Regional Integration and Technology Diffusion: The case of Uruguay
Preliminary Draft

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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 firm 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.

In addition the impact of trade related spillovers on TFP will be discriminated in function of different regional integration scenarios of MERCOSUR with the EU and the NAFTA.

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). Our contribution adds to the stock of this literature by using more refined estimates of TFP at the firm level. These estimates are further aggregated at the 2 and 3 ISIC level. A further contribution is the use of data on domestic R&D of Uruguay, allowing a better insight on the complementarities between domestic R&D and trade related R&D from the various trading partners.

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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, 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 to enlarge the MERCOSUR by joining the EU and NAFTA blocs. 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 are prima facie evidence of positive effects arising from potential increase in productivity and technology transfers from MERCOSUR enlargement (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[2]. On the other hand, some of the new geography models predict catastrophic agglomeration and de-industrialization in the less developed countries when developed and developing countries integrate. Nevertheless, these effects depend on the way and intensity of the integration process, as well as specific policies aimed to reduce the negative effects[3], such as those that promotes technology spillovers would reduce the negative impacts on the less developed countries (Baldwin et al, 2003).

The integration between MERCOSUR and NAFTA and EU can be visualised as an increase in trade openness[4]. There are three main conventional arguments to link trade liberalisation and economic performance[5].

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.

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

[1] Knowledge diffuses across national boundaries in many ways: imports, FDI, internet, technology licensing, scientific journals and personal contacts, among others.
[2] For a survey see Epifani P. (2003).
[3] Roughly speaking an increase in the mobility in goods and labor 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).
[4] Though RIAs have some differences with unilateral trade liberalisation since it can also generate trade diversion.
[5] Pack (1988) surveyed the mechanisms by which trade liberalisation may improve performance.

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), 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) which includes Uruguay among the 77 countries analysed.

The methodology to be used will follow the lines of the works of Lumenga-Neso et al (2002), Schiff et al.(2002) and Schiff and Wang (2003), using the concepts of trade-related spillovers and 'indirect' foreign 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. The contribution of this work to the existing literature is the use of TFP estimated at the firm level and aggregated, afterwards, at the 2 or 3 digit level. Furthermore, the availability data on domestic R&D for the Uruguay allows the analyses of the complementarities between 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 effect of an enlarged integration 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 in 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[6].

In the fist 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, 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 of Ethier's (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 a 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 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.

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

They used three different specifications. The simplest one [7] includes domestic and foreign R&D plus a country specific constant. To capture the role of openness[8] 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[9]) 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 produced R&D 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.

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

[8] 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.

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

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 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 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^f_{CH}	Weighted average of foreign produced R&D Weights: bilateral import shares.
Keller's definition of Foreign R&D	S^f_K	Simple sum of the rest of the world R&D.
Total R&D available in each country **Total Foreign R&D (LOS)**	S^t $S^f_T = S^f_{CH} + S^f_I$	Sum of domestically produced R&D and the import weighted sum of foreign R&D available in each trading partner. 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[10] 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[11]). The results show that 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

[10] 1) $\log F_{c,t} = \alpha_c + \beta^d \log S^d_{c,t} + \beta^f \log S^f_{c,t} + \varepsilon_{c,t}$; 2) $\log F_{c,t} = \alpha_c + \beta^d \log S^d_{c,t} + \beta^G (G_7) \log S^d_{c,t} + \beta^f \log S^f_{c,t} + \varepsilon_{c,t}$
3) $\log F_{c,t} = \alpha_c + \beta^d \log S^d_{c,t} + \beta^G (G_7) \log S^d_{c,t} + \beta^f \log\left[T_{c,t} S^f_{c,t}\right] + \varepsilon_{c,t}$; where $F_{c,t}$ stands for total factor productivity; α_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; $S^f_{c,t}$ foreign R&D: $S^t = S^f_{CH}$, $S^t = S^f_K$, $S^t = S^f_{CH} + S^f_I$.

[11] 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.

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 countries[12] for the years 1970-1995, he examined if the magnitude of the productivity effects from G-5 countries[13] (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[14]. 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, based on micro-data analysis, works for developing countries that deal with these issues, 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.

There are few empirical studies of North-South trade related technology diffusion. Furthermore they 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

[12] Australia, Canada, Denmark, Finland, France, West Germany, Italy, Japan, the Netherlands, Norway, Spain, Sweden, the United Kingdom and the United States.

[13] These countries are: France, Germany, Japan, UK and USA, and they account for the 92.6 % of the total R&D in the sample.

[14] The estimated magnitude of this effect varies across specifications.

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. Thus, 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.

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 performs as well as actual shares.	Doubts on the relevance of trade for accessing foreign R&D.
Lumenga-Neso, Olarreaga, Schiff, 2001	Specifications similar to those of CH.	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	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	Magnitude of technology diffusion declines with distance. Over time knowledge has

	from each other's R&D spending.				distance. Decrease importance of localisation over time.	become more global.
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	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	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.

IV. Empirical Strategy

The conceptual framework is based on the endogenous growth theory and on the empirical implementations developed by LOS (2001), 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[15] 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[16], 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 negotiation aimed to enlarge MERCOSUR with the EU and NAFTA. 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 its enlargement with northern blocs (EU and NAFTA), not only at the aggregate level but at the industry level. The idea is to be able to have some insight to questions such as: has Uruguay benefited from MERCOSUR creation?. Have some sector in particular benefited and, if so, which?. Are there positive effects on TFP from trading with NAFTA and the EU?. How is the impact of trading with the different blocs on the various industries?. Once we have specific estimations, various simulations can be tried out.

IV.1. Methodology

Following the works of LOS (2001), SWO (2002) and SW (2003) the methodology will be the following:

1. Estimation of TFP, which is carried out at the plant level for the Uruguayan Manufacturing industries and further aggregate 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 - total R&D from EU and NAFTA - (NRD^t), discriminating for NAFTA countries (NRD_i^N) and US (NRD^{US}), for European Union countries (NRD_i^{EU}), and for the rest of the world (NRD^{ROW}). 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, US or EU 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

[15] For a survey see World Bank (2000) and Schiff and Winters (2003).
[16] Bachrach and Mizrahi, 1992; Brown, Deardorff and Stern, 1991; Roland-Host et al., 1992; Sobarzo, 1992.

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 industry j foreign R&D obtained through imports, multiplied by a_{ij}, the share of import 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.
This specification separates imports of intermediate and capital goods from imports of final consumer goods, i.e. $\sum_j a_{ij<1}$.

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 process, 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 Tecnologia" (RICYT) from 1990 onwards. The R&D content of each industry can be proxied using the percentage of R&D expenditures in Spain[17] –which is supposed to be more similar to developing countries than other OECD countries - for which there is information available.

The idea is to estimate MERCOSUR's knowledge stock by both methods, comparing afterwards the results and the goodness of fit of the regressions tried.

For Uruguay there are available figures of domestic R&D at the plant level, from the Surveys carried out by the INE from 1990 onwards, which will be aggregated at the corresponding 2 or 3-ISIC digit level (DRD^U). The figures for 1988 and 1989 are estimated by extrapolation.

The models to estimate would be:

$$\ln TFP_{it} = \beta_0 + \beta_u \ln DRD_{it}^U + \beta_M \ln SRD_{it}^M + \beta_T \ln NRD^T + \sum_t \beta_t D_t + \sum_i \beta_i D_i + \varepsilon_{cit}$$

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

$\beta_M, \beta_N > 0$; where: D_t, D_i represent time and industry dummies respectively.

17 Also these estimations were carried out using the percentage of expenditure in R&D of US manufacturing industries.

Different specifications will be tried for pooled data and interactive terms according to the R&D intensity of the industries, as well as single regressions by industry. Special attention will be given to multi-collinearity problems as well as the presence of unit roots.

The complementarity between domestic R&D and foreign R&D from the various blocs could be analyzed through the introduction of interactive terms.

IV.2. Data Sources

We work with 16 manufacturing industries at a 2 and 3 -digit ISIC code level for the period 1988-1995. TFP index is calculated at the firm level, using Levinshon and Petrin's methodology, and aggregate 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 Estadisticas del Uruguay" (INE), for the period 1988-1995.

We will distinguish between high and low intensive industries[18] and we propose to construct proxies for the absorptive capacity of each industry taking into account the employment by skill, amounts spent in R&D and payments by licences, patents and royalties which has been registered annually by the "Instituto Nacional de Estadisticas" (INE), Uruguay, from 1988 onwards. In this case we have to deal with the possible collinearity between the dummies by industry and these variables.

The stock of NRD will be 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). R&D flows will be deflated by the corresponding GDP deflators (with 1990 GDP deflator=100). Cumulative R&D stocks will be estimated with the perpetual inventory method with a depreciation rate of 10 %.

The import input-output matrix is not available, so use is made from the input-output matrix from GTAP (1998).

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

[18] As in SWO (2002), R&D intensity is classified according to its share of R&D expenditures in the US as in Schiff and Wang (2003). 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.

V. Expected Results

From the expected results an assessment is made in the first place of the existence of trade related spillovers from MERCOSUR's partners, as well as from the EU and the NAFTA blocs. This could give us some insight of the possible consequences of enlarged integration of MERCOSUR with the EU and NAFTA on Uruguayan TFP on the various manufacturing industries.

V. 1. Some Preliminary Results

Though no final estimation could be perform due to the delay in the delivery on the firm data set from the "Instituto Nacional de Estadistica de Uruguay", a "maquette" estimation at the 2 digit industry level can provide preliminary results.

The TFP estimates the plant level for the Uruguayan Manufacturing industries and further aggregated at a 2 ISIC code level for the years 1988-1995 were provided by G. Fachola, C. Casacuberta and N. Gandelman (2003). The 35 and 38 industries are defined as the R&D intensive industries (even though they include activities with different degree of R&D intensity, globally –at the 2 digit – they can be considered R&D intensive).

We estimate the stock of foreign R&D by industry for the North - total R&D from EU and NAFTA – (NRD^t), discriminating for NAFTA countries (NRD_i^N) and US (NRD^{US}), for European Union countries (NRD_i^{EU}). 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, US or EU countries, j indexes industries, M denotes imports, VA value added for the importing country –in this case Uruguay -, 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*).

The estimation for the EU in this first exercise considers only Italy, Spain, UK and France since they that have the greater share of imports from the EU by Uruguay.
The data of R&D for Mexico was taken from RICYT (*Red Iberoamericana de Indicadores en Ciencia y Tecnologia*), while for OECD countries the data was taken from the ANBERD database (OECD, 2000) and the stock of R&D was estimated by the perpetual inventory method with a rate of depreciation of 10 %.

The stock of knowledge of MERCOSUR partners (SRD_i^M) and Uruguay were estimated using data on R&D from the RICYT which register R&D from 1990 onwards. Since these are aggregate figures of expenditures in R&D, the R&D content of each industry was proxied using the percentage of R&D expenditures in Spain[19] which is supposed to be more similar to developing countries than others more developed OECD countries. The years 1989 and 1988 were estimated by extrapolation.

[19] Also these estimations were carried out using the percentage of expenditure in R&D of US manufacturing industries.

All the measures of R&D stock were deflated by GDP country specific deflators (base year 1990) and converted in dollars using 1990 exchange rate for each country.

Figures and percentages of imports of the various countries and blocs are provided in Table 3. In Table 4 we present the correlation matrix between the logarithm of TFP and the various measures of domestic and foreign R&D stock estimated.

Table 3: Uruguayan Total Imports: 1988-1995

	Mercosur			Nafta			EU	%Blocs	ROW	Total
1988	Arg	Bra	PRY	US	CAN	MEX				
Thousands USD	160213	276296.5	6160.652	87135.35	4139.662	15725.68	144526.6		282824.5	977021.9
% country	16.40	28.28	0.63	8.92	0.42	1.61	14.79			
% Bloc			45.31			10.95	14.79	71.05	28.95	100.00
1989	ARG	BRA		USA	CAN	MEX	EU	%Blocs	ROW	Total
Thousands USD	165481	302039.5	7704.138	122160.8	6494.187	18757.45	128799.1		285624	1037060
% country	15.96	29.12	0.74	11.78	0.63	1.81	12.42			
% Bloc			45.82			14.21	12.42	72.46	27.54	100.00
1990	ARG	BRA	PRY	USA	CAN	MEX	EU	%Blocs	ROW	Total
Thousands USD	199463.5	299252.7	7367.378	130456.8	4594.955	19825.29	154525.3		303215.6	1118702
% country	17.83	26.75	0.66	11.66	0.41	1.77	13.81			
% Bloc			45.24			13.84	13.81	72.90	27.10	76.80
1991	ARG	BRA	PRY	USA	CAN	MEX	EU	%Blocs	ROW	Total
Thousands USD	226283.8	335658.5	9452.376	142634.3	7239.78	28356.2	157907.2		334647.5	1242180
% country	18.22	27.02	0.76	11.48	0.58	2.28	12.71			
% Bloc			46.00			14.35	12.71	73.06	26.94	77.69
1992	ARG	BRA	PRY	USA	CAN	MEX	EU	%Blocs	ROW	Total
Thousands USD	292918.6	433493	9029.061	183250.7	8458.406	37760.74	197627.9		579162.1	1741700
% country	17	25	1	11	0	2	11			
% Bloc			42			13	11	67	33	72
1993	ARG	BRA	PRY	USA	CAN	MEX	EU	% Blocs	ROW	Total
Thousands USD	400942.1	564159.1	5930.038	207900.4	22658.78	46327.26	391820.2		550508.5	2190246
% country	18.31	25.76	0.27	9.49	1.03	2.12	17.89			
% Bloc			44.33			12.64	17.89	74.87	25.13	80.56
1994	ARG	BRA	PRY	USA	CAN	MEX	EU	% Blocs	ROW	Total
Thousands USD	552214.8	691592	7809.379	255714.8	12363.06	39024.4	336936.4		649826.7	2545482
% country	22	27	0	10	0	2	13			
% Bloc			49			12	13	74	26	78
1995	ARG	BRA	PRY	USA	CAN	MEX	EU	% Blocs	ROW	Total
Thousands USD	485953.5	632656	12934	280520.3	13850	41360	389560.5		665214.8	2522049
% country	19.27	25.08	0.51	11.12	0.55	1.64	15.45			
% Bloc			44.87			13.31	15.45	73.62	26.38	76.52

Table 3 is self-explanatory of the importance of imports from MERCOSUR's partners which are approximately 45 % in the period. Also it should be noted that the figures for the EU are underestimated since they only include Italy, Spain, UK and France.

Table 4: Correlation Matrix

	ltfp	lrdd	ltfrd	lrdmerc	lrdnafta	lrdeu
Ltfp	1					
lrdd	0.3524	1				
Ltfrd	0.0834	0.2677	1			
Lrdmerc	0.0834	0.2677	0.2677	1		
Lrdnafta	-0.0417	0.5734	0.5734	0.8210	1	
Lrdeu	-0.1638	0.4130	0.8714	0.8714	0.9546	1

ltfp: logarithm of TFP, lrdd: logarithm of the stock of domestic R&D, ltfrd: logarithm of total foreign stock of R&D, lrdmerc: logarithm of Mercosur's stock of R&D, lrdnafta: logarithm of NAFTA'S stock of R&D, lrdeu: logarithm of EU's stock of R&D. (obs=72)

Domestic stock of R&D is the variable that presents the highest association with TFP and a high correlation with the stock of R&D from NAFTA. Also there are high correlations between the knowledge stock from NAFTA and MERCOSUR, as well as EU and MERCOSUR and NAFTA and EU which prevent us from including the different measures in the same equation.

We estimate simple models with pooled data and a surprising result comes out: domestic stock of R&D has significant and positive effect in all the regressions performed, while foreign R&D behave in a less consistent manner showing different levels of significance and signs in the case of knowledge stock from NAFTA and from the EU[20]. The results are presented in Table 5. Contrary to expectations foreign R&D is not affecting positively domestic productivity of a small country, which was the common finding in the empirical literature.

[20] We should keep in mind the possibility of multi-collinearity problems since the correlation between the logarithm of domestic R&D and NAFTA R&D is 0.57, and the correlation of domestic R&D and EU R&D is 0.41. Thus, test of collinearity should also be performed.

Table 5: Determinants of log TFP
(Pooled Regression Results)

Variable	(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)
Cons	3.80 (13.02)***	3.80 (13.02)***	4.20 (17.44)**	4.20 (18.54)**	3.18 (9.13)***	3.23 (9.03)***	2.58 (5.49)***	2.70*** (3.53)
Log DRD	0.0458 (2.98)***	0.0458 (2.98)***	0.0722 (4.98)***	0.0652 (4.86)***	0.125 (5.54)***	0.12 (5.20)***	0.12 (5.40)***	0.11*** (3.81)
LogTFRD	-0.0012 (-0.15)							
LRDMERC		-0.0012 (-0.15)					0.008 (0.90)	0.03 (0.96)
LRDMERC_DR							-0.012 (-3.54)***	
LRDNAFTA			-0.0398 (-3.99)***		-0.0224 (-2.43)**			-0.02 (-0.68)
LRDNAFTA_DR					-0.014 (-3.07)***			
LRDEU				-0.0381 (-4.55)***		-0.022 (-2.63)**		-0.02 (-0.84)
LRDEU_DR						-0.014 (-2.88)***		
Adj. R2	0.12	0.12	0.21	0.24	0.29	0.31	0.24	0.26
No. Obs.	72	72	72	72	72	72	72	72

Estimations were conducted using the White Covariance matrix to obtain robust estimates. Figures in parenthesis are t statistics. Significance levels of 1 %, 5 %, and 10 % are indicated by ***, **, and * respectively.
ltfp: logarithm of TFP, lrdd: logarithm of the stock of domestic R&D, ltfrd: logarithm of total foreign stock of R&D, lrdmerc: logarithm of Mercosur's stock of R&D, lrdnafta: logarithm of NAFTA'S stock of R&D, lrdeu: logarithm of EU's stock of R&D, dr is equal to one for high intensive industries and zero otherwise.
(obs=72)

We should note that we did not perform till the moment the unit roots tests, nevertheless since the time series is not too long and the number of observations is greater than T this should not pose major difficulties. In addition the low number of observations may be biasing the results. To avoid the reduction in the degrees of freedom no dummy variables for industries and years were introduced. Results may also be due to the restrictive assumptions in estimating the model[21]. A more flexible estimation method would be the Feasible Generalized Least Squares estimation technique, but since the number of years is lower than the number of individuals (industries) it can not be applied[22] in this preliminary work.

When trying panel models with fixed effects by industry the results are slightly different as shown in Table 6. While domestic R&D is positive and significant foreign stock of R&D of the different blocs are not significant different from zero and present a positive sign.

Three important remarks emerge from these very preliminary results: in the first place the need of searching a more adequate econometric specification. Secondly, and on a more specific basis, we have not estimated yet 'indirect' R&D which probably throws out different results since it takes into account not only knowledge produced domestically but also the available stock of

[21] The restrictive assumptions are: 1) the variance of the disturbance term should be constant and thus not be different across cross-sections -i.e. cross-sectional heterocedasticity not allowed -; 2) the disturbance term may not be correlated across the cross-sections - no cross-sectional or contemporaneous correlation -; 3) No autocorrelation of the disturbance terms.

[22] If T<N the residual covariance matrix is an N*N matrix with rank T and is thus singular so that it can not be inverted.

knowledge that can be transmitted through imports (LOS, 2001). Thirdly, no attempt has been made to disentangle the role that FDI could have played in influencing R&D based on country of origin. Furthermore accurate future estimations and testing would allow more precise results. Nevertheless, it is worth to note that domestic R&D has a positive effect on TFP using both methods and in all the specifications. Thus it seems that even in the case of a small developing country investing in domestic R&D seems to be worthwhile.

Table 6: Determinants of log TFP
Panel Model Fixed Effects

Variable	(i)	(ii)	(iii)	(iv)	(v)
Const	0.65 (0.35)	0.65 (0.33)	2.93*** (6.39)	1.72 (1.46)	2.11
LRDD	0.12*** (4.53)	0.12*** (4.53)	0.075*** (2.54)	0.10*** (4.35)	0.11*** (3.11)
LTFRD	0.67 (1.27)				
LRDMERC		0.07 (1.27)			0.04 (0.64)
LRDNAFTA			0.021 (0.69)		-0.05 (-0.09)
LRDEU				0.07 (1.09)	-0.12 (-0.41)

Figures in parenthesis are t statistics. Significance levels of 1 %, 5 %, and 10 % are indicated by ***, **, and * respectively.
ltfp: logarithm of TFP, lrdd: logarithm of the stock of domestic R&D, ltfrd: logarithm of total foreign stock of R&D, lrdmerc: logarithm of Mercosur's stock of R&D, lrdnafta: logarithm of NAFTA'S stock of R&D, lrdeu: logarithm of EU's stock of R&D, Number of observations is 72.

VI. Extensions

One possible extension of this work is to estimate the impact of foreign R&D directly on the production function estimation.

Also it would be possible to take advantage of firm level dataset to analyse the impact of firms that import and those that do not import, of firms that import and export and by origin of capital (foreign vs. domestic firms).

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