

Does technological innovation cause Exports in Brazil and Argentina?

João Alberto de Negri¹
Fernanda de Negri²
Fernando Freitas³

1 Introduction

Economic theory maintains that developed countries traditionally concentrate their exports in higher tech, higher value-added goods, while developing nations center their exports on labor-intensive, natural-resource-based commodities. Therefore, in markets where the standards of competition are based on product differentiation and innovation, it is only reasonable that developing countries should wish to export higher value-added goods. This desire is motivated by international experience, which consistently shows that any country that has attained high income and development levels has already migrated in the direction of a knowledge-intensive, higher value-added export list.

The problem is that to export is not simply to wish or desire, but depends on the capacities of the firms. Moreover, does technological innovation lead to exports in Brazil and Argentina? It is to answering this question that this article is directed. On the basis of firm-level data for Brazil and Argentina, export functions are estimated for the two countries using various econometric methods. Causality problems are solved through simultaneous equations.

This study is part of the recent IPEA effort to compare the impact of technological innovation across countries. By way of background to the arguments presented, the theoretical literature is reviewed in Section 2 and the database and econometric procedures are described in Section 3. The results of the estimates are given in Section 4 and the principal findings summarized in Section 5.

1 Director of IPEA

2 IPEA researcher

3 IPEA consultant

2 Technology and exports

The literature on international trade is relatively consistent. Generally speaking, the theoretical models contend that factor endowment ratios, production scales and technology underlie international trade. Thus, the idea that technology may be a key to driving trade between countries is not a new concept in the literature.

One of the pioneer contributions to international trade theory was the comparative advantage model developed by Ricardo. The classic Ricardian comparative advantages arise from differences in the productivity of labor across countries. These differences, in turn, are linked to climatic variables, national characteristics and, according to some authors, technological disparities (Grossman and Helpman, 1994).

Heckscher (1919) and Ohlin (1933) later formulated an international trade model that holds differences in the endowment of labor, capital and natural resources to be the determinants of trade between countries. According to the Heckscher-Ohlin (H-O) model, a country exports goods intensive in the factor with which it is relatively well endowed. In the factor endowment models, technology is considered a production function and is presumably identical in all countries. These models also assume that competition is perfect and that preferences are identical across countries. Fagerberg (1996) argues that such models fail to give due attention to the impact of technology on foreign trade.

In contrast to the Ricardian model, in which trade is determined by differences in the productivity of labor between countries, the H-O model does not consider such differences to be an incentive to foreign trade. However, even if productivity were identical, there would still be room for comparative advantages because of variations in factor endowment ratios. In the H-O model, differences in the relative prices of countries are explained by differences in factor endowments, which comprise the determinants of foreign trade. Hence, a country with a high capital/labor ratio should export capital-intensive goods, while one with a low capital/labor ratio should export labor-intensive goods.

Complementary models based on the relative factor scarcity cannot, however, explain the growth in foreign trade arising from the simultaneous expansion of imports and exports within a given industry. Since technological innovation grants the innovator monopolistic control of the new product, it undermines the assumption of perfect competition that constitutes one of the pillars of these theories. Moreover, it must be taken into account that while technological progress is cumulative and generates dynamic economies of scale, it

also carries acquisition and learning costs. From the foreign trade standpoint, the implications of these factors therefore vary widely.

Even so, contributions have been made with regard to including technological differences between countries in essentially classical models. Among the initial contributions were the inclusion of these differences as a factor in the production function and the concept of human capital as developed by Johnson (1968). Over time, the H-O models also evolved in this direction, seeking to explain why countries were paradoxically exporting goods intensive in factors of production that were relatively scarce and importing goods intensive in factors they possessed in abundance. As part of this attempt, the traditional capital/labor approach of the H-O models was modified when the labor factor was broken into skilled and unskilled labor.⁴

Starting in the 1970s,⁵ the growth of intra-industry trade among industrialized countries awakened theoretical interest. To explain this feature of foreign trade, the theory that arose reflected the product-differentiation, economy-of-scale and monopolistic-competition hypotheses posited by Chamberlin⁶. By embodying increasing returns to scale, the new foreign trade models provided a framework that complemented the explanations of international trade based on H-O models.

Chamberlin trade models can be found in works by Krugman (1979 and 1981), Lancaster (1980), Helpman (1981) and Helpman and Krugman (1985). These models assume that different countries use the same production technology or production function. However, they also assume that two types of goods are produced, one homogeneous and subject to constant returns to scale and the other differentiated, potentially highly diversified and subject to increasing returns to scale. In the presence of economies of scale arising from

⁴ The article by Leontief (1956) gave rise to the so-called Leontief paradox. Since the Vanek equation (1968) provided the basis for the Heckscher-Holin-Vanek theorem, it could be argued that the H-O paradox is attributable to measurement errors in the quantification of the relative abundance of production factors.

⁵ Grubel and Lloyd (1971) created an index for measuring intra-industry trade.

⁶ The Chamberlin (1933) imperfect, monopolistic competition model sought to demonstrate that competitive equilibrium and increasing returns could be compatible in the absence of Marshallian external economies. This model served as the framework for introducing increasing returns to scale into models in the late 1970s. Especially relevant is the work of Dixit and Stiglitz (1977), who, adopting the monopolistic competition perspective, formalized a model used by economists concerned with the foreign-trade theme, including Krugman (1979) and Ethier (1982).

specialization linked to diversification, different countries should produce different kinds of the latter, which should subsequently be traded internationally.⁷

Before the new international trade theories were consolidated, Posner (1961) constructed a model with two countries, one of them being in the technological forefront and the other managing to imitate the innovation of the first only after some time. In this model, an innovation grants monopolistic power to the leader during the period of time it takes the follower to copy him. Vernon (1966), in turn, defended the thesis that the competitive advantages of American firms were tied to their capacity to innovate new products and processes. According to the product cycle concept, the tendency of firms to produce in their home countries is stronger in the case of new technologies than in the case of mature technologies or products. These ideas, however, were rarely exploited within the context of conventional foreign trade theory. Then, in a product cycle model, Krugman (1979) adopted this type of approach, postulating that a low rate of technological diffusion across countries serves as a determinant of foreign trade.

In a technological gap model, Krugman (1986) subsequently endeavored to explain why more developed countries produce and export higher tech goods. He also held technical progress to be an endogenous factor in a model in which the monopoly enjoyed by the innovator may benefit society because it encourages innovation (Krugman, 1990). The conclusion derived from this model is that an integrated economy will always be more productive and register higher growth rates than an isolated economy. This, for the author, is the explanation for trade gains. However, the answer as to which country innovates is not stipulated in this model.

Other models in which technical progress is held to be endogenous to the economic system are presented by Grossman and Helpman (1994). The models are divided into two groups according to the type of learning. In the first, or learning-by-doing group, the firm learns from its own production tasks or from activities destined to other ends. The classic example is that of the firm that discovers a better way of doing something while in the

⁷ The discussion as to the nature of increasing returns to scale and their impact on foreign trade was initiated by Knight (1925) and Graham (1923 and 1925). The debate between these authors centered on the question as to whether increasing returns to scale could be either internal or external to the firm, but had to be internal to the industry to which it belonged. One or both of them would be capable of increasing foreign trade. The reciprocal dumping model of Brander and Krugman (1983) also shows that oligopolistic behavior on the part of firms is among the determinants of foreign trade.

course of production. In the second group of models, learning is the outcome of deliberate efforts to create knowledge, that is, of the innovation activities conducted by the firm.

As a rule, in the learning-by-doing models, technology is a function of the experience each country has in producing different goods. There are various specific cases, however, in which the spillovers are limited, whether due to the sector or to the country in which the firm is located. The findings of the innovation and learning-by-doing models are summarized by Grossman and Helpman (1994) as follows:

1. When the learning process is unrestricted and technology rapidly disseminated across countries – that is, when technology is freely available – trade is determined by natural comparative advantages. Thus, we once again have a traditional factor endowment model.
2. When spillovers are limited, whether by distance or by the nationality of the source of knowledge, factors such as country size and existing conditions at the time trade is initiated may play an important role. Examples of this occur when the technological development of small countries is retarded by foreign trade or when countries enter the foreign market at a technological disadvantage. Under these circumstances, competitive forces push these countries to specialize in lower tech, lower growth goods, thereby aggravating the initial discrepancies. This is the case in the Lucas (1988) model, for example. According to Lucas, countries that specialize in technologically advanced industries tend to grow more rapidly than those that do not. Moreover, in virtue of the cumulative nature of technological progress, this standard of specialization tends to be reinforced over time.
3. When the learning process is characterized by dynamic economies of scale, the range of benefits derived from integration and trade may be broader than suggested by static trade models. The Neo-Schumpeterian economists have devoted special attention to foreign trade issues. The theoretical proposition of this school is summarized by Dosi et. al. in the following manner: (i) the microeconomic foundations for analyzing foreign trade lie in extending an interpretation of the innovation process to the international plane; (ii) the innovation process leads, *ex post*, to a comparative advantage tied to the learning process since innovation, imitation and organizational change are characterized by features specifically related to the sectors and countries in which they are performed rather than to relative factor endowment advantages; (iii) the innovation process, by allowing for various kinds of increasing returns (static and dynamic), tends to occasion forms of market

interplay that diverge from perfect competition; (iv) because certain characteristics of technological change imply that the process may be irreversible, a possibility arises of virtuous or vicious circles with regard to innovation, competitiveness and growth; (v) lastly, international competitiveness is determined by constant technological learning and limited short-term substitution in relation to production and consumption.

In essence, the theories on the determinants of foreign trade are complementary, for any of the aspects stressed in any of the models may be more or less influential, depending on the country, the sector or even the type of good exported.

When the focus of analysis is shifted from factor endowment to technology, firms assume a more important role in shaping the specialization patterns across countries. This occurs because the learning and technological innovation processes are developed at the firm level. In addition, the response to external stimuli may vary widely across firms or groups of firms due to the capabilities and skills previously acquired by each.

Various models show that productivity and the rate of innovation are higher in countries specialized in higher tech goods. Likewise, the growth rates and income levels of these countries tend to be superior to those of countries specialized in standardized goods. Furthermore, in the majority of the models, the initial specialization pattern tends to be reinforced over time, widening the already existing gap between countries in the forefront and those that lag behind. In this context, it is clear that some form of domestic stimulus, such as innovation incentives or technological policies, should be designed to close or substantially narrow this gap.

The pattern of specialization that emerges from these models is one in which the development of new goods falls to the developed countries. In turn, the trade flows between these nations and the developing countries is via continuous innovation by nations in the lead and technological diffusion to those in the rear. Empirically, however, it would be interesting to know if there are circumstances under which this pattern of specialization does not prevail. It would be revealing to ascertain, for example, if countries such as Brazil and Argentina could become competitive in high-tech goods and if product innovation could significantly contribute to their ability to compete in world markets.

3 Database and econometric strategy

The findings presented in this article are based on data from the National Innovation Survey (PINTEC, 1998-2000) for Brazil and the Second Innovation and Technological Behavior Survey (EICT, 1998-2001) for Argentina.

The PINTEC was designed and conducted by the Brazilian Geographic and Statistical Institute (IBGE). Of the 11,000 firms covered by the sample, 10,328 responded to the questionnaire. When the sample is weighted, the number of firms rises to 72,000. According to IBGE (2004), the general concept and methodology for the PINTEC were derived from the Oslo Manual (1997). In specific terms, the undertaking was guided by the model proposed by EUROSTAT for the third Community Innovation Survey (CIS3), in which fifteen countries belonging to the European Community participated.

The EICT was formulated by the Argentine National Statistics and Census Institute (INDEC). The sample contained 2,225 firms, of which 1,688 responded to the questionnaire. This sample represents the 11,000 manufacturing firms with more than ten employees. According to the survey, the theoretical reference is also the Oslo Manual. However, with the aim of covering the peculiarities of the process of technological innovation in Latin America, certain aspects of the process are considered from the standpoint of the Bogotá Manual, which provides a specific methodology for innovation research in Latin America.

It should be mentioned that the innovation concept used in the EICT is broader than that employed in the PINTEC, for the EICT also stresses the importance of organizational, administrative and trade innovations⁸ aimed at obtaining productivity and competitiveness gains. For the sake of this article, however, including these concepts does not prejudice the comparability of the Brazilian and Argentine surveys because the study focuses on innovation expenditures related to research and development (R&D) investments. As pointed out in the Bogotá Manual, "...as a rule, but even more so with respect to R&D,

⁸ According Methodological Report of the Second Innovation and Technological Behavior Survey (EICT, 1998-2001) for Argentina, "organizational innovation embraces the adoption of new ways of organizing and managing an establishment or locale; changes in the organization and management of the production process; the implantation of a significantly modified organizational structure; and the adoption of new or significantly modified strategic guidelines. Trade innovation involves the introduction of means for commercializing new products; new methods for delivering existing products; or changes in packaging and/or wrapping. Having determined if any such innovations have been performed, when in the affirmative, indicate if each of the innovations implemented was new only for the firm (already known on the market); only for the local or domestic market (though not known in the country, the process already used, product sold or organizational/ trade technique in question already employed abroad); or for the world market (a product, process or technique formerly unknown in the sector or manufacturing branch).

organizational modernization ...is a prerequisite to technological change” (Jaramillo; Lugones; Salazar, 2001, p.58). In other words, R&D investments are intimately tied to technological process and product innovation.

To answer the question as to whether or not technological innovation leads to exports in Brazil and Argentina, the econometric strategy adopted in this article consists in estimating an export equation specified in accordance with the international trade theories:

$$X_j = \beta_0 + \beta_1 I_j + \beta_2 E_j + \beta_3 C_j + \beta_4 S_j + \xi \quad (1)$$

where X is the export coefficient, I is R&D expenditure as a share of revenue and E is the production scale of the firm as measured by number of employees. C is a dummy variable for foreign firms and S are dummies for the manufacturing sectors. The index j stands for the firm. Foreign firms are defined as those having 50% or more foreign capital. The sectoral controls are set in accordance with the two-digit National Classification of Economic Activities (CNAE) for Brazil and the Uniform International Industrial Classification (CUCI) for Argentina.⁹

Equation (1) will be estimated using ordinary least squares (OLS) and Tobit procedures. The estimate based on Tobit models is necessary because, as Wooldridge (2000) contends, OLS estimates are biased in the presence of censored data.

Even correcting the coefficients of the OLS model using Tobit estimates, the coefficient of the innovation variable may be biased, for there are reasons to believe that the fact that a firm both exports and innovates may result in simultaneity. In this case, the variable that measures innovation, R&D expenditures/revenue, may be correlated with the term ξ in the export equation. Thus, to determine and measure if the fact that a firm innovates implies that it has a propensity to export, it is necessary to estimate equation (1) using instrumental variable methods. To this end, a variable must be found that is simultaneously exogenous to exports and strongly correlated with innovation. For the OLS,

⁹ Since, as Lachmaier and Wöbmann (2004) point out, the “propensity to export and propensity to innovate have strong sector-specific components, the sectoral fixed effects are vital to evade bias from unobserved heterogeneity between sectors”.

two-stage least squares (2SLS) will be employed. For correcting the Tobit model, an estimate will be made using the Amemiyas general least squares (AGLS) procedure.

To correct the models, suitable instruments must be found. According to Wooldridge (2000), an instrument Z candidate has to meet two conditions: (i) it cannot be correlated with ξ , that is, $Cov(Z_h, \xi) = 0 \quad h = 1, 2, 3 \dots$ and (ii) it should be strongly correlated with the variable I in equation (1). An instrument can violate neither of these conditions, for the plim of the instrumental variable estimator is given by $\beta_{estimated} = \beta + Cov(Z, \varepsilon) / Cov(Z, I)$.

Lachenmaier and Wöbmann studied the innovations and exports of German manufacturing firms. As instruments, they chose variables that measure impulses and obstacles to innovation at the firm level. They showed that the push and pull variables were strongly correlated with the propensity of the firm to innovate, even after taking into account the size of the firm and the sector to which it belonged. In the German case, these variables met all the requirements for instrumenting an innovation variable.

To instrument equation (1) for Argentina, lagged variables will be used for innovation activity expenditures. In the EICT, data on such expenditures were gathered for the years 1998-2001 and cover the entire period. Lagged variables are generally good candidates as efficient instruments. For Argentina, therefore, in addition to the innovation push and pull variables, the innovation expenditures of manufacturing firms in 1998 were tested as instruments.

For Brazil, the past innovation expenditures of firms cannot be used to instrument equation (1) because although the PINTEC was conducted in 2000 and covers the period 1998-2000, data on innovation activity expenditures were collected for the final year only. As an alternative, the number of products patented by firms and recorded at the National Institute for Intellectual Property (INPI) in 1996, 1997, 1998 and 1999 will be used, together with the instruments suggested by Lachenmaier and Wöbmann (2004).

To validate the instruments, the Wu-Hausman and Sargan tests will be employed. The Wu-Hausman test will serve to verify the exogeneity of the innovation variable and the Sargan test to verify the orthogonality of the instruments to the random term in the export

equation. Lastly, the Shea partial R^2 ¹⁰ will be used to verify the relevance of the instruments in explaining the endogenous variable I in equation (1).

4 Does innovation lead to exports in Brazil and Argentina?

Table 1 shows that there are approximately 10,000 manufacturing firms with more than 10 employees in Argentina and 72,000 such firms in Brazil. While there are also numerically more export firms in Brazil, the export coefficient for the Argentine firms is higher at 23.20% compared to 15.77% for the Brazilian firms. On average, the R&D expenditures of Brazilian firms stand at roughly 0.7% of revenues and those of Argentine firms at 0.2%.

Table 1 – Characteristics of Brazilian and Argentine manufacturing firms

Variable	Argentina (2001)	Brazil (2000)
Total number of manufacturing firms	10,000	72,000
Total number of export firms	3,340	7,299
R&D expenditures/Revenue (%)	0.22	0.75
Export coefficient for export firms (%)	23.20	15.77

Sources: IBGE/PINTEC and INEGI/EICT.

The results of the estimates for equation (1) are presented in three tables. Those obtained using OLS and Tobit procedures are shown in Table 2, while those derived from 2SLS and AGLS are shown in Table 3. On the basis of these findings, the coefficients for Argentina and Brazil cannot be directly compared, nor can it be confirmed that technological innovation is more important to the exports of one country than to those of the other. Only the hypothesis that innovation leads to exports in the two countries can be verified. In Table 4, however, findings are presented that do provide a basis for comparing the countries. These results were obtained by stacking the databases. This procedure allowed for the introduction of a dummy variable having a value of 1 for firms located in Brazil and of 0 for firms located in Argentina. In addition, crossed dummies were constructed between the country variable and three other variables: R&D expenditures in relation to revenues, production scale as measured by number of employees and nationality of firm.

¹⁰ According to Shea (1996) the correlation between the instrument and the endogenous variable is among the determinants that assure the good performance of the instrumental variable estimates.

Table 2 – Export determinants in Brazil (2000) and Argentina (2001). Dependent variable: export coefficient of firm

Country	Argentina	Brazil	Argentina	Brazil	Argentina	Brazil
Procedure	OLS		Tobit			
Equation	1	2	3	4	5	6
R&D/Revenue	-0.28 (0.38)	0.02 (0.04)	-0.42 (0.41) [-0.17]	0.22** (0.11) [0.04]	1.54* (0.83) [0.61]	2.07*** (0.26) [0.41]
(R&D/Revenue) ²	-	-	-	-	-0.22** (0.08) [-0.09]	-0.12*** (0.01) [-0.02]
Foreign dummy	3.44*** (1.60)	6.46*** (0.59)	5.75*** (1.42) [2.30]	16.53*** (0.91) [3.34]	5.94*** (1.43) [2.38]	16.77*** (0.91) [3.38]
Ln of number of employees	3.66*** (0.41)	2.13*** (0.08)	14.33*** (0.44) [5.75]	18.76*** (0.23) [3.79]	14.27*** (0.44) [5.71]	18.63*** (0.23) [3.75]
Constant	-7.13*** (1.77)	-5.96*** (0.34)	-75.42*** (2.15)	-121*** (1.50)	-75.20*** (2.15)	-120.83*** (1.50)
Number of observations	10,571	70,063	10,571	70,063	10,571	70,063
F-statistic	8.40***	54.01***	-	-	-	-
R-square	0.11	0.11	-	-	-	-
Log likelihood	-	-	-19,432	-44,260	-19,428	-44,228

Sources: IBGE/PINTEC and INEGI/EICT * Standard deviation in parentheses –Marginal effect in brackets – Level of statistical significance ***1% **5% *10%. Fixed effect control for 2-digit CNAE and CUCI not reported. Cutoff point: export coefficient of firm below 100% and, in the case of Brazil, values over the 99.5 percentile due to their being outliers.

The results for equations (1) to (6) presented in Table 2 indicate that the scale of production is important in both Brazil and Argentina. They also show that the export coefficients of foreign firms are higher than those of domestic firms in both countries. In addition, the R&D expenditure/revenue ratios of firms tend to be positively correlated with their export coefficients.

The results of equations (5) and (6) reveal that the R&D expenditure/revenue ratio is positively linked to increases in the firm export coefficient once the scale, ownership and sectoral controls have been taken into account. A one-percent increase in the R&D expenditure/revenue ratio would therefore raise the export coefficient of Argentine firms by 0.61 percentage points and that of Brazilian firms by 0.44 percentage points. This indicates that technological innovation makes an important contribution to increasing both Argentine and Brazilian exports. It can also be seen that the returns to scale for R&D are

decreasing in both countries, as suggested by the negative sign for the squared R&D/revenue variable.¹¹

Another hypothesis tested refers to the possibility of increased R&D expenditures exerting a differentiated impact on the export coefficients of foreign firms vis-à-vis domestic firms. To verify this hypothesis, the P&D variable was crossed with the foreign dummy and introduced into the model. The result was significant for neither Brazil nor Argentina. In other words, a one-unit increase in R&D expenditure raises the export coefficient to a similar degree regardless of the firm being domestic or foreign. Consequently, these findings are not reported.

The positive and significant estimates for the firm size and firm nationality variables conform to the economic theory that associates these variables and export performance. Production scale is indeed a relevant factor in explaining the exports of Brazilian and Argentine firms. At the same time, the fact that foreign firms have access to trade channels that are not available to domestic firms gives them competitive advantages in the world market. The estimates for production scale and firm nationality are 2.38 and 5.71, respectively, for Argentina and 3.38 and 3.75 for Brazil. These results were obtained by calculating the marginal effects¹² of the coefficients estimated.

Another procedure for calculating the marginal effect is that suggested by MacDonald and Moffitt (1980). The breakdown proposed by these authors splits the effect of the coefficient into two parts, both of which are of interest: (i) the change in Y_i caused by values over the limit weighted by the probability of being over the limit and (ii) the change in the probability of being over the limit weighted by the expected value of y when over the limit:

¹¹ To determine if the variable (R&D/revenue)² is significant in the export model, one can simply apply a likelihood test given by $\Omega = -2*(L0-L1)$, where L0 stands for the log likelihood of the restricted model and L1 for that of the complete model. Ω follows an approximate chi-square distribution with one degree of freedom. Thus, $\Omega = -2*(-19432 - (-19428)) \rightarrow 8$, which is higher than the table value χ^2_1 of 3.84. For Argentina, the variable therefore contributes to explaining the export model. However, at $\Omega=64$, it is not significant for Brazil.

¹² The marginal effect of a variation in X_{ik} on the expected value of Y_i is

given by
$$\frac{\partial E[y_i | X_i]}{\partial x_{ik}} = \beta_k \phi(X_i' \beta / \sigma)$$

$$\frac{\partial E[y_i | X_i]}{\partial x_k} = F(z)\beta_i \left[1 - \frac{zf(z)}{F(z)} - \frac{f(z)^2}{F(z)^2} \right] + \frac{f(z)\beta_i}{\sigma} \left(z + \frac{f(z)}{F(z)} \right)$$

Table 3 – Export determinants in Brazil (2000) and Argentina (2001). Dependent variable: export coefficient

Country	Argentina	Brazil	Argentina	Brazil
Procedure	2SLS		AGLS	
Equation	7	8	9	10
R&D/Revenue	0.70 (0.49)	-0.24 (0.15)	5.80*** (1.24) [1.42]	3.62*** (0.95) [0.50]
Number of employees	3.61*** (0.15)	2.13*** (0.03)	13.99*** (0.45) [3.44]	18.82*** (0.24) [2.59]
Foreign dummy	3.50*** (0.61)	6.41*** (0.22)	6.94*** (1.46) [1.80]	17.16*** (0.95) [2.74]
Constant	-7.07*** (0.67)	-10.23*** (1.64)	-74.97*** (2.17)	-131.75*** (9.92)
F-statistic/ LR chi2	58.32***	348***	1721***	7557***
R2 / Log likelihood	0.21	0.13	-34628	-193918
Sargan test	0.199	0.191	-	-
Sargan P-value	0.65	0.66	-	-
Hausman Test	7.10	4.85	28.36***	12.97***
Hausman P-value	0.007	0.02	0.001	0.001
Shea partial R2	0.09	0.0092	-	-
R2 F-statistic	521***	325***	-	-
First Stage: Dependent Variable:– R&D Expenditure/ Revenue)				
Number of employees	-0.0005 (0.03)	-0.04*** (0.007)	-0.0005 (0.03)	-0.04*** (0.007)
Foreign dummy	-0.12*** (0.03)	-0.21*** (0.05)	-0.12*** (0.03)	-0.21*** (0.05)
Innovation expenditures (1998)	0.92*** (0.02)		0.92*** (0.02)	
Patents registered (1996-1999)		0.58*** (0.05)		0.58*** (0.05)
Machinery expenditures (1998)	-0.15*** (0.02)	-	-0.15*** (0.02)	-
Innovation risk	-	-0.69*** (0.08)	-	-0.69*** (0.08)
R2	0.14	0.06	0.14	0.06
Instrument F-test	52.03***	95***	52.03***	95***

Sources: IBGE/PINTEC and INEGI/EICT * Standard deviation in parentheses –Marginal effect in brackets – Level of statistical significance ***1% **5% *10%. Fixed effect control for 2-digit CNAE and CUCI not reported. Cutoff point: export coefficient of firm below 100% and, in the case of Brazil, values over the 99.5 percentile due to their being outliers.

Using the MacDonald and Moffitt breakdown, in the case of Argentine firms, an estimated 69% of the overall change in export coefficients resulting from a shock to the R&D/revenue variable would be generated by changes in the propensity to export. In the case of

Brazilian firms, the corresponding figure would be 78%. For Brazil and Argentina alike, these findings indicate that a policy aimed at increasing R&D investments would exert its strongest impact on previously non-export firms that came to export. While this finding is highly relevant for both countries, it is especially important for Brazil, which has eight times more manufacturing firms than Argentina.

The estimates obtained using instrumental variables as a means of correcting eventual biases in the parameters are presented in Table 3.

While the estimates using instrumental variables do not generally modify the interpretations already presented, they do serve to correct the estimated betas in the equations for both Brazil and Argentina. In the AGLS model, the parameter estimates for the variable R&D/revenue are higher than those in the Tobit model. This indicates that the Tobit estimates were too low. The results of the model equations (9) and (10) show that, for Brazil, a one-percent increase in the R&D/revenue ratio would raise the export coefficient an average 0.50 percentage points. For Argentina, a one-percent in the ratio would raise the coefficient an average 1.42 percentage points.

The Sargan test does not reject the null hypothesis, which means that the instruments satisfy the orthogonality hypothesis, as required. In turn, since the Hausman test does reject the null hypothesis, it can be affirmed that, as anticipated, the R&D variable is endogenous. This means that estimates of the R&D investment/export ratio may be biased if the instrumental variables are not previously corrected. Once again, in relation to the quality of the instruments used, the partial R² shows that the instruments significantly contribute to explaining the endogenous variable. From these tests, it can be concluded that the instruments used to estimate the equation for Argentina are generally superior to those used to obtain the estimates for Brazil.

For the Argentine equation, the best instruments were R&D expenditures of firms in 1998 and machinery expenditures of firms in 1998. For the Brazilian estimates, the most adequate instrumental variables were number of patents obtained by firms in the period 1996-1999 and the variable associated with innovation risk.¹³

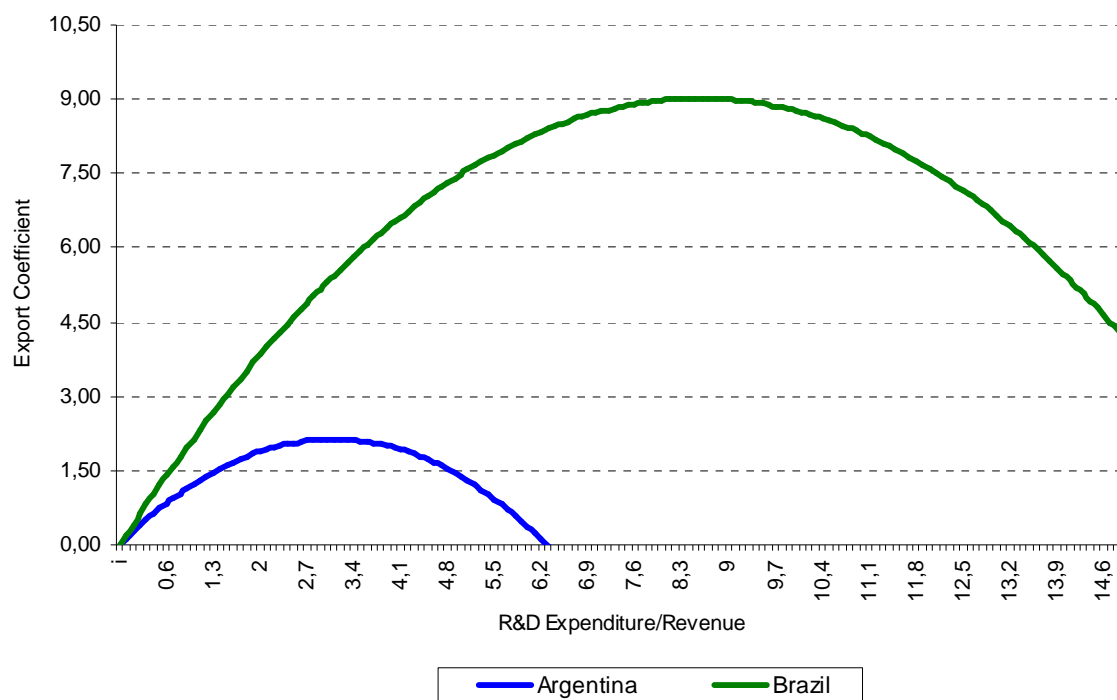
¹³ This is a binary variable having a value of 1 when a firm declares that the greatest obstacle to technological innovation is linked to the high risk of innovative processes. We have therefore followed the suggestion of Lachenmaier and Wöbmann (2004) and used obstacles to innovation as instruments in the export equation.

For Brazil, the results of the instrumental variable models suggest that although the instruments meet the requirements, they may be less than ideal for the export equation. An indication of this is the low partial R², which may be signaling that the variables chosen have limited explanatory power in relation to R&D expenditures.

At any rate, the results of all the models employed – OLS, Tobit, 2SLS and AGLS – confirm the hypothesis that technological innovation leads to exports in both Brazil and Argentina. This having been determined, the question that naturally arises is whether or not stronger innovation efforts (R&D/revenue) would have greater impacts on Brazilian and Argentine exports. In an attempt to answer this question, two procedures were followed. In the first, equations (5) and (6) were used to mount a graph depicting the relations between the export coefficients of firms and the R&D/revenue ratios of the two countries. This graph is displayed in Figure 1.

The graph shows that, for Brazil, the inflection point on the curve linking innovation efforts and exports corresponds to R&D expenditures equal to 8.62% of firm revenues. In other words, on average, if the innovation efforts of Brazilian firms were increased, the increase would have a positive impact on their export coefficients up to 8.62% of their revenues. Beyond this point, the impact on exports would become negative, revealing that, from there on, R&D investments would have decreasing returns with respect to their impact on exports. For Argentina, the inflection point is lower at 3.5% of the R&D expenditure/revenue ratio. The graph therefore indicates that Brazilian exports are more closely tied to R&D investments than are Argentine exports. This suggests that, given the characteristics of the manufacturing frameworks of the two countries, the potential for raising the export coefficients of firms via increased R&D expenditures is greater in Brazil than in Argentina.

Figure 1 – Export coefficient and R&D expenditure/revenue curve for Brazilian (2000) and Argentine (2001) firms



The second procedure used for answering the question as to whether or not higher R&D expenditures would have greater impacts on export coefficients in Brazil and Argentina was to stack the databases. This having been done, a single equation was estimated for the two countries using a dummy for Brazil, in addition to crossed dummies between the variable for Brazil and the R&D expenditure/revenue, production scale and firm nationality variables. The results of these estimates are reported in Table 4.

Table 4 – Export determinants in Brazil (2000) and Argentina (2001). Tobit model. Dependent variable: export coefficient.

	Coefficient	Standard Deviation	Marginal Effect
R&D/Revenue	0.87**	(0.44)	[0.19]
(R&D/Revenue) ²	-0.13***	(0.01)	[-0.02]
Number of employees	14.38***	(0.40)	[3.23]
Foreign dummy	7.43***	(1.34)	[1.67]
Brazil dummy	-44.04***	(1.79)	[-9.91]
Brazil dummy*R&D/Revenue	1.27***	(0.45)	[0.28]
Brazil dummy*Foreign dummy	9.36***	(1.62)	[2.10]
Dummy Brazil*Number of employees	4.57***	(0.44)	[1.02]
Constant	-77.71***	(1.75)	-
Number of observations	81,009		
Number of observations (Brazil)	70,292		
Number of observations (Argentina)	10,717		
Parcial R-2	0.15		
Log Likelihood	-63.909		
LR chi2(8)	21.238***		

Sources: IBGE/PINTEC and INEGI/EICT. Level of statistical significance ***1% 5% *10%. Fixed effect control for 2-digit CNAE and CUCI not reported. Cutoff point: export coefficient of firm below 100% and, in the case of Brazil, values over the 99.5 percentile due to their being outliers.

These results indicate that a one-percent increase in R&D expenditures in relation to revenues would have a stronger impact on the exports of Brazilian firms than on those of Argentine firms. The scale variable (number of employees) remains significant and is also more important for Brazil than for Argentina. Likewise, the foreign firms located in Brazil have a stronger propensity to export than those located in Argentina. However, the negative dummy for Brazil suggests a higher export coefficient for Argentine firms than for Brazilian firms, as already verified in the descriptive statistics, possibly due to the larger size of the Brazilian market.

5 Summary and conclusions

This study tested the hypothesis that technological innovation leads to exports among Brazilian and Argentine manufacturing firms. An export function was estimated for the two countries using various econometric methods, thereby allowing for an original comparison of microdata from the national innovation surveys conducted in the two countries. Employing information on the major obstacles to innovation, lagged expenditures on innovation activities and lagged exports by firms as instruments for R&D expenditures, a vector exogenous to exports was found, thus making it possible to estimate the causal effect of innovation on exports. Since the results of these tests suggest that the OLS and

Tobit estimates are biased by the presence of endogeneity, the 2SLS and AGLS estimates are better adjusted.

The findings show that raising R&D expenditures also raises the export coefficients for both Brazil and Argentina. However, the inflection point between exports and the R&D expenditure/revenue ratio is higher for Brazil than for Argentina, indicating that Brazilian exports are more closely linked to R&D than are Argentinean exports. Therefore, given the characteristics of the manufacturing frameworks of the two countries, the possibility of increasing export coefficients by increasing R&D investments is greater for Brazilian than for Argentine firms.

As a means of comparing Brazilian and Argentine exports simultaneously, microdata from the technological innovation surveys were stacked. By using this procedure, the heterogeneity of the data was minimized and the difference in the effects of R&D spending in the two countries was isolated. The results of the crossed dummies employing the country variable and the production scale, firm nationality and R&D expenditure/revenue variables demonstrate that: (i) Argentine firms have higher export coefficients than Brazilian firms; (ii) firm size is more important to exports in Brazil than in Argentina; (iii) in comparison to the foreign firms located in Argentina, those in Brazil are more oriented to the external market and; (iv) the R&D expenditure/revenue ratio has a greater impact on the exports of Brazilian firms than on those of Argentine firms.

6 Bibliography

- BRANDER, J. and KRUGMAN, P. (1983), A "Reciprocal Dumping" Model of International Trade. *Journal of International Economics* 15, pp.313-321.
- CHAMBERLIN, E. (1933). *The Theory of Monopolistic Competition*. Cambridge: Harvard University Press.
- DIXIT, Avinash K. and STIGLITZ, Joseph E., (1977). "Monopolistic Competition and Optimum Product Diversity," *American Economic Review*, American Economic Association, vol. 67(3), pp. 297-308.
- DOSI, G., PAVITT, K. SOETE, L. (1990). *The Economics of Technical Change and International Trade*. Harvester Wheatsheaf.
- ETHIER, W. (1982), National and International Returns to Scale in the Modern Theory of International Trade. *American Economic Review*, 72: 389-405.
- FAGERBERG, J. "Technology and competitiveness". *Oxford Review of Economic Policy*", vol 12, n. 3. 1996.

- GRAHAM, F. (1923), Some Aspects of Protection Further Considered. *Quarterly Journal of Economics* 37.
- GRAHAM, F. (1925), Some Fallacies in the Interpretation of Social Cost: A Replay. *Quarterly Journal of Economics*, 39:324-330.
- GROSSMAN, G. M., HELPMAN, E. "Technology and trade". Working paper n. 4926, National Bureau of Economic Research - NBER: Cambridge: Nov/1994.
- GRUBEL H.G. and LLOYD, P.J. (1971) The Empirical Measurement of Intra-industry Trade. *The Economic Review* 47:494-517.
- HECKSCHER, E. (1919), The Effect of Foreign Trade on the Distribution of Income. *Ekonomisk Tidskrift*, p. 497-512. [Republished in A.E.A. *Readings in the Theory of International Trade*. Blakiston, Philadelphia, 1949, Chap. 13, p. 272-300].
- HELPMAN, E. (1981) International Trade in the Presence of Product Differentiation, Economies of Scale and Monopolistic Competition: a Chamberlin-Heckscher-Ohlin Approach. *Journal of International Economics*, 11:305-40.
- HELPMAN, E. and KRUGMAN, P.(1985) *Market Structure and Foreign Trade: Increasing Returns, Imperfect Competition and the International Economy*. MIT Press.
- IBGE (2004). Pesquisa industrial de inovação tecnológica, da Série Relatórios Metodológicos, volume 30, seção 1, p. 11-15.
- IBGE, Pesquisa Industrial de Inovação Tecnológica, 2000.
- JARAMILLO, H.; LUGONES, G.; SALAZAR, M. (2001) Normalización de indicadores de innovación tecnológica en América Latina y el Caribe: manual de Bogotá. [Bogotá]: Red Iberoamericana de Indicadores de Ciencia y Tecnología: Organización de Estados Americanos: Programa CYTED.
- JOHNSON, H. (1968). "The state of theory in relation to the empirical analysis". In Vernon, R. (ed.) *The technology factor in international trade*. New York: Columbia University Press, p. 9-21.
- KNIGHT, F. H. (1925), On Decreasing Cost and Comparative cost: A Rejoinder. *Quarterly Journal of Economics*, 39:331-333.
- KRUGMAN, P. (1979), Increasing Returns, Monopolistic Competition and International Trade. *Journal of International Economics*, 9(4): 469-79.
- KRUGMAN, P. (1980), Scale Economies, Product Differentiation, and the Pattern of Trade. *American Economic Review* 70, pp 950-959.
- KRUGMAN, P. (1981), Intra-industry Specialization and the Gains from Trade. *Journal of Political Economy*, 89(51): 956-73.
- LACHENMAIER S. and WÖBMANN L.(2004). Does Innovation Cause Exports? Evidence from Exogenous Innovation Impulses and Obstacles Using German Micro Data.
- LANCASTER, K. (1980) Intra-industry Trade Under Perfect Monopolistic Competition. *Journal of International Economics* 10:151-75.
- LEONTIEF, W. (1956), Factor Proportions and the Structure of American Trade: Further Theoretical and Empirical Analysis. *Review of Economics and Statistics*, New York, v. 38, p. 386-407.

- LUCAS, R. E. (1988). On the Mechanisms of Economic Development, *Journal of Monetary Economics*, 22(1), 3-42.
- OHLIN, B. (1933), *Interregional and International Trade*. Cambridge: Harvard University Press.
- OSLO manual (1997), Proposed guidelines for collecting and interpreting technological innovation data. Paris: OECD: Statistical Office of the European Communities, 1997.
- POSNER, M. (1961). *International trade and technical change*. Oxford Economic Papers 30.
- SHEA, John (1996). Instrument relevance in multivariate linear models: A simple measure. NBER, Technical Working Paper Series n° 193;
- VENON, R. (1966), International Investment and International Trade in the Product Cycle. *Quarterly Journal of Economics*, v 80, pp. 190-207.
- WOOLDRIDGE, J. M. (2001), *Econometric analysis of Cross Section and Panel Data*. The MIT Press, Cambridge, Massachusetts. London, England.