Cuadernos de Economía, Año 40, Nº 121, pp. 469-476 (diciembre 2003)

AND PRODUCTIVITY IN MEXICO

MAURICE SCHIFF AND YANLING WANG*

1. INTRODUCTION

The literature on regional integration agreements (RIAs) is vast.[1] It deals mostly with static effects, and concludes that these effects are ambiguous in general. This has led a large number of economists to be skeptical about the benefits of RIAs, particularly for South-South ones. Bhagwati and Panagariya (1996), World Bank (2000) and Schiff and Winters (2003) show that, under homogeneous goods, a South-South RIA is likely to lower bloc welfare. The latter two studies also show that the less developed member country is likely to lose relative to the more developed one.

In the case of North-South RIAs, the Southern member is likely to lose in the case of homogeneous goods because it typically has higher trade barriers than the Northern member, so that it provides larger transfers to the North than it obtains through its improved access to it.[2] For instance, Panagariya (1999) finds that NAFTA resulted in a static loss for Mexico in 1996 of US$ 3.26 billion, or 0.98% of GDP.

CGE models using the Armington assumption of products differentiated by country of origin typically generate gains for Mexico from NAFTA. These gains are small under the assumptions of constant returns to scale and perfect competition (Bachrach and Mizrahi, 1992) and are larger under increasing returns to scale and imperfect competition (e.g., Brown, Deardorff and Stern, 1991; Roland-Holst *et al*., 1992; Sobarzo, 1992). Brown *et al*. (1991) obtain a gain of US$ 1.98 billion, or 0.63% of GDP, due to the removal of tariffs and NTBs under NAFTA.

There has been little analysis of the dynamic effects of RIAs and none of NAFTA. Some studies have used CGE models to examine the potential impact of NAFTA on industry location and productivity (Hunter *et al*., 1992; Krugman and Hanson, 1993). Hunter *et al*. conclude that NAFTA would result in relocation of production of the auto industry to Mexico, with fewer but larger firms in Mexico producing more output with a lower price-cost margin.

* The World Bank. E-mail: Mschiff@worldbank.org. The opinions expressed in this paper are those of the authors and do not necessarily reflect those of the World Bank, its Board of Directors or the governments they represent.

1 A recent overview of that literature is World Bank (2000) and Schiff and Winters (2003).

2 A sufficient (though not necessary) condition for this result is an internal solution where the Southern member continues to import from excluded countries after formation of the RIA.

So far, there has been no empirical analysis of the dynamic effects of RIAs based on their impact on technology diffusion. This paper is a first attempt in this direction. It examines the impact of NAFTA on TFP in Mexico through its impact on trade-related technology diffusion from OECD countries. The paper is part of a World Bank Project on Trade and Technology Diffusion.

The paper is organized as follows. Section 2 provides a brief analytical framework. Section 3 describes the empirical implementation. Section 4 presents the empirical results, Section 5 simulates the impact of NAFTA and Section 6 concludes.

2. Analytical Framework

The theoretical basis for the approach used here is endogenous growth theory (Romer 1986, 1990; Lucas 1988). Grossman and Helpman (1991) extend the analysis to an open economy setting. The basic idea is that goods embody technological know-how and therefore countries can acquire foreign knowledge through imports. Coe and Helpman (1995) provide an empirical implementation of the open economy endogenous growth model. They construct an index of the foreign R&D to which a country has access as the trade-weighted sum of that country's trading partners' stocks of R&D. They find for a sample of developed countries that both domestic and foreign R&D have a significant impact on TFP, and that TFP increases with the general degree of openness of the economy and with openness towards the larger R&D producing countries.[3]

The same issue was examined by Coe, Helpman and Hoffmaister (1997) for developing countries. They find that developing countries benefit more from foreign R&D spillovers, the more open they are and the more skilled is their labor force. This paper builds on Schiff, Wang and Olarreaga (2002). That paper expanded on Coe and Helpman (1995) and Coe *et al*. (1997) by examining these issues at the industry level in developing countries.[4] The idea is that importing countries learn from the knowledge embedded in the *inputs* that they import, as is shown in Section 3 below.

3. Empirical Implementation

Coe and Helpman (1995) estimate the following equation:

$$\text{(1)} \qquad \ln TFP_{ct} = \alpha_{ct} + \beta_d \ln RD^{d}_{ct} + \beta_f \ln RD^{f}_{ct} + \varepsilon_{ct}; \beta_d, \beta_f > 0,$$

3 Keller (1998) argues that Coe and Helpman's finding on trade as a channel for R&D spillovers is not entirely conclusive. Lumenga-Neso *et al.* (2001) show that Coe and Helpman's results do seem to hold once "indirect" trade-related R&D spillovers are taken into account.

4 Keller (2002a) did examine trade-related R&D spillovers at the industry level for the G-7 countries and Sweden.

where RD^{d}_{ct} (RD^{f}_{ct}) is the domestic (foreign) R&D stock, ε is an error term, and c (t) denotes country (year). Due to lack of data for Mexico (and for developing countries in general)– and as in Coe *et al.* (1997) and Schiff *et al.* (2002) –the estimation in this paper does not include domestic R&D. This is unlikely to be a problem because most of the world's R&D is performed in developed countries.[5]

We estimate TFP equations with pooled data for a panel of industries. We define the stock of foreign R&D available in industry i, NRD_i, as:

$$NRD_i \equiv \sum_j a_{ij}\overline{RD}_j = \sum_j a_{ij}\left[\sum_k \left(\frac{M_{jk}}{VA_j}\right) RD_{jk}\right] \qquad (2)$$

where k indexes OECD countries, j indexes industries, M (VA) (RD) denotes imports (value added) (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 first part of equation (2) says that foreign R&D in industry i, NRD_i, is the sum, over all industries j, of $\overline{RD}_j$, the industry-j R&D obtained through imports from OECD countries, multiplied by a_j, the share of imports of industry j that is sold to industry i. The second part of equation (2) says that $\overline{RD}_j$ 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 (i.e., the bilateral openness share), multiplied by RD_{jk}, the stock of industry-j R&D in OECD country k.

In fact, we split NRD (foreign R&D) into two parts, the NRD obtained through imports from the US and Canada (NRD^N), and NRD obtained through imports from the other 13 OECD countries in our sample (NRD^{OT}).

The estimated equation is:

$$\ln TFP_{it} = \beta_0 + \beta_N \ln NRD^{N}_{it} + \beta_{OT} \ln NRD^{OT}_{it} + \sum_t \beta_t D_t + \sum_i \beta_i D_i + \varepsilon_{cit}; \beta_N, \beta_{OT} > 0, \qquad (3)$$

where D_t (D_i) represents time (industry) dummies.

Our sample consists of 6 R&D-intensive and 10 low R&D-intensive manufacturing industries over the period 1981-98. Details on data sources and construction for R&D stocks, input-output matrices, the sixteen industries, their R&D intensity, and the bilateral openness shares, are available from the authors.

5 In 1990 (1995), 96% (94.5%) of the world's R&D expenditures took place in industrial countries. Moreover, recent empirical work has shown that much of the technical change in OECD countries is based on the international diffusion of technology among OECD countries (Eaton and Kortum, 1999; Keller 2002a). For instance, Eaton and Kortum (1999) estimate that 87% of French growth is based on foreign R&D. Since developing countries invest much fewer resources in R&D than OECD countries, foreign R&D must be even more important for developing countries as a source of growth.

4. Estimation Results

Before turning to the results, we need to consider the issue that two or more variables may be trended and contain unit roots, making the regression results spurious (unless the variables are co-integrated). We reject the hypothesis that there is a panel unit root for all three variables: TFP, NRD^N and NRD^{OT}. The results are available from the authors.

Column (i) of Table 1 shows the estimation results of equation (3). Coefficients of time and industry dummies are not shown. The elasticity of TFP with respect to NRD^N is equal to .361 and is significant at the 1% level (t = 3.01). The elasticity of TFP with respect to NRD^{OT} is equal to .041 and is not significantly different from zero (t = .21).

TABLE 1
REGRESSION RESULTS
(Dependent variable: lnTFP)

Variable	(i)	(ii)	(iii)	(iv)
$\ln(NRD^N)$	0.361	0.37		0.403
	(3.01)***	(3.27)*		(2.52)**
$\ln(NRD^{OT})$	0.041		0.233	0.062
	(0.21)		(1.26)	(0.27)
$\ln(NRD^N)$*DR				-0.070
				(-0.37)
$\ln(NRD^{OT})$*DR				0.058
				(0.27)
Adjust R^2	0.80	0.80	0.79	0.80
Nº of observations	282	282	282	282

Note: Figures in parenthesis are t-statistics. The *** (**) (*) means that the coefficient is significant at the 1% (5%) (10%) significance level. NRDN is the trade-related R&D from NAFTA countries (USA and Canada), and NRDOT is the trade-related R&D from other OECD countries. DR = 1 for high R&D-intensity industries, and DR = 0 for low R&D- intensity industries.

Thus, Mexico obtains large and statistically significant productivity gains from its trade with its NAFTA partners, and obtains very small and statistically non-significant productivity gains from its trade with the other OECD countries. Why such a difference? One possibility is that trade between Mexico and its Northern neighbors involves more than just an exchange of goods. It may entail personal interaction, including sub-contracting relationships where Mexican firms import intermediate goods from US firms and export finished products back to the same firms. In that case, learning is associated not only with the knowledge-content of the imported goods but also with the close contacts associated with trade. This is more likely to hold inside NAFTA than with the more distant countries of Europe, Japan and Australia.

The two measures of foreign R&D, NRD^N and NRD^{OT}, happen to be highly correlated. This might affect the regression results. We therefore also examined the effect of each measure of foreign R&D separately. This is shown in columns (ii) and (iii) of Table 2. The results for NRD^{N} are very similar to those when both measures are used. This is not surprising, given that NRD^{OT} was highly non-significant in the first regression. The elasticity of TFP with respect to NRD^{OT} is larger, though still not significant. The larger coefficient is probably due to the fact that NRD^{OT} is capturing some of the effect of NRD^{N}.

We also examined whether the elasticities differed in the post-NAFTA period (post-1994) and found no significant difference. Moreover, we ran regressions with interaction effects of the foreign R&D variables and a dummy variable (DR) for the R&D-intensive industries, in order to examine whether the elasticities are different in those industries. As shown in column (iv) of Table 2, the interaction effects are not significantly different from zero. Thus, the elasticity of TFP with respect to foreign R&D appears invariant with respect to the industry's R&D intensity.

TABLE 2
REGRESSION RESULTS
(Dependent variable: lnTFP)

Year	All R&D Intensity Industries			
	Import			NAFTA/Total (%)
	NAFTA	Other OECD[1]	Total	
1993	46.7	10	56.7	82
1994	47.9	11.2	59.1	81
1995	49	9.3	58.3	84
1996	63.8	10.5	74.3	86
1997	79	13.6	92.6	85
1998	89.5	14.9	104.4	86

[1] Other OECD does not include the USA and Canada.

5. Simulation

We must first assess the extent of trade creation and trade diversion associated with NAFTA. Mexico's total imports for the 16 industries are shown in Table 2. Comparing 1994 and 1995, we see that imports remained approximately unchanged, falling by \$.85 billion. Imports from NAFTA countries increased by \$1.1 billion and those from other OECD countries fell by \$1.95 billion. Under trade diversion, total imports remain unchanged. Assume that total imports remain at \$59.1 billion in 1995 and that the change in imports due to trade diversion is equal to the average of \$1.1 billion and \$1.95 billion, or a \$1.5 billion increase in imports from NAFTA neighbors and the same decrease from the other OECD countries. In that case, imports from NAFTA neighbors in 1995 would have been $49.4 billion and those from the rest of the OECD $9.7 billion.

How about trade creation? We assume that the increase in imports from the rest of the OECD to $10.5 billion in 1996 is due to factors unrelated to NAFTA, including unrelated changes in the world and Mexican economies. In percent, that change is equal to (10.5 -9.7)/9.7 = 8.25%. Second, we assume that the non-NAFTA forces that led to the increase in imports from the rest of the OECD had the same proportional impact on Mexico's imports from NAFTA countries. Imports from NAFTA are $63.8 billion in 1996. If we correct these for the 8.25% increase, we obtain that imports from NAFTA countries would have been $58.9 billion in 1998 in the absence of unrelated shocks in the Mexican or world economies. Finally, we attribute the remaining increase to trade creation. Thus, trade creation is estimated to have led to an increase in imports from NAFTA countries from $49.4 billion to $58.9 billion, or of 19.3%.

Note that if we do the same calculations but use 1997 as a base year, we obtain an estimate of trade creation of 14.1%, and if we use 1998 as a base year, we obtain an estimate of 17.9%. In what follows, we use the range of estimates for trade creation (14.1% to 19.3%) to calculate the impact of NAFTA on Mexico's TFP.

We calculate the effect on TFP based on the estimation in column (i) of Table 1. With an elasticity of .361, and assuming that trade creation has the same proportional effect on imports for all industries, a 14.1% increase in imports from NAFTA countries results in a 14.1% increase in NRD^N and in a 5.1% increase in TFP. And a 19.3% increase in imports results in a 7.0% increase in TFP. Thus, we conclude that trade creation resulted in an increase in the level of productivity of the manufacturing sector of between 5.1% and 7%.

As for trade diversion, the $1.5 billion increase in imports from NAFTA countries is about a 3% increase in imports and in NRD^N, which –with the elasticity of .361– raises TFP by 1.1%. The reduction in imports from the rest of the OECD of $1.5 billion amounts to a 15.4% reduction in imports and in NRD^{OT} and –with the elasticity of .041– in a reduction of .63% in TFP. Thus, the net impact of trade diversion on TFP is (1.1% - .63%) = .47%.

The total effect of NAFTA on TFP in Mexico's manufacturing sector ranges from about 5.6% (5.1% from trade creation plus .47% from trade diversion) to 7.5% (7% from trade creation plus .47% from trade diversion). The share of manufacturing in Mexico's GDP averaged 21.5% in 1996-98. Consequently, NAFTA's impact on manufacturing TFP amounted to an increase in GDP ranging from 1.2% to 1.6%. Panagariya (1999) obtained a loss from NAFTA of close to 1% of GDP while Brown *et al.* (1991) obtained a gain of 0.63% of GDP. Thus, our results based on the impact of NAFTA on technology diffusion seem to dominate the static losses or gains from NAFTA based on the standard approaches found in the literature. And, due to a lack of data, we have abstracted from the service sector where benefits from technology flows are likely to be important.

Mexico's economy is about one twentieth of that of the rest of NAFTA (US + Canada). It thus seems reasonable to assume that NAFTA has only had a minor impact on the economies of the US + Canada. Thus, NAFTA has resulted in some convergence of Mexico's economy to those of the US and Canada.

6. Conclusion

This paper examines the separate effects on Mexico's TFP of foreign R&D from the US and Canada, on the one hand, and from the rest of the OECD, on the other. We find that the impact of foreign R&D on the TFP of Mexico's manufacturing sector is large for imports from Mexico's NAFTA partners but not for imports from the rest of the OECD.

Based on the estimated TFP equation, we show that NAFTA has led to an increase in TFP in Mexico's manufacturing sector of 5.5% to 7.5%. Given the plausible assumption that it has had negligible effects on the joint economies of the US and Canada, NAFTA has resulted in some convergence of Mexico's economy to those of the US and Canada.

REFERENCES

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

Bhagwati, J., and A. Panagariya (1996), "Preferential Trading Areas and Multilateralism-Stangers, Friends, or Foes?" In J. Bhagwati and A. Panagariya, eds., *The Economics of Preferential Trade Agreements*. Washington, D.C: American Enterprise Institute Press.

Brown, D. K., A. V. Deardorff and R. H. Stern (1991), "A North American Free Trade Agreement: Analytical Issues and a Computational Assessment," Unpublished manuscript, University of Michigan.

Coe, D. T., and E. Helpman (1995), "International R&D Spillovers." *European Economic Review* 39 (5): 859-887.

Coe, D. T., E. Helpman and A. W. Hoffmaister (1997), "North-South R&D Spillovers", *Economic Journal* 107, 134-149.

Eaton, J. and S. Kortum (1999), "International Technology Diffusion: Theory and Measurement." *International Economic Review* 40 (3): 537-70.

Grossman, M. G. and E. Helpman (1991), "Innovation and Growth in the Global Economy." The MIT Press, Cambridge, MA: London.

Hunter, L., J. R. Markusen, and T. F. Rutherford (1992), "U.S.-Mexico Free Trade and the North American Auto Industry: Effects on the Spatial organization of Production of Finished Autos." *World Economy* 15(1): 65-81.

Krugman, P. and G. Hanson (1993), "Mexico-U.S. Free Trade and the Location of Production." In Peter Garber, ed., *The Mexico-U.S. Free Trade Agreement*. Cambridge, Massachusetts; London: MIT Press.

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. (2002 a) "Trade and the Transmission of Technology", *Journal of Economic Growth* 7: 5-24.

Keller, W. (2002 b), "Geographic Localization of International Technology Diffusion," *American Economic Review*. V.92, Nº 1 (March):120-42.

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

Lumenga-N., M. Olarreaga and M. Schiff (2001), "On 'Indirect' Trade-Related Research and Development Spillovers." World Bank Policy Research Working Paper No. 2580 (April). www.worldbank.org/research/trade.

Panagariya, A. (1999), "An Empirical Estimate of Static Welfare Losses to Mexico from NAFTA." In A. Panagariya. *Regionalism in Trade Policy: Essays on Preferential Trading*. Singapore: World Scientific Press.

Roland-H., D., K.A. Reinert, and C. R. Shiells (1992), "North American Trade Liberalization and the Role of Nontariff Barriers," Unpublished manuscript, U. S. International Trade Commission.

Romer, P. M. (1986), "Increasing Returns and Long-Run Growth." *Journal of Political Economy* 94 (5): 1002-37.

Romer, P. M. (1990), "Endogenous Technical Change." *Journal of Political Economy* 98: S71-S102.

Schiff, M., Y. Wang and M. Olarreaga (2002), "North-South and South-South Trade-Related Technology Diffusion: An Industry-Level Analysis," Policy Research Working Paper 2861, Development Research Group, the World Bank.

Schiff, M., and L. A. Winters (2003), *Regional Integration and Development*. Oxford: Oxford University Press.

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 México.

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