiff, Wang and Olarreaga, 2002 | Analyse the effect of N-S and S-S trade related technology diffusion on developing countries TFP. | Similar specifications as CH. Estimation of each industry separately and with pooled data. | Industry level analysis. | 25 developing countries, 1976-1998 | N-S R&D spillovers have a greater effect than S-S, and increase TFP in R&D intensive industries; S-S spillovers raise TFP in low intensive industries. | S-S integration may retard economic transformation of intensive R&D sectors in developing countries. |
| Schiff and Wang, 2003 | Examine the impact of NAFTA on trade related foreign R&D on TFP in Mexico. | Similar specification as CH and SWO. | Industry level analysis. | 16 Mexican industries, 1981-1998 | Mexico has benefited from technology transfers from its NAFTA partners and very little from the rest of the OECD countries. | NAFTA has lead to and increase in TFP in Mexico. |
| Schiff and Wang, 2004 | Analyse the effect of openness and the R&D content of trade for N-N and N-S trade. | Estimation of two alternative equations to evaluate the elasticity of NRD with respect to openness and other with respect to the R&D content of trade. | For N-N trade country level analysis, while for N-S trade industry level data. | For N-N trade: 21 OECD countries plus Israel, 1971-1990. For N-S trade: 25 developing countries, 1976-1998 | The R&D component of trade has a greater impact than openness of N-N trade, while for N-S trade the impact of openness has a greater impact than R&D. | The impact of openness on developing countries is greater than previously obtained in the literature. |
| Schiff and Wang, 2004 | Examine the impact of N-S trade related technology diffusion; governance and education. | Econometric specification relating TFP, foreign R&D, education and governance. | Industry level analysis. | Sample of 25 countries (6 of which are LAC countries) and 16 industries for 23 years. | Education and governance affect TFP of LAC countries directly, while foreign R&D only through the | By reforming simultaneously trade, governance and education policies the impact on growth of |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | | interaction with education and governance. | LAC countries would be higher. |
| Schiff and Wang, 2004 | Examine the impact of trade related technology diffusion for Korea, Mexico and Poland | Econometric specification relating TFP to foreign R&D. | Industry level analysis. | 3 importing countries in the South (Korea, Mexico and Poland), 14 OECD countries and 16 industries, for 18, 19 and 22 years. | Technology diffusion and productivity gains tend to be regional. | The dynamic version of “natural trading partners” seems to hold for Korea and Mexico but not for Poland. |
| Kraay, Soloaga and Tybout, 2001 | Impact of FDI, imports and exporting on productivity and product quality. | Structural estimation of production functions and demand systems to measure product quality and productivity at the plant level. | Plant level analysis. | Plants of Colombian, Moroccan and Mexican Chemical industries. Periods vary according to availability of data for the three countries. | Activities are highly persistent and tend to go together. They reflect mainly unobserved plant characteristics. | Focusing on one single conduit of technology transfer could lead to misleading conclusions. |

## IV. Empirical Strategy

The conceptual framework is based on the endogenous growth theory and on the empirical implementations developed by SWO (2002) and SW (2003). The basic idea is that goods embody technological knowledge and therefore countries can acquire foreign knowledge through imports.

The literature on the economics of RIAs deals mostly with static effects, and concludes that these effects are in general ambiguous[17] casting doubts on the benefits of RIAs, particularly for South-South ones, like the MERCOSUR one.

Though there are some simulations using CGE models to evaluate the potential gains from integration for member countries[18], there has been little analysis of the dynamic effects of RIAs based on their impact on technology diffusion from partner and non-partner countries. Following the study carried out by Schiff and Wang (2003) for the NAFTA, and in particular for the Mexican economy we proposed to undertake a similar study for the case of Uruguay, a small developing country that underwent a process of regional integration in the early 90s, joining the Southern Common Market. As we have already stated, nowadays there are on going negotiations aimed to form new FTAs between the MERCOSUR and the EU and NAFTA blocs. Thus it is quite important to analyze not only the effects of MERCOSUR creation on the productivity of the Manufacturing sector, but as well to analyse and foresee the possible impact of the FTAs with northern blocs (EU and NAFTA) at the industry level.

### IV.1. Methodology

Following the works of SWO (2002) and SW (2003) the methodology will be the following:

1. Estimates of TFP, carried out at the plant level for the Uruguayan Manufacturing industries and further aggregated at the 2 and 3-digit ISIC code level for the years 1988-1995.

2. Estimation of the stock of foreign R&D available by industry for the North discriminating for NAFTA countries ( $NRD_i^N$ ) and for European Union countries ( $NRD_i^{EU}$ ), and for the rest of the world (NRD$^{ROW}$)[19]. Additionally, we defined the extra-region stock of knowledge as the sum of the stock of knowledge of the EU, NAFTA and the rest of the world (NRD$^{T}$). These measures are defined as: $NRD_i = \sum_j a_{ij} \overline{RD_j} = \sum_j a_{ij} \left[ \sum_k \left( \frac{M_{jk}}{VA_j} \right) RD_{jk} \right]$ where *k* indexes northern-OECD countries, NAFTA, EU or for the rest of the world (ROW) countries, j indexes industries, *M* denotes imports, *VA* value added, *RD* stands for R&D stock, and $a_{ij}$ is the import input-output coefficient (which measures the share of imports of industry *j* that is sold to industry *i*). As explained in SWO (2002), the first part of this equation says that, in the country of concern, in this case Uruguay, North foreign R&D in industry *i*, $NRD_i$ is the sum, over all industries *j* of $RD_j$, the

[17] For a survey see World Bank (2000) and Schiff and Winters (2003).
[18] Bachrach and Mizrahi, 1992; Brown, Deardorff and Stern, 1991; Roland-Host et al., 1992; Sobarzo, 1992.
[19] The rest of the world for the period analyzed includes Australia, Japan, Finland, Norway and Sweden.

industry $j$ foreign R&D obtained through imports, multiplied by $a_{ij}$, the share of imports of industry $j$ that is sold to industry i. Since data on import input-output flows is not available, they are proxied by domestic input-output flows. The second part of the equations says that $RD_j$ is the sum, over OECD countries $k$, of $M_{jk}/VA_j$, the imports of industry $j$ products from OECD country $k$ per unit of industry $j$ value added in the importing country, multiplied by $RD_j$, the stock of industry-$j$ R&D in OECD country $k$.

3. Estimation of the stock of knowledge of MERCOSUR partners ($SRD_i^M$). For this purpose two avenues can be followed. One is to construct a measure of 'indirect' South-foreign R&D. This concept developed by LOS (2002) and is based on the idea that developing countries obtain knowledge from the North, absorb and adapt it, and incorporate it into their production processes, and that this transformed knowledge diffuses across the South through trade. South-foreign R&D, $SRD_{ci}$, captures this 'indirect' learning effect. This measured is given by:

$SRD_{ci} = \sum_j a_{cij}\left[\sum_n \left(\frac{M_{cjk}}{VA_{cj}}\right) NRD_{jn}\right]$; where $M_{cjk}$ are industry-j imports by developing country $c$ from developing country $n$. This enables to estimate foreign R&D even without data on domestic R&D for developing countries, which usually is not available.

The second way is to use data for Argentina and Brazil, since there are aggregate figures of expenditures in R&D, which are registered by the "*Red Iberoamericana de Indicadores en Ciencia y Tecnología*" (RICYT) from 1990 onwards. The R&D content of each industry is estimated using the percentage of R&D expenditures from the industrial Surveys from Argentina and Brazil respectively. In this work we follow this second avenue.

For Uruguay there are available figures of domestic R&D at the plant level, from the Surveys carried out by the *Instituto Nacional de Estadística* (INE) for 1990 and 1994, which are aggregated at the corresponding 2 or 3-ISIC digit level ($DRD^U$). Also used is made of data from RICYT.

The baseline equation to estimate is:

$$\ln TFP_{it} = \beta_o + \beta_U \ln DRD_{it}^U + \beta_M \ln SRD_{it}^M + \beta_N \ln NRD_{it}^N + \beta_{EU} \ln NRD_{it}^{EU} + \beta_{ROW} \ln NRD_{it}^{ROW} + \sum_t \beta_t D_t + \sum_i \beta_i D_i + \varepsilon_{cit}$$

$D_t$, $D_i$ represent time and industry dummies respectively.

### IV.2. Data Sources

We work with 16 manufacturing industries at a 2 and 3 -digit ISIC code level, revision 2, for the period 1988-1995, distinguishing between high and low intensive industries[20]. TFP index is calculated at the firm level, using Levinshon and Petrin's methodology, and aggregated at the 2 or 3 digit ISIC level. The data sources from the Industrial Censuses and the Annual Surveys carried out by the "Instituto Nacional de Estadísticas del Uruguay" (INE), for the period 1988-1995. The TFP estimates the plant level for the Uruguayan Manufacturing industries and further aggregated at a 2 and 3 ISIC code level for the years 1988-1995 were provided by C. Casacuberta and N. Gandelman, G. Fachola (2003)[21].

The stock of NRD is based on the ANBERD 2000 (OECD) database (DSTI/EAS Division), which covers OECD countries from 1973 to 1998 at either the two, three or four digit International Standard Industrial Classification (ISIC). Data of R&D for Mexico was taken from RICYT (*Red Iberoamericana de Indicadores en Ciencia y Tecnología).* R&D flows are deflated by the corresponding GDP deflators (with 1988 GDP deflator=100). Cumulative R&D stocks are estimated with the perpetual inventory method with a depreciation rate of 10 %.

The stock of knowledge of MERCOSUR partners ( $SRD^M$ ) and Uruguay were estimated using data on R&D from the RICYT which register R&D from 1990 onwards. Since these are aggregated figures of expenditures in R&D, the R&D content of each industry was proxied using the percentage of R&D expenditures from the Industrial Surveys of each country. The years 1989 and 1988 were estimated by extrapolation.

All the measures of R&D stock were deflated by GDP country specific deflators (base year 1988) and converted in dollars using 1988 exchange rate for each country. The construction of deflators was done using data on GDP from IMF, and the exchanges rates are of the same source.

The import input-output matrix was provided by the *Secretaria del MERCOSUR* for the year 1996.

Bilateral openness shares are from the World Bank database "Trade and Production 1976-1998" (Nicita an Olarreaga, 2001).

[20] As in SWO (2002) and SW (2003) R&D intensity is classified according to its share of R&D expenditures in the US. The six R&D intensive industries: 351/2: Chemicals, Drugs and Medicines; 353/4: Petroleum, Refineries and Products; 382: Non Electrical Machinery and Communications; 383: Electrical Machinery and Communication Equipment; 384: Transportation Equipment; 385: Professional Goods. The 10 low R&D intensive industries are: 31: Food, Beverage and Tobacco; 32: Textiles, Apparel and Leather; 33: Wood Products and Furniture; 34: Paper, Paper products and printing; 355/6: Rubber and plastic products; 36: Non-metallic mineral products; 371: Iron and Steel; 372: Non ferrous metals; 381: Metal products; 39: Other manufacturing industries.

[21] The authors aggregated the data weighting the TFP of each plant by its contribution to the Value Added of the Manufacturing industry.

## V. Results

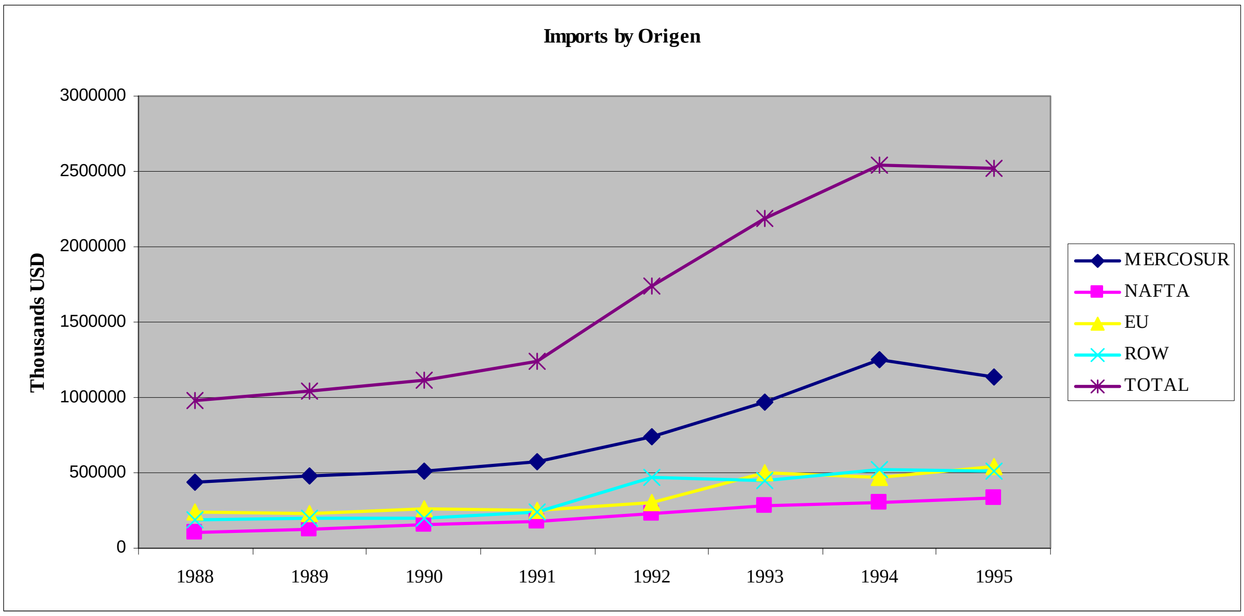
Figures and percentages of imports from the various blocs are provided in Table 3. Table 3 is self-explanatory of the importance of imports from MERCOSUR's partners which are approximately 45 % in the period. Nearly 55 % of Uruguayan imports from MERCOSUR's partners come from Brazil.

Table 3: Uruguayan Total Imports, period 1988-1995

| Year | MERCOSUR (%) | NAFTA (%) | EU (%) | ROW (%) | Total (thousands USD) |
|---|---|---|---|---|---|
| 1988 | 45.31 | 10.95 | 24.44 | 19.30 | 977,022 |
| 1989 | 45.82 | 14.21 | 22.41 | 17.55 | 1,037,060 |
| 1990 | 45.24 | 13.84 | 23.51 | 17.40 | 1,118,702 |
| 1991 | 46.00 | 14.35 | 20.08 | 19.57 | 1,242,180 |
| 1992 | 42.23 | 13.18 | 17.60 | 27.00 | 1,741,700 |
| 1993 | 44.33 | 12.64 | 22.66 | 20.36 | 2,190,246 |
| 1994 | 49.17 | 12.06 | 18.23 | 20.54 | 2,545,482 |
| 1995 | 44.87 | 13.31 | 21.41 | 20.41 | 2,522,049 |

Source: own elaboration based on data from "Trade and Production 1976-1998" (Nicita an Olarreaga, 2001, World Bank).

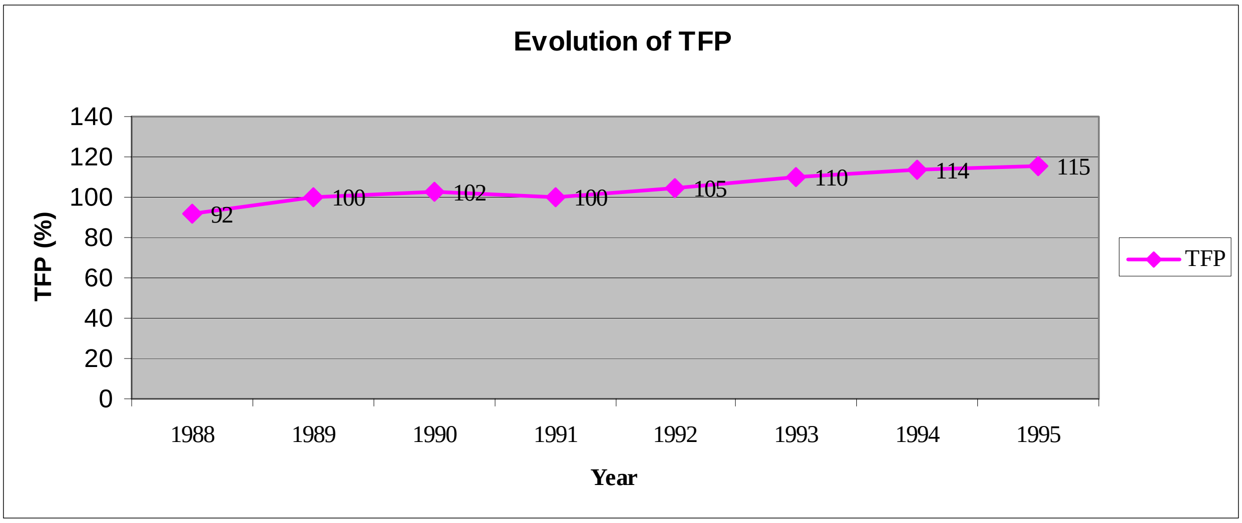
Chart 1: Uruguayan Imports by Origin, 1988-1995




Source: own elaboration based on data from "Trade and Production 1976-1998" (Nicita an Olarreaga, 2001, World Bank).

Regarding to the evolution of Manufacturing total factor productivity, it shows a slight increase in the period as can be observed from the aggregated figures in Chart 2. While in 1988 aggregated Manufacturing TFP was approximately 92 %, the figure increased in the period and rise to 115 % in 1995.

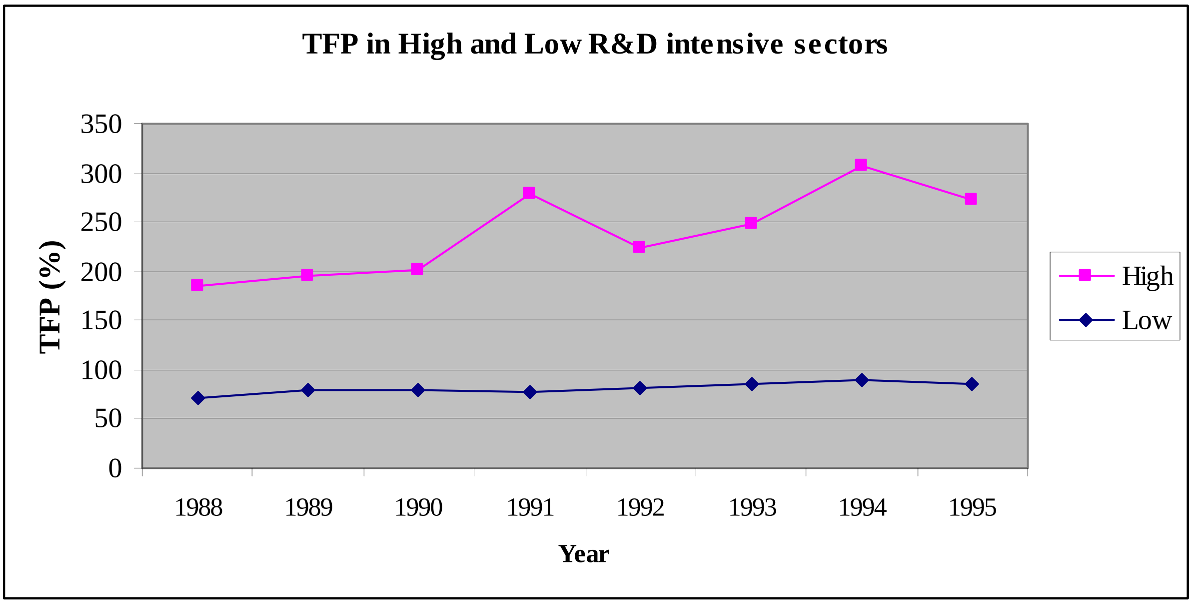
Chart 2: Evolution of Uruguayan Manufacturing Total Factor Productivity, 1988-1995.




Source: own elaboration based on data from Casacuberta, C., Gandelman, N., and Fachola, G. (2004).

In chart 3 we present the evolution of the simple average of TFP discriminating between industries of high and low R&D intensity. The simple average shows a higher TFP for high R&D intensive industries.

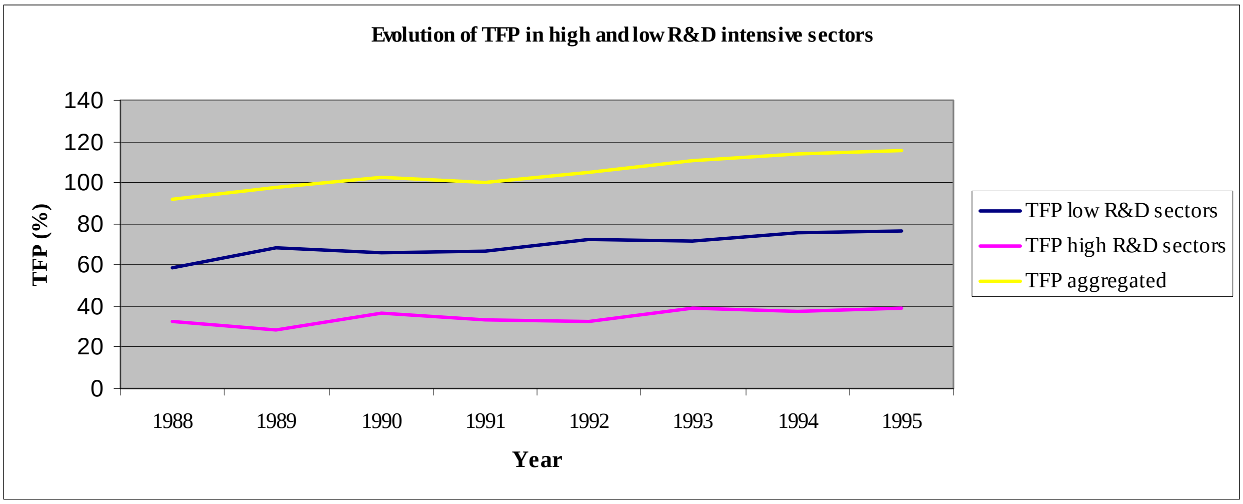
Chart 3: Evolution of TFP in sectors of low and high R&D intensity (simple average)




Source: own elaboration based on data from Casacuberta, C., Gandelman, N., and Fachola, G. (2004).

Nevertheless, when we weighted TFP of high and low R&D intensive sectors by its contribution to Manufacturing VA we observe a high weight of low R&D intensive industries (Chart 4) which reflects the productive specialization of the Manufacturing sector in Uruguay.

Chart 4: Evolution of weighted TFP in sectors of low and high R&D intensity




Source: own elaboration based on data from Casacuberta, C., Gandelman, N., and Fachola, G. (2004).

In Table 4 we present the correlation matrix between the logarithm of TFP and the logarithms of the various measures of domestic and foreign R&D stock estimated.

Table 4: Correlation Matrix

| | LTFP | $LDRD^U$ | $LSRD^M$ | $LNRD^{EU}$ | $LNRD^N$ | $LNRD^{ROW}$ | $LNRD^T$ |
|---|---|---|---|---|---|---|---|
| LTFP | 1.0000 | | | | | | |
| $LDRD^U$ | 0.2406 | 1.0000 | | | | | |
| $LSRD^M$ | 0.1332 | 0.1753 | 1.0000 | | | | |
| $LNRD^{EU}$ | 0.2587 | 0.5184 | 0.7166 | 1.0000 | | | |
| $LNRD^N$ | 0.1685 | 0.4379 | 0.7004 | 0.9155 | 1.0000 | | |
| $LNRD^{ROW}$ | 0.1776 | 0.3712 | 0.7436 | 0.9090 | 0.7437 | 1.0000 | |
| $LNRD^T$ | 0.1909 | 0.4445 | 0.7497 | 0.9507 | 0.9899 | 0.9490 | 1.0000 |

LTFP: logarithm of TFP, $LDRD^U$: logarithm of the stock of domestic R&D , $LSRD^M$: logarithm of Mercosur's stock of R&D, $LNRD^N$: logarithm of NAFTA stock of R&D, $LNRD^{EU}$: logarithm of EU's stock of R&D, $LNRD^{ROW}$: logarithm of ROW's stock of R&D, $LNRD^T$: logarithm of the stock of knowledge from EU, NAFTA and ROW. Number of observations: 128.

The stocks of knowledge from the EU ($LNRD^{EU}$), followed by the domestic stock of knowledge, are the variables that present the highest association with TFP. It can be observed from Table 4 high correlations between the explanatory variables which may generate multi-collinearity problems when including all the different measures of foreign knowledge in the same equation.

The results of the estimation of panel models with fixed effects by industry are presented in Table 5. For all the specifications we performed the Hausman's test which allows comparing between the fixed and random effects models. In all cases the fixed effect model seems to be the more appropriate. Furthermore, we run regressions with industry and time dummies. From the comparison of the F tests we retain those models without time effect, since the Fs indicate that year dummies do not need to be included in the regressions, as was expected since the number of periods is lower than the number of industries.

Domestic stock of knowledge is positive and significant in all the regressions performed, with an elasticity ranging from 0.18 to 0.22. Keller (2001) finds that the elasticities of TFP with respect to domestic R&D ranges from 0.08 to 0.26, while other studies for industrial countries report elasticities ranging from 0.06 to 0.10 (Griliches, 1988), and Schiff et al (2003, 2004) report higher elasticities. On the other hand, our results are consistent with Keller's (2001) finding in the sense that owns R&D is the most important source of increases in productivity[22].

We find positive and significant trade related spillovers from MERCOSUR's stock of knowledge with an elasticity of 0.13, higher than those obtained by SWO (2002) which ranged from 0.068 to 0.084 for the Southern stock of knowledge. The stock of knowledge from the EU and the NAFTA blocs were not significant. Nevertheless, we observed that the correlation between domestic R&D and the stock of foreign knowledge was higher than 0.40[23], which could generate multi-collinearity problems.

Table 5: Determinants of logarithm of TFP, Panel Model with Fixed Effects by Industry

| | (i) | (ii) | (iii) | (iv) | (v) | (vi) | (vii) |
|---|---|---|---|---|---|---|---|
| Cst. | -1.40<br>(-0.84) | 1.37<br>(0.98) | 2.57**<br>(2.52) | 2.73***<br>(3.24) | -2.16<br>(-1.12) | 2.62**<br>(2.36) | -1.17<br>(-0.66) |
| $LDRD^{U}$ | 0.2227***<br>(6.45) | 0.1868***<br>(5.81) | 0.1802***<br>(5.53) | 0.1805***<br>(5.52) | 0.2344***<br>(6.29) | 0.1809***<br>(5.57) | 0.2263***<br>(6.32) |
| $LSRD^{M}$ | 0.1306**<br>(2.70) | | | | 0.1283**<br>(2.52) | | 0.1362**<br>(2.70) |
| $LNRD^{EU}$ | | 0.0787<br>(1.20) | | | 0.1220<br>(1.14) | | |
| $LNRD^{N}$ | | | 0.0196<br>(0.41) | | -0.078<br>(-0.92) | | |
| $LNRD^{ROW}$ | | | | 0.013<br>(0.32) | -0.005<br>(-0.10) | | |
| $LNRD^{T}$ | | | | | | 0.01709<br>(0.34) | -0.0206<br>(-0.40) |
| R. sq. | 0.28 | 0.24 | 0.23 | 0.23 | 0.29 | 0.23 | 0.28 |

Figures in parenthesis are t statistics. Significance levels of 1 %, 5 %, and 10 % are indicated by ***, **, and * respectively. LTFP: logarithm of TFP, $LDRD^{U}$: logarithm of the stock of domestic R&D, $LSRD^{M}$: logarithm of MERCOSUR's stock of R&D, $LNRD^{N}$: logarithm of NAFTA'S stock of R&D, $LNRD^{EU}$: logarithm of EU stock of R&D, $LNRD^{T}$: is the logarithm of EU, NAFTA and ROW stocks of R&D. Number of observations is 128.

A possible explanation to the lack of significance of Northern R&D may be the high distance with developed countries that undertake most of the R&D. In relation to distance Uruguay is far from all the Northern or developed countries (Japan) producing most of the new technology and carrying out most of the R&D expenditures[24]. Furthermore, Keller (2002b), analyses knowledge spillovers from G5 countries to other nine OECD countries in the period 1970-1995 and found that knowledge is geographically localized in the sense that the elasticity of TFP with respect to foreign R&D decreases with distance. He defines the effective R&D as $ERD = RD * e^{-\delta D}$, where $D$ is the bilateral distance between the importing and exporting countries, normalized to one for the shortest distance. He obtains a value of $\delta$=1.005. In other words the impact of foreign R&D stocks on TFP decrease approximately 50 % after 1,200 km. Keller's results are further confirmed by Schiff and Wang (2004) who find that technology diffusion and productivity gains tend to be regional. They find that Korea benefits mostly from Japan, and Mexico from North America, while results for Poland are not so clear cut. Therefore, the dynamic version of the "natural trading partners" seems to hold for Korea and Mexico, and

[22] Keller (2001) find that the contribution of own R&D explains about 50 % of the total effect on productivity, while domestic inter-industry and foreign technology spillovers account for about 30 % and 20 % respectively.
[23] For instance the correlation between domestic R&D (DRD) and trade related R&D from the EU is 0.52, between DRD and the stock of knowledge from the NAFTA bloc is 0.44, while between DRD and the stock of knowledge from MERCOSUR is 0.17.
[24] In this regard it is worth noting that in 1990, 96 % of the world's R&D took place in industrial countries (Keller, 2002a).

this could also be the case for Uruguay with its MERCOSUR’s partners. In Appendix 1 we report bilateral distances between capitals for some countries. Thus the relatively small distance between Uruguay and its MERCOSUR’s partners could explain the positive impact of MERCOSUR’s stock of knowledge on Uruguayan Manufacturing productivity. As pointed out by Keller (2002) and Schiff and Wang (2004) it is possible that trading with the neighbours involves more than just a simple exchange of goods. It is likely to entail more personal interaction, including sub-contracting relationships where firms import intermediate goods from firms in the neighbours and export finished products back to the same firms. In this case knowledge diffusion is associated not only with the knowledge content of the imported goods but also with the close contacts associated with trade.

Other possible explanation for the lack of positive effects of the stock of knowledge from the EU and NAFTA blocs[25] is the high association between domestic R&D and R&D from these blocs, which at its time is related with the presence of MNEs from these blocs in the Uruguayan Manufacturing sector.

Finally, so far we have considered NRD and SRD for high and low R&D intensive industries indistinctly. Nevertheless, it could be the case that Northern R&D benefits mainly those sectors which are R&D intensive and less in low R&D intensive sectors, in which the region and the country enjoy some comparative advantage. To analyse this point we distinguish between high and low R&D intensive industries. To this end we create a dummy variable, named HRD that takes the value of one for high R&D industries and zero otherwise, and we interact the stock of knowledge from the various blocs with this dummy. Thus, we define: $LNRD^{EU}\_h=LNRD^{EU}*hrd$, $LSRD^{M}\_h=LSRD^{M}*hrd$, $LNRD^{N}\_h=LNRD*hrd$, $LNRD^{ROW}\_h=LNRD^{ROW}*hrd$, and $LNRD^{T}\_h=LNRD^{t}*hrd$. We interact also the measures of foreign stock of knowledge with a dummy that takes the value of one for low intensive industries and zero otherwise. Thus, we define: $LNRD^{EU}\_l=LNRD^{EU}*lrd$, $LSRD^{M}\_l=LSRD^{M}*lrd$, $LNRD^{N}\_l=LNRD^{N}*lrd$, $LNRD^{ROW}\_l=LNRD^{ROW}*lrd$ and $LNRD^{T}\_l=LNRD^{T}*lrd$. These interactive terms would allow analysing the impact of foreign R&D on productivity according to the R&D intensity of the sector.

In Table 6 we report the results obtained. Domestic stock of knowledge is always positive and significant with an elasticity ranging from 0.158 to 0.199 according to the specification. Except for the stock of knowledge of the rest of the world, the interactive terms with high R&D intensive industries present a positive and significant effect on TFP of Uruguayan Manufacturing Industries. Thus, foreign R&D from the EU, NAFTA and the MERCOSUR have a positive and significant effect on Uruguayan TFP of high R&D intensive sectors, with a higher elasticity for knowledge from NAFTA, followed by the EU and the MERCOSUR.  On the other hand the interactive term with low R&D intensive sectors is not significant for all the blocs. The interaction of MERCOSUR’s stock of knowledge with high R&D intensive industries is positive and significant, with an elasticity of 0.14, this would be telling us that the hypothesis that South-South trade benefits mainly low R&D intensive industries has no empirical support for trade between MERCOSUR’s partners and Uruguay. In this regard we observe that Manufacturing Uruguayan imports from MERCOSUR’s partners are mainly from high R&D intensive industries as shown in Table 7 and Chart 5 and 6. In appendix 2 we present the share of imports from the various blocs according to its R&D intensity.

The interaction between the knowledge stock from EU and high R&D intensive industries is positive and significant with an elasticity of 0.16, while for the NAFTA bloc the interaction is

[25] Multi-collinearity increases the standard errors and thereby drains the model of statistical power to test parameters.

also positive and significant with an elasticity of 0.20. Thus, the magnitude of the elasticity is slightly lower for imports from MERCOSUR's partners than for the NAFTA and EU blocs. This could imply that an increase of imports from NAFTA and EU would increase even more Uruguayan TFP in high R&D intensive sectors.

Table 6: Determinants of log TFP: Panel Model Fixed Effects by Industry and interactive terms

| | (i) | (ii) | (iii) | (iv) | (v) | (vi) | (vii) | (viii) | (ix) | (x) |
|---|---|---|---|---|---|---|---|---|---|---|
| Cst. | 1.329 (0.77) | 1.20 (1.47) | 3.26** (2.38) | 1.7945** (2.36) | 4.251*** (4.76) | 1.639** (2.61) | 3.245*** (4.44) | 2.4777*** (4.20) | 1.6656** (2.43) | 4.28*** (4.42) |
| $LDRD^U$ | 0.1997*** (5.45) | 0.1945*** (6.14) | 0.1806*** (5.45) | 0.1783*** (5.61) | 0.1820*** (5.73) | 0.158*** (4.89) | 0.1831*** (5.69) | 0.1726*** (5.22) | 0.1624***(5. 02) | 0.1811*** (5.69) |
| $LSRD^M$_l | 0.078 (0.97) | | | | | | | | | |
| $LSRD^M$_h | | 0.1441** (2.48) | | | | | | | | |
| $LNRD^{EU}$_l | | | -0.02326 (-0.23) | | | | | | | |
| $LNRD^{EU}$_h | | | | 0.1631* (1.85) | | | | | | |
| $LNRD^N$ _l | | | | | -0.0981 (-1.64) | | | | | |
| $LNRD^N$ _h | | | | | | 0.2048** (2.78) | | | | |
| $LNRD^{ROW}$_l | | | | | | | -0.0247 (-0.48) | | | |
| $LNRD^{ROW}$_h | | | | | | | | 0.0824 (1.18) | | |
| $LNRD^T$_h | | | | | | | | | 0.1905** (2.43) | |
| $LNRD^T$_l | | | | | | | | | | -0.0981 (-1.51) |
| R sq. | 0.23 | 0.27 | 0.23 | 0.25 | 0.25 | 0.28 | 0.23 | 0.24 | 0.27 | 0.24 |

Figures in parenthesis are t statistics. Significance levels of 1 %, 5 %, and 10 % are indicated by ***, **, and * respectively.

LTFP: logarithm of TFP, $LDRD^U$: logarithm of the stock of domestic R&D, $LSRD^M$: logarithm of Mercosur's stock of R&D, $LNRD^N$: logarithm of NAFTA'S stock of R&D, $LNRD^{EU}$: logarithm of EU's stock of R&D, $LNRD^{ROW}$: logarithm of the stock of R&D of the ROW,. HRD dummy that takes the value of one for high R&D intensive industries, LRD dummy that takes the value of one for low R&D intensive industries, $LSRD^M$_l=$LSRD^M$*lrd, $LSRD^M$_h=$LSRD^M$*hrd, $LNRD^{EU}$_l=$LNRD^{EU}$*lrd, $LNRD^{EU}$_h=$LNRD^{EU}$*hrd, $LNRD^N$ _l=$LNRD^N$*lrd, $LNRD^N$_h=$LNRD^N$*hrd, $LNRD^{ROW}$_l=$LNRD^{ROW}$*lrd, $LNRD^{ROW}$_h=$LNRD^{ROW}$*hrd and $LNRD^T$_l=$LNRD^T$*lrd, (obs=128).

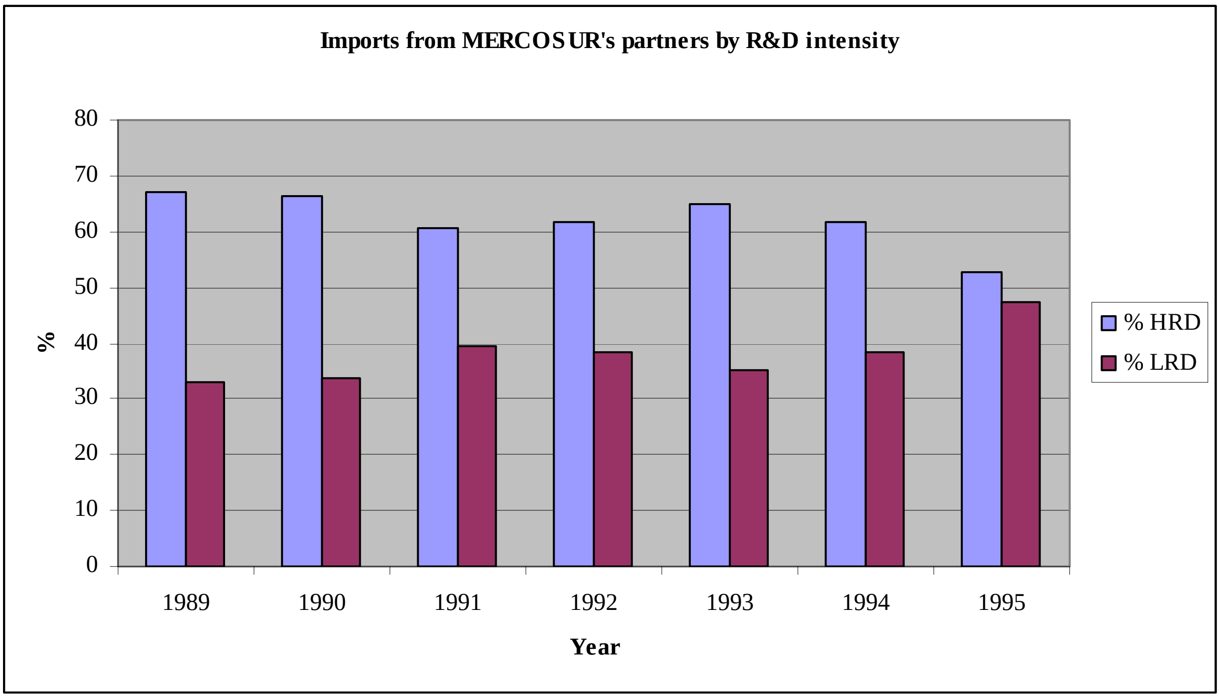
Table 7: Uruguayan imports from MERCOSUR's partners according to the R&D intensity (in thousands of USD and %)

| Year | HRD | LRD | Total | % HRD | % LRD |
|---|---|---|---|---|---|
| **1989** | 297,222.27 | 145,447.88 | 442,670.15 | 67.14 | 32.86 |
| **1990** | 334,970.95 | 171,112.65 | 506,083.60 | 66.19 | 33.81 |
| **1991** | 345,803.46 | 225,591.19 | 571,394.65 | 60.52 | 39.48 |
| **1992** | 452,785.89 | 282,654.75 | 735,440.63 | 61.57 | 38.43 |
| **1993** | 630,823.88 | 340,207.34 | 971,031.22 | 64.96 | 35.04 |
| **1994** | 773,008.94 | 478,607.25 | 1,251,616.18 | 61.76 | 38.24 |
| **1995** | 597,320.45 | 534,223.05 | 1,131,543.50 | 52.79 | 47.21 |

HRD: high R&D intensive industries, LRD: low R&D intensive industries

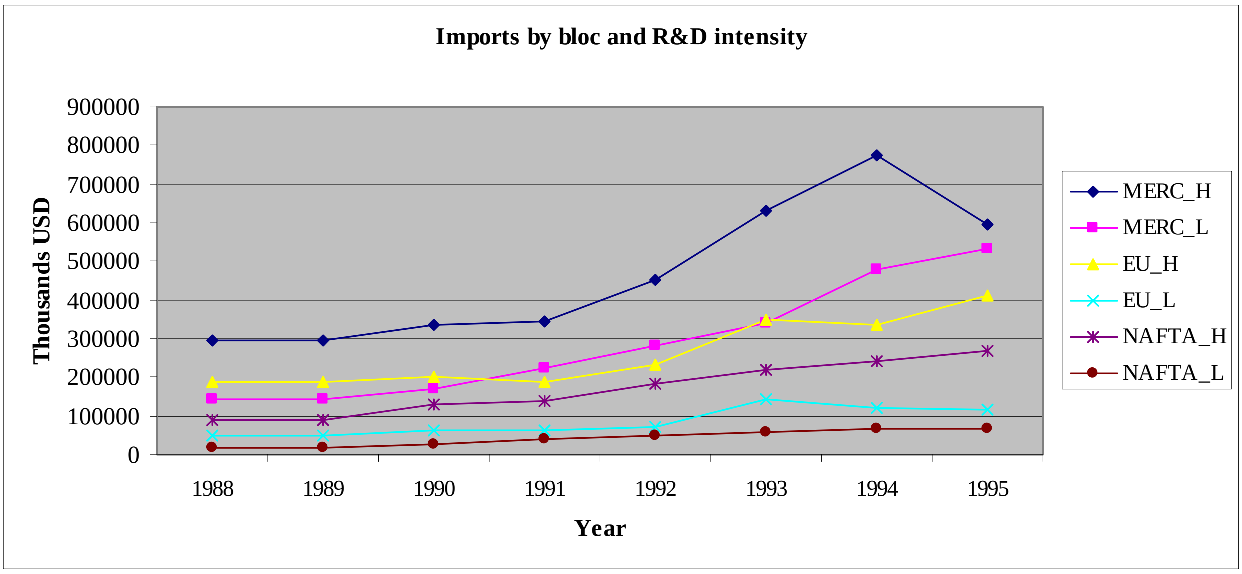
Source: own elaboration based on data from "Trade and Production 1976-1998" (Nicita an Olarreaga, 2001, World Bank).

Chart 5: Uruguayan imports from MERCOSUR's partners according to R&D intensity (in % of total imports from MERCOSUR)




Source: own elaboration based on data from "Trade and Production 1976-1998" (Nicita an Olarreaga, 2001, World Bank).

Chart 6: Uruguayan imports by Bloc and R&D intensity (in thousands of USD)




Source: own elaboration based on data from "Trade and Production 1976-1998" (Nicita an Olarreaga, 2001, World Bank).

Thus the results show that domestic R&D has a positive impact on TFP. On the other hand there is evidence of positive trade related spillovers for foreign R&D from MERCOSUR's partners. Furthermore, the stock knowledge from MERCOSUR, EU and NAFTA blocs has a positive impact on TFP of high R&D intensive industries. Thus, there is evidence of positive trade related technology diffusion from the EU and the NAFTA blocs on those sectors, even in spite of the high distance. The EU and NAFTA have a comparative advantage in R&D intensive industries, so it is likely that Uruguay would absorb more knowledge in the R&D intensive industries from its trade with these blocs. Hence, since the technology gap between Northern blocs and Uruguay is larger for R&D intensive industries by trading with them there would be a greater "catch up" effect on those industries compared to the whole sample. On the other hand, there is no evidence of trade related spillovers from imports of low R&D intensive industries. Thus, manufacturing industry productivity would benefit most from imports from the NAFTA and the EU on high R&D intensive sectors, possibly due to the high technological advancement of these blocs, and that this knowledge it is not completely depreciated along distance. Therefore, if trade with these blocs increase productivity, a policy aimed to increase productivity in high R&D intensive sectors should be one that promotes trade with the NAFTA and the EU blocs.

## VI. Conclusions

The results show that there is evidence of trade related technology diffusion from MERCOSUR's partners confirming the results that technology diffusion and productivity gains tend to be regional, as found by Keller (2202b) and Schiff and Wang (2004) when we analyse jointly high and low R&D intensive sectors.

Nevertheless, when we distinguish between low and high R&D intensity industries by interacting the measures of foreign stock of knowledge with a dummy that takes the value of one for high R&D intensive industries we find positive effects from MERCOSUR, EU and NAFTA on Uruguayan TFP. There is no evidence of trade related spillovers from imports from the ROW. On the other hand the interaction of the foreign stock of knowledge of the various blocs with a dummy that takes the value of one for low R&D intensive industries did not present significant effect on TFP.  Thus is seems that trade related spillovers verifies also for trade with the EU and NAFTA for high R&D intensive sectors, industries in which Uruguay has no comparative advantages and are far from the technology frontier.

It is worth to note that there is also trade related technology diffusion from MERCOSUR s partners in high R&D intensive sectors though the elasticity is lower. This finding is similar to previous works on South-South (Schiff et al., 2002). Moreover, it should be noted that most of Uruguayan imports are from high R&D intensive sectors. Thus, though the impact from NAFTA and the EU is large, there are also positive impacts from imports from MERCOSUR on TFP of high R&D sectors.

Domestic R&D has a positive and significant effect in all the specifications tried. Thus it seems that even in the case of a small developing country investing in domestic R&D seems to be worthwhile.

Summing up, the results suggest that there is evidence of trade related technology diffusion from MERCOSUR's partners. Thus it seems that even in the case of South-South integration as the MERCOSUR one, it could enhance the productivity of a small country. Furthermore, there is a positive impact of imports from the EU and NAFTA blocs on productivity of high R&D intensive sectors. Thus, imports from NAFTA and the EU could increase even more than the ones from MERCOSUR Uruguayan Manufacturing productivity of high R&D intensive industries. Therefore, the empirical results indicate that productivity can be affected by domestic R&D as well as by trade policy, so investing on domestic R&D and decreasing trade barriers are likely to raise domestic producitivity.

## References


Aghion, Philippe, and P. Howitt (1998), *Endogenous Growth Theory*, Cambridge, mass: MIT Press.

Audretsch, D., and M. Feldman (1996): “R&D spillovers and the geography of Innovation and Production”, *American Economic Review*, Vol. 86, pp. 253-273.

Barba Navaretti, Giorgio, and David G. Tarr (2000): “International Knowledge Flows and Economic Performance: A Review of the Evidence”, The *World Bank Economic Review, 14*, 1-16.

Bachrach and Mizrahi, (1992): “The Economic Impact of a Free Trade Agreement Between the United States and Mexico: A CGE Analysis”, Unpublished manuscript, KPMG Peat Marwich.

Baldwin, R.E., Forslid R., Martin, P., Ottaviano G. I. P. and F. Robert-Nicoud (2003): *Economic Geography and Public Policy,* Princeton University Press.

Bittencourt, G., and R. Domingo (2004): “Efectos de “derrame” de las empresas transnacionales en la industria manufacturera uruguaya (1990-2000)”, draft, Facultad de Ciencias Sociales, Universidad de la Republica, Uruguay.

Brown, Deardorff and Stern (1991*):* “A North American Free Trade Agreement: Analytical Issues and a Computational Assestment”, unpublished manuscript, University of Michigan.

Casacuberta, C., G. Fachola and N. Gandelman (2003): “The Impact of Trade Liberalization on Employment, Capital and Productivity Dynamics: Evidence from the Uruguayan Manufacturing Sector”, Departamento de Economia, FCS, Universidad de la Republica, mimeo.

Calfat, G., Flores R. and M. Granato (2003): “Dynamic Effects of Mercosur: An assestment for Argentina”, Journal of Economic Integration 18(3), September 2003, 482-505.

Coe, D. and E. Helpman (1995): “International R&D spillovers”, *European Economic Review* 39 (5), 859-887.

Coe, D., E: Helpman; and A. Hoffmaister (1997): “North-South R&D spillovers”, *Economic Journal 107*, 134-149.

Dixit, Avinash, and Joseph E. Stiglitz (1977); “Monopolistic Competition and Optimum Product Diversity”, *American Economic Review* 67 (3):, 297-308.

Epifani, Paolo (2003): “Trade Liberalisation, Firm Performance and Labour Market Outcomes in the Developing World. What can we learn from Micro-level Data?, Working Paper 3063, World Bank.

Ethier, William (1982): “National and International Returns to Scale in the Modern Theory of International Trade”, American Economic Review 72 (3), 389-405.

Falvey, N., N. Foster and D. Greenaway (2002): “North-South Trade, Knowledge Spillovers and Growth”; Research Paper Series, Globalisation, Productivity and Technology, Research Paper 2002/23, University of Nottingham.

Grossman and Helpman (1991): Innovation and Growth in the Global Economy, Cambridge, Mass, MIT Press.

Kraay A.; I. Soloaga and J. Tybout (2002): “Product Quality; Productive Efficiency and Intenational Technology Diffusion: Evidence from Plant Level Data”; World Bank, Policy Research Working Papers 2759; January 18.

Keller W. (1998): “Are International R&D spillovers trade-related: Analyzing spillovers among randomly matched trade partners”, *European Economic Review 42*, 1469-1481.

Keller W. (2000a): “Do trade patterns and technology flows affect productivity growth?”, *World Band Economic Review 14*, 1-47.

Keller W. (2002): “Geographic Localization of International Technology Diffusion”, *The American Economic Review 92*, 121-142.

Kokko, A., R. Tansini, M. Zejan (1994): "Productivity Spillovers from FDI in the Uruguayan Manufacturing Sector", Working Paper 1/94, Departamento de Economia, FCS, Universidad de la Republica, Uruguay.

Kokko, A., R. Tansini, M. Zejan (1995): "Trade Regimes and Effects of FDI, Working Paper 6/95, Departamento de Economia, FCS, Universidad de la Republica, Uruguay.

Krugman, Paul (1998): "The Narrow Moving Band, the Dutch Disease, and the Consequences of Mrs. Thatcher: Notes on Trade in the Presence of Scale Economies", *Journal of Development Economics 27* (1), 41-55.

Lucas, Robert (1988): "On the Mechanics of Economic Development", *Journal of Monetary Economics 22*, (1), 3-42.

Lucas, Robert (1993): "Making a Miracle", *Econometrica 61* (2), 251-72.

Lumenga-Neso, O., M. Olarreaga, M. Schiff (2001): "On 'Indirect' Trade-Related R&D Spillovers", *World Bank Policy Research Working Paper 2580,* forthcoming in *European Economic Review.*

Nicita, Alessandro and Marcelo Olarreaga (2001): "Trade and Production, 1976-99", World Bank Policy Research Working Paper, 2701, Washington, D.C. (November), www.worldbank.org\research\trade.

Olarreaga, M. and I. Soloaga (1998): "Endogenous Tariff Formation: the case of Mercosur" , The World Bank Economic Review, Vol. 12, No. 2, 297-320.
Pack; H.(1988):"Industrialization and Trade", in H. Chenery and T. Srinivasan, Handbook of Development Economics, Amsterdam, North Holland.

M. Olarreaga, M. Schiff and Y. Wang (2002): "Trade-Related Technology Diffusion and the Dynamics of North-South and South-South Integration", *World Bank Policy Research Working Paper 2861*.

World Bank (2000): *Trade Blocs, A Policy Research Report*, Washington, D.C.

Roland-Host, D., K.A. Reinert, and C.R. Shiells, (1992): "North American Trade Liberalization and the Role of Non-tariff Barriers", Unpublished manuscript, U.S. International Trade Commision.

Rivera-Batiz , Luis, and Paul M. Romer (1991): "Economic Integration and endogenous Growth", *Quarterly Journal of Economics, 106* (2), 531-55.

Schiff M. and Yanling Wang (2003): "Regional Integration and Technology Diffusion: The case of NAFTA" , *World Bank Policy Research Working Paper* 3132, September 2003.

Schiff, M. and Y. Wang (2004): "Education, Governance and Trade-Related Technology Diffusion in Latin America"; Discussion Paper Series 1028, IZA, February 2004.

Schiff, M. and Y. Wang (2004): "On the Quantity and Quality of Knowledge: the Impact of Openness and Foreign Research and Development on North-North and North-South Technology Spillovers"; World Bank; Policy Research Working Papers, 3190, January 15.

Schiff, M. and Y. Wang (2004): "North-South Technology Diffusion, Regional Integration, and the Dynamics of the "Natural Trading Partners" Hypothesis", mimeo.

Sobarzo, H. E. (1992): "A general Equilibrium Analysis of Gains from Trade for the Mexican Economy of a North American Free Trade Agreement", Unpublished manuscript, El Colegio de Mexico.

Stokey, Nancy (1988): "Human Capital, Product Quality, and Growth". *Quarterly Journal of Economics 106* (2), 587-616.

Tansini, R., M. Zejan (1998): "Estimulos de la Inversion Extranjera Directa sobre Empresas Nacionales", Working Papers 15/98, Departamento de Economia, FCS, Universidad de la Republica, Uruguay.

Young, Alwyn (1991): "Learning-by-doing and the Dynamic Effects of International Trade", *Quarterly Journal of Economics* 106 (2), 369-405.

**Appendix 1: Distance between capitals.**

Montevideo, Uruguay-Buenos Aires, Argentina: 209.35 km.
Montevideo, Uruguay-Washington DC, US: 8,464.21 km.
Montevideo, Uruguay-Tokyo, Japan: 18,555.14 km.
Montevideo, Uruguay-Rome, Italy: 11,023.13 km.
Montevideo, Uruguay-Paris, France: 10,952.13 km.
Montevideo, Uruguay-Mexico City, Mexico: 7, 545 km.
Montevideo, Uruguay-Madrid, Spain: 9, 939. 48 km.
Montevideo, Uruguay-London, UK: 11, 037.70 km.
Montevideo, Uruguay-Brussels, Belgium: 11,207.60 km.
Montevideo, Uruguay-Brasilia, Brazil: 2, 276. 60 km.
Montevideo, Uruguay-Amsterdam, The Netherlands: 11, 351 km.

**Appendix 2: Imports by bloc and R&D intensity (in %)**

| | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 |
|---|---|---|---|---|---|---|---|---|
| **MERC_H** | 30.42 | 30.42 | 29.94 | 27.84 | 26.00 | 28.80 | 30.37 | 23.68 |
| **MERC_L** | 14.89 | 14.89 | 15.30 | 18.16 | 16.23 | 15.53 | 18.80 | 21.18 |
| **EU_H** | 19.17 | 19.17 | 17.93 | 15.05 | 13.30 | 16.04 | 13.24 | 16.40 |
| **EU_L** | 4.90 | 4.90 | 5.53 | 4.98 | 4.23 | 6.52 | 4.75 | 4.70 |
| **NAFTA_H** | 8.98 | 8.98 | 11.53 | 11.23 | 10.47 | 10.07 | 9.44 | 10.61 |
| **NAFTA_L** | 1.97 | 1.97 | 2.32 | 3.11 | 2.70 | 2.57 | 2.63 | 2.70 |
| **ROW_H** | 14.55 | 14.55 | 12.55 | 13.50 | 21.23 | 14.15 | 13.94 | 13.34 |
| **ROW_L** | 5.13 | 5.13 | 4.90 | 6.12 | 5.84 | 6.32 | 6.83 | 7.38 |
| **TOTAL** | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |