EXPORTS, PRODUCT DIFFERENTIATION AND KNOWLEDGE SPILLOVERS

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Abstract

Empirical studies on aggregate export behavior have recently emphasized the role played by innovation as the main force driving product differentiation and competitiveness for developed countries. These studies treat foreign innovation as a variable that affects negatively national export shares. We incorporate the impact of foreign innovation in a standard new trade theory model and find that, if knowledge spillovers exist, foreign knowledge accumulation could even have a positive effect on national exports. We then test the model using aggregate export data for a set of 21 OECD economies and find that the foreign stock of knowledge affects exports positively for the less advanced countries in the sample and has no impact on exports for the G7 economies.

Keywords: knowledge spillovers, product differentiation, export functions, panel cointegration.

JEL classification numbers: F12, O31, C22, C23

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NON-TECHNICAL SUMMARY

What determines that some countries are able to export more than others? Why do some countries gain export market share at the expense of others? These questions lay at the heart of empirical studies on trade performance. The traditional answer to these questions relied on the role played by the ability of countries to have lower costs than their competitors. However, we now know that, especially for developed countries, the quality of the product and the capacity to produce different varieties of goods are the crucial factor explaining export performance.

How can a country improve quality and variety? Economists usually look at innovation and the accumulation of knowledge. Developed countries, with a long standing tradition of research, marketing, entrepreneurial organization, etc. have accumulated a stock of knowledge that allows them to be more dynamic in the creation of products with market potential.

However, as much of the knowledge generated in one economy can be enjoyed by other countries with similar characteristics, the capacity to export will be determined not only by the country's stock of knowledge but also by other countries' knowledge. This is the central argument of this article. Unlike previous studies, we do consider if foreign knowledge could have a positive impact in a country's capacity to export. We develop a theoretical model in which we argue that foreign technology can have a positive and a negative impact on a country's competitiveness. A negative impact because it improves the foreign country's competitiveness and hence reduces our country's market share. A positive impact because the spillover of foreign technology into our economy will enhance our capacity to produce new and/or higher quality varieties of goods.

Our empirical findings for a set of 21 OECD advanced countries show that i) the net effect of foreign technology on exports in the G7 countries is statistically close to zero; ii) the net effect on the rest of OECD countries is positive; iii) this impact is larger the higher the degree of openness of the economy to trade and FDI. This points out that, for many countries, improvements in export capacity crucially depend not only on its own capacity to innovate but also on their capacity to absorb foreign knowledge.

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1. Introduction.

Product differentiation and technological advantages have been widely recognized as crucial factors determining the export performance of countries and sectors. The basic specification of aggregate export functions, however, typically only considers foreign income and relative prices as determinants of exports.[1] These aggregate export equations contain little information about the determinants of export market shares and competitiveness. Also, the use of aggregate trade equations implies that exports of different countries are imperfect substitutes for one another. Imperfect substitutability points out to product differentiation as in the standard new trade theory models. Indeed, Krugman (1989) develops a model in which income elasticities of demand for exports and imports depend on the number of varieties produced at home and abroad.

Recently, in empirical studies of export behavior it has become usual to incorporate proxies for product quality and variety by using measures of innovation such as R&D investment, patents, FDI and physical capital investment.[2] In these studies it is assumed that national innovation affects exports positively while foreign innovation will affect national exports negatively due to the fact that exports of different countries compete with each other for market share. These specifications, however, ignore the possibility

[1] See Houthakker and Magee (1969) and, recently, Senhadji and Montenegro (1999).

[2] See the empirical studies of export competitiveness of Blake and Pain (1994), Carling et al (2001), Driver and Wren-Lewis (1999), Fagerberg (1988), Greenhalgh et al (1994) and Wakelin (1997) among others.

that knowledge generated in one country could spillover to the rest, increasing their potential to produce new varieties or higher quality products. Empirical evidence supports the view that there are knowledge spillovers between countries related to their trade links (Coe and Helpman, 1995), FDI links (Barrell and Pain, 1997), or even geographical distance (Jaffe and Trajtemberg, 1998). Foreign innovation, hence, could also have a positive impact on domestic exports.

In this paper we test the impact of international knowledge spillovers on export competitiveness for a set of 21 OECD countries. By doing so we will be able to assess to what extent developed countries' exports rely on nationally or internationally produced knowledge. We do so by estimating aggregate export equations that incorporate both national and foreign R&D stocks as a proxy for product variety and quality. The empirical model is directly derived from a model of trade with monopolistic competition where the number of varieties depends on the stock of both domestic and foreign knowledge. Our results show that, for the G7 group, foreign knowledge has a neutral impact on exports and, for the less advanced countries of the sample, foreign knowledge has a positive impact on competitiveness.

The paper is organized as follows. In the next section we will present a simple model of trade with monopolistic competition that develops the empirical model we investigate. Section 3 presents the empirical specification of the aggregate export equations, data, and estimation technique, and Section 4 presents the results. Finally, Section 5 concludes.

2. The model: aggregate exports and knowledge spillovers.

The starting point of the model is based on the standard product diversity models of trade *a la* Dixit and Stiglitz (1977) of for instance, Krugman (1979) and Helpman and Krugman (1985). Given that consumers have a preference for variety and production embodies economies of scale, identical economies can engage in trade with positive welfare effects. In our model the number of firms or varieties is not fixed and hence we focus on the determinants of the number of varieties. Following Driver and Wren-Lewis (1999), the number of firms (product varieties) is not fixed and depends on investment on innovation. Innovation is here understood as investment on the production of a new variety. Investment in new varieties, in turn, is a positive function of the stock of available knowledge. That is, the stock of ideas or knowledge available in the economy will determine how much of this knowledge is transformed into the production of new varieties. Since knowledge can be nationally produced or available through international spillovers, the export demand function will now depend on both the national and international stock of knowledge. The impact of foreign knowledge is ambiguous. On the one hand, an increase in the foreign stock of knowledge increases the market share of foreign firms reducing national exports. On the other hand, it increases knowledge spillovers and enhances the number of varieties produced at home, thus increasing exports.

Individuals maximize a utility function in which the different product varieties i = 1, 2, ..., n enter symmetrically,

$$U = n^{\frac{\theta-1}{\theta}} \left[\sum_i c_i^{\theta} \right]^{\frac{1}{\theta}}, \qquad 0 < \theta < 1 \tag{1}$$

subject to a normal budget constraint.[3] This yields the following expression for the demand for variety *i*:

$$c_i = \frac{D}{nP} \left(\frac{p_i}{P} \right)^{\frac{1-\theta}{\theta}}, \tag{2}$$

where D is total expenditure on all varieties, P is the aggregate price index,[4] and p_i is the price of variety *i*.

Production is carried out using only one factor of production that we call 'labor' but that can be envisaged as a composite of inputs. The production technology exhibits increasing returns because of the existence of a fixed cost α:

$$l_i = \alpha + \beta{\cdot}x_i, \tag{3}$$

where l_i is the quantity of resources needed to produce x_i units of output of variety *i*. The full employment condition is $L = \sum_i l_i$. The fixed cost α can be seen as the investment of the firm in the production of its variety. Hence, $R = \alpha{\cdot}n$ is the total investment in

[3] The parameter θ is equal to (ω-1)/ω, where ω is the elasticity of substitution between two varieties and ω > 1.

[4] The expression for the aggregate price index is $P = \left[\frac{1}{n} \sum_i p_i^{\frac{1}{\theta}} \right]^{\frac{\theta-1}{\theta}}$.

innovation (new varieties) in the economy. The existence of increasing returns ensures that each variety will be produced by only one firm located in one country. The profit maximizing price is found by equalising marginal cost and marginal revenue, and therefore:

$$p_i = \frac{\beta w}{\theta}, \tag{4}$$

where w is the real wage or the return to the composite of inputs.

Following Dixit and Stiglitz (1977), the free entry condition of zero profits will then determine output in equilibrium:

$$x_i = \frac{\alpha\theta}{\beta(1-\theta)} \tag{5}$$

Within this framework, if we open up the economy, trade will take place because each differentiated good is produced by a single producer located in one of the countries. Given the symmetry of the problem, all consumers in the world will consume identical quantities of each variety and from (2) we obtain

$$c_i = \frac{D_T}{n_T P_T}\left(\frac{p_i}{P}\right)^{\frac{1}{\theta-1}}, \tag{6}$$

where a subscript T denotes total world variables. Total expenditure ($p_i \cdot c_i$) on products of the home country D_H is the sum of the expenditures on the number of goods produced at home n_H. We define $n_T = n_H + n_F$, where n_F is the number of varieties produced abroad. Substituting the aggregate price index expression for the home economy into (6) we then get:

$$D_H = \frac{D_T n_H}{n_T} \left(\frac{P_H}{P_T} \right)^{\frac{\theta}{\theta - 1}}. \tag{7}$$

The aggregate output, Y, of each country is given by its real expenditure D/P. Given that consumers consume identical quantities of each variety, exports will simply be proportional to real output, and will depend on the same factors as in (7).[5] Hence, real exports of the home country, X_H, are proportional to D_H/P_H and from (7) we obtain an expression for the export function:

$$X_H = Y_T \frac{n_H}{n_T} \left(\frac{P_H}{P_T} \right)^{\frac{1}{\theta - 1}} \tag{8}$$

This yields an export function that is similar to those used in empirical studies of aggregate export functions but now augmented by the proportion of varieties produced by the home economy (n_H/n_T).

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[5] We are obviously assuming throughout that all output in the economy is internationally tradable. Even if this is not the case, the proportionality between output and exports would still hold if the proportion of tradable goods on output was the same at home and abroad.

In order to model the number of varieties produced, we assume, without loss of generality, that the home country is small enough so as to have a negligible impact on world level of innovation. As mentioned earlier, total investment in innovation R is equal to $\alpha \cdot n$. Since we assume the same production function for firms located in both countries, the ratio n_H/n_T in equation (8) becomes R_H/R_T. Innovation will depend on the existing stock of knowledge. However, due to the existence of knowledge spillovers, the available stock of knowledge at home will be a function of both home produced knowledge and foreign produced knowledge. Given the small country assumption, foreign innovation will only depend on the stock of foreign knowledge. We then have that:

$$R_H = \gamma KH^{\varphi} KF^{\varepsilon}, \tag{9}$$

and

$$R_F = \lambda KF^{\phi}, \tag{10}$$

where KH and KF are the stocks of knowledge produced at home and abroad respectively. The parameters γ and λ reflect the efficiency with which knowledge converts to innovation. The parameter ε reflects the degree to which foreign knowledge flows into the home economy and is incorporated into their system. The amount of foreign stock of knowledge used at home will also depend on factors such as the degree of openness of the economy to trade and FDI flows as in Parente and Prescott (1994). Given our treatment, the stock of knowledge variable should be thought of as a conglomerate of ideas that could potentially be used in productive activity. In our model we assume that investment in new varieties (innovation) is a function of this stock of ideas because innovators are assumed to build or improve upon existing ideas. Countries with more developed university and research sectors will hence enjoy higher opportunities of using the knowledge generated in these sectors to improve product variety or quality. The higher the degree of contact between economies the higher the flow of ideas will be. It could well be the case that, even though one economy may be producing most of the ideas, other countries may be more effective in transforming this knowledge into new varieties and hence become more competitive.

Substituting (9) and (10) into (8) and taking logs we obtain a log-linear expression for the export function as follows:

$$\ln X_H = \ln\left(\frac{\gamma}{\lambda}\right) + \ln Y_T + \varphi \ln KH + (\varepsilon - \phi)\ln KF + \left(\frac{1}{\theta - 1}\right)\ln\left(\frac{P_H}{P_T}\right). \qquad (11)$$

This is a traditional export demand equation augmented with two technology variables representing product variety and/or quality. We expect the impact of the stock of home knowledge to be positive while the impact of the foreign stock of knowledge is unknown a priori. The negative impact would come about because of a 'competition' effect. That is, because foreign innovation increases the market share of the rest of the world. The positive impact is due to the knowledge spillover effect. Export demand equations capturing technological variables in previous studies such as, for instance, Fagerberg (1988), implicitly assume that $\varepsilon = 0$ and $\varphi = \phi$. By doing so they assume no knowledge flows and equal innovation rates out of knowledge stock between countries (or sectors). This is, however, an empirical question in our model.

3. Specification, data and estimation.

In this section we will subject equation (11) to empirical scrutiny. We will start with the basic specification of an export function and then augment it with the innovation variables considered in the model. Therefore consider five specifications:

$$X_{it} = a_i + b \cdot RER_{it} + c \cdot Y^F_{it} \quad \text{(i)}$$

$$X_{it} = a_i + b \cdot RER_{it} + c \cdot Y^F_{it} + d \cdot KH_{it} \quad \text{(ii)}$$

$$X_{it} = a_i + b \cdot RER_{it} + c \cdot Y^F_{it} + d \cdot KH_{it} + e \cdot KF_{it} \quad \text{(iii)}$$

$$X_{it} = a_i + b \cdot RER_{it} + c \cdot Y^F_{it} + d \cdot KH_{it} + e \cdot (m_{it} \cdot KF_{it}) \quad \text{(iv)}$$

$$X_{it} = a_i + b \cdot RER_{it} + c \cdot Y^F_{it} + d \cdot KH_{it} + e \cdot (fdi_{it} \cdot KF_{it}) \quad \text{(v)}$$

Where i is a country index, t is a time index, X is the level of real exports, RER is the export price divided by the import price of goods and services times the effective nominal exchange rate and Y^F is the world's income. All variables are expressed in logs unless stated to contrary. World income is defined as the sum of the income of the j countries considered in constant 1991 US PPPs, minus the income of country i:

$$Y^F_{it} = \sum_j Y_{jt} \quad \text{with} \quad j \neq i$$

The knowledge stock variables, *KH* and *KF*, deserve special attention. We have proxied the stock of home and foreign knowledge using stocks of home and foreign R&D. This is not devoid of the measurement problems which beset innovation data. Other studies such as Blake and Pain (1994) or Driver and Wren-Lewis (1999) have used cumulated investment or FDI stocks as a proxy for innovation. In our case, however, R&D stocks would be a more appropriate variable, since we intend to measure the degree to which knowledge spillovers affect export competitiveness. Although many new products and quality improvements do not require R&D, this variable is a better measure of the stock of ideas that could potentially be used to innovate, that is, invest in the production of new varieties at home and abroad. Cumulated investment, hence, would not be a good proxy of the stock of knowledge itself, but of the innovation efforts. Given that we want to test the impact of knowledge spillovers, using cumulated investment would not be meaningful since it cannot flow between economies. On the other hand, in our model FDI could be a means through which knowledge flows between countries but not a measure of the stock of ideas. Hence, we make use of the R&D stock data calculated by Coe and Helpman (1995). Foreign R&D, however, is not measured as the trade weighted stock of foreign R&D as in Coe and Helpman (1995). This is because in our model R&D spillovers do not necessarily arise from the import of new intermediate goods. We measure the foreign stock of R&D of country i as the sum of R&D stocks of the j countries considered with $i \neq j$. Note, however, that given that we use R&D as a proxy for both home and foreign knowledge stocks, the parameter estimates will also reflect the capacity of the different countries to transform R&D into economically valuable knowledge.

As regards the different specifications, specification (i) is the basic export demand equation with foreign income and relative prices as the only arguments. We then augment the basic specification with the stock of home knowledge (ii), and the stock of foreign knowledge (iii). Specification (iii) would directly correspond to equation (11) in the previous section. As mentioned earlier, more open economies would be able to enjoy a higher share of foreign knowledge. That is why in specification (iv) we multiply *KF* by the import-output ratio, m_{it}, as a measure of openness.[6] For the same reason in specification (v) we multiply *KF* times the share of FDI stock in total output, fdi_{it}, given that FDI is one of the main channels of international technology transfer.

We estimate equations (i) to (v) for a panel of 21 OECD countries for the period 1971 to 1990. The choice of the period was determined by the availability of the R&D data from Coe and Helpman (1995). The countries used for estimation are United States, Japan, Germany, France, Italy, United Kingdom, Canada, Australia, Austria, Belgium, Denmark, Finland, Greece, Ireland, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden and Switzerland. We also estimated the different specifications separating the panel into G7 and non-G7 countries. Given that most of the R&D is generated in the G7 countries, we would expect non-G7 countries to rely more on foreign knowledge for the production of new varieties, while the richest countries of the G7 would rely more on locally produced knowledge.

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[6] It would obviously be more accurate to measure openness by using the ratio of imports plus exports to output. This, however, would generate problems of spuriousness because of having the same variable, exports, in both the left and right hand side of the equation.

All the data is obtained from OECD Main Economic Indicators (2001) except the R&D stock data, as already mentioned, and the FDI stock data that was obtained from the estimates of Lane and Milesi-Ferretti (2001).

We estimate the model in levels as derived from the previous theory. This fact poses some difficulties because the time series component of the panel may not be stationary, and there is the possibility of obtaining spurious relations amongst the variables. One possibility to control for this problem is to run separate regressions for each country using different well-known cointegration techniques. There are two problems with this. First, the limited number of observations in our panel makes it difficult to make inference about the presence of unit roots or cointegration relations in the variables. Both due to this shortage and the small sample period all the tests developed in the time series literature suffer from a serious lack of power. This could lead us to accept the null of a unit root or no cointegration when the alternative is true. Secondly, estimating the model using time series data will leave us with few degrees of freedom to carry out statistical inference, especially in models like ours in which we can have 4 independent variables. Using recent panel cointegration techniques we can increase the power of the tests and the degrees of freedom by combining cross-section and time series information.[7]

The estimation procedure consists of 3 stages. We first test for the existence of unit roots in the variables considered. Then the OLS estimation of a fixed effects model is carried out and the residuals of this estimation are used to test for panel cointegration in order to unveil the existence or otherwise of long run relationships between the variables

[7] See Banerjee (1999) and Baltagi and Kao (2000) for an overview of the literature on panel data unit roots and cointegration. We refer the reader to these and the other references mentioned for technical descriptions of the tests and estimation methods used.

considered. Finally, we estimate the cointegration vector using recently developed techniques to overcome the problems of bias arising in OLS estimation.

We use the Levin and Lin (1993) (LL) and Im et al (1997) (IPS) tests for unit roots in panels. These are tests based on ADF regressions in a panel context. The main difference between the two being that the LL test assumes the same autoregressive coefficient for all the units of the panel, whilst the IPS test allows for a higher degree of heterogeneity allowing for different autoregressive coefficients. Both the LL and IPS tests have a one-tailed standard normal distribution.

The tests for cointegration are based on Pedroni (1999). He presents a battery of panel cointegration tests and we make use of four of them. The first two belong to the family of panel tests which assume the same autoregressive coefficient for the errors of the OLS regression. These tests, hence, are appropriate when we assume homogeneous panels. We provide the ADF and non parametric Phillips-Perron (panel-ADF and panel-PP) versions of these cointegration tests. The second family of tests is the group mean approach. In this case, cointegration tests are based on transformations of the average of the individual unit root tests, thus allowing for a high degree of heterogeneity in the panel. Here we also carried out a parametric ADF test (group-ADF) and a non parametric one (group-PP). It is easy to see that, in the case of ADF tests, the first family is equivalent to the LL unit root test and the second to the IPS test.

Finally, the estimation of the cointegration vector is based on Pedroni's (2000) Fully Modified OLS (FMOLS) estimator for heterogeneous panels. The FMOLS produces asymptotically unbiased estimates of the parameters of the model and standard normal distributions free of nuisance parameters. These estimations use a semi-parametric correction for endogeneity and residual autocorrelation bias in the OLS estimation. The FMOLS estimator of Pedroni (2000) allows for a high degree of heterogeneity in the panel. This is a particular advantage over pooled estimators such as Pedroni (1996) especially when dealing with aggregate data as in this application. It is based on the group mean of individual FMOLS estimators and it provides consistent point estimates of the sample mean of the heterogeneous panel. The heterogeneous version of the FMOLS has as an advantage over other parametric methods such as Dynamic OLS in that it does not assume a specific form of the nuisance parameters, making it more robust (Pedroni, 2000).

4. Results.

Table 1 provides the results of the panel unit root tests on the variables used for estimation.[8] The table contains the LL and IPS tests both for the levels of the variables and its fist difference. All variables seem to be I(1) – in all cases we cannot reject the null of a unit root in the levels of the variables and we can reject the null in the first difference. The only exception is *KH*, for which the LL test cannot reject the null of a unit root in the first difference. The more reliable IPS test, however, rejects the null. Given these results it is clear that we need to make use of cointegration analysis in order to establish if our specifications are long run equilibrium equations.

Cointegration tests are incorporated in the tables containing the estimation results using FMOLS (Tables 2 to 4). In most of the cases the four cointegration tests reject the

[8] All the results were obtained using the econometrics package RATS 5.0.

null of no cointegration between the variables involved, with the panel tests usually yielding smaller negative numbers due to their homogeneity restrictions. The main exceptions are specification (i), in which the ADF tests cannot reject the null in any of the groups considered, and specification (v) for the G7 countries, in which both panel tests point to no cointegration. The general picture, however, shows that all our specifications constitute long run cointegration vectors, which supports the theory model.

The results from Table 2 show the point estimates of the coefficients for the whole sample of 21 countries. Income and price elasticities are highly significant in all specifications, with price elasticities remaining pretty stable in all five specifications. Income elasticities are less stable and in all but one case, specification (iv), significantly exceed one. The impact of the home stock of R&D is always positive and highly significant and its elasticity ranges between 0.12 and 0.35, confirming the results of previous studies. The impact of the foreign knowledge stock appears to be positive but insignificant in specification (iii). However, once we control for the degree of openness by using both trade and FDI-output ratios, the impact of foreign R&D is positive and highly significant. The parameter is, as we would expect, smaller than that of the home stock of R&D. The important fact, however, is that, once we control for the degree of openness, the net effect of the foreign stock of knowledge is positive. According to the model presented above, this would point to a strong impact of the knowledge spillover effect, and would be larger the higher the degree of openness of the economy.[9]

[9] We carried out a sensitivity analysis of the results to the sequential dropping of one of the countries in the sample. The results, not reported here for the sake of space, show a remarkable stability. The only case in which there was a significant change in the parameter estimates was when we dropped the US from the estimations for the G7 group reported in Table 3. This can also be due, however, to the small cross-sectional dimension of the G7 panel.

Table 3 reports the results for the group mean FMOLS estimates for the G7 countries. The results for the income and price elasticities do not differ from the whole sample estimates. The main difference lies on the technology variables. When we introduce the foreign technology variable the impact of domestic R&D is significantly larger than that obtained previously for the 21 countries. Specification (iii) shows that the foreign stock of technology has a significantly negative impact on exports that nearly mirrors the positive impact of domestic technology. This result would support the standard specification that uses relative innovation levels, and assumes $\varepsilon = 0$ and $\varphi = \phi$ for the G7 countries. This is consistent with the hypothesis that most advanced countries rely more on home produced technology. When we control for the degree of openness, however, the impact of the foreign stock of R&D becomes insignificant. That is, the spillover effect seems to choke off the competing market share effect when we control for the degree of openness to trade and FDI. The elasticity of the home stock of knowledge, however, is less stable in this case and in some cases the cointegration tests cannot reject the null of no cointegration. This calls for a certain degree of caution when interpreting the G7 results.

Table 4, finally, presents the results for the less advanced countries of the sample. In this case the elasticity of the home stock of knowledge is more stable and, in most cases, presents a lower value than that for the G7. An important result here is that, in all three specifications incorporating the foreign stock of knowledge, the impact is highly significantly positive. Regardless of whether or not we control for the degree of openness, the spillover effect seems to have a strong impact on exports for these countries. This is an expected result, given that this set of economies is more likely to rely on knowledge produced abroad that is then incorporated at home in the production of new varieties or qualities of goods.

Overall, the results support the view that knowledge spillovers are an important factor determining export competitiveness for this set of OECD economies.

5. Conclusions.

Product differentiation and increases in quality are key factors in explaining the export performance of advanced economies. These factors are usually associated in the empirical literature with innovation variables. The usual assumption made by empirical studies, however, is that knowledge accumulation will only affect positively the export performance of the economy producing it. We have argued in this paper that this is not necessarily the case if international knowledge spillovers exist. We presented a simple model of trade with monopolistic competition in which the number of varieties depends on both the stock of home and foreign knowledge. We show that it is possible for foreign knowledge accumulation to have a positive impact on home exports due to the international flow of ideas that takes place between open economies.

The model is then estimated for a set of 21 OECD economies for the period 1971-1990 using panel cointegration techniques. The results show that, for the G7 group, foreign knowledge has a negative impact on exports that becomes neutral when we control for the degree of openness. For the less advanced countries in the sample, however, we find that foreign knowledge has a strong positive impact on competitiveness. These results are relevant for research addressing the impact of technology and innovation on export capacity. An important question for future research is to identify the importance of knowledge spillovers in studies trying to analyze export performance at the sectoral level.

REFERENCES

Baltagi, B.H. and Kao, C.W. 2000. 'Nonstationary Panels, Cointegration in Panels and Dynamic Panels: a Survey.' *Advances in Econometrics*, 15, 7-51.

Banerjee, A. 1999. 'Panel Data Unit Roots and Cointegration: And Overview.' *Oxford Bulletin of Economics and Statistics*, Special Issue, 607-629.

Barrell, R. and Pain, N. 1997. 'Foreign Direct Investment, Technological Change and Economic Growth within Europe.' *Economic Journal*, 107, 1770-1786.

Blake, A.P. and Pain, N. 1994. 'Investigating Structural Changes in UK Exports: The Role of Innovation and Direct Investment.' National Institute of Economics and Social Research, Discussion paper No. 71.

Carlin, W., Glyn, A. and Van Reenen, J. 2001. 'Export Market Performance of OECD Countries: an Empirical Examination of the Role of Cost Competitiveness.' *Economic Journal*, 111, 128-162.

Coe, D.T. and Helpman, E. 1995. 'International R&D Spillovers.' *European Economic Review*, 39, 859-887.

Dixit, A. and Stiglitz, J.E. 1977. 'Monopolistic Competition and Optimum Product Diversity.' *American Economic Review*, 67, 297-308.

Driver, R. and Wren-Lewis, S. 1999. 'New Trade Theory and Aggregate Export Equations: an Application of Panel Cointegration.' University of Exeter Discussion papers in Economics 99/17.

Fagerberg, J. 1988. 'International Competitiveness.' *Economic Journal*, 98, 355-374.

Greenhalgh, C., Taylor, P. and Wilson, R. (1994), 'Innovation and Export Volumes and Prices, a Disaggregated Study.' *Oxford Economic Papers*, 46, pp. 102-134.

Helpman, E. and Krugman, P.R. 1985. *Market Structure and Foreign Trade*. MIT Press, Cambridge, Massachusetts.

Houthakker, H. and Magee, S.P. 1969. 'Income and Price Elasticities in World Trade.' *Review of Economics and Statistics*, 51, 111-125.

Im, K.S., Pesaran, M.H. and Shin, Y. 1997. 'Testing for Unit Roots in Heterogeneous Panels.' Mimeo, Department of Applied Economics. University of Cambridge.

Jaffe, A. and Trajtenberg, M. 1998. 'International Knowledge Flows; Evidence from Patent Citations.' NBER Working Paper No. 6507.

Krugman, P.R. 1979. 'Increasing Returns, Monopolistic Competition, and International Trade.' *Journal of International Economics*, 9, 469-479.

Krugman, P.R. 1989. 'Differences in Income Elasticities and Trends in Real Exchange Rates.' *European Economic Review*, 33, 1031-1054.

Lane, P.R. and Milesi-Ferretti, G.M. 2001. 'The External Wealth of Nations: Measures of Foreign Assets and Liabilities for Industrial and Developing Nations.' *Journal of International Economics*, 55, 295-316.

Levin, A. and Lin, C-F. 1993. 'Unit Root Tests in Panel Data: New Results.' Department of Economics, University of California, San Diego. Discussion Paper, 93/56.

OECD 2001. *Main Economic Indicators*. OECD, Paris.

Parente, S.L. and Prescott, E.C. 1994. 'Barriers to Technology Adoption and Development.' *Journal of Political Economy*, 102, 298-321.

Pedroni, P. 1996. 'Fully Modified OLS for Heterogeneous Cointegrated Panels and the Case of Purchasing Power Parity.' Working Paper in Economics 96/020, Indiana University.

Pedroni, P. 1999. 'Critical values for Cointegration tests in Heterogeneous Panels With Multiple Regressors.' *Oxford Bulletin of Economics and Statistics*, Special Issue, 653-670.

Pedroni, P. 2000. 'Fully Modified OLS for Heterogeneous Cointegrated Panels.' *Advances in Econometrics*, 15, 93-130.

Senhadji, A. S. and Montenegro, C.E. 1999. 'Time Series Analysis of Export Demand Equations: A Cross-Country Analysis,' *IMF Staff Papers*, 46, 259-273.

Wakelin, K. 1998. 'The Role of Innovation in Bilateral OECD Trade Performance.' *Applied Economics*, 30, 1335-1346.

TABLES

Table 1. Panel unit roots tests.

	Levels		First difference	
	LL-ADF	IPS-ADF	LL-ADF	IPS-ADF
Y^F	5.703	8.077	**-10.614**	**-14.491**
Z	6.097	8.229	**-13.012**	**-17.225**
RER	1.320	-0.023	**-7.489**	**-10.352**
KH	7.326	11.162	**-2.124**	**-2.788**
KF	5.375	6.611	-1.436	**-3.079**
$m{\cdot}KF$	5.008	5.458	**-8.977**	**-12.447**
$fdi{\cdot}KF$	3.862	4.304	**-15.187**	**-18.918**

Notes:

(1) The LL-ADF is the modified panel unit root test of Levin and Lin (1993). The IPS test is based on Im et al. (1997).

(2) Bold characters denote the rejection of the null of a unit root at the 5% level (critical value –1.64)

Table 2. Export function 21 countries. Panel estimation using FMOLS.

	(i)	(ii)	(iii)	(iv)	(v)
Y^F_{it}	1.73	1.28	1.70	1.05	1.41
	(88.19)	(24.70)	(27.04)	(20.94)	(28.15)
RER_{it}	-0.25	-0.26	-0.34	-0.33	-0.27
	(-13.85)	(-18.71)	(-28.32)	(-21.28)	(-22.59)
KH_{it}		0.19	0.35	0.15	0.12
		(5.20)	(8.82)	(5.25)	(3.69)
KF_{it}			0.09		
			(1.23)		
$m \cdot KF_{it}$				0.04	
				(4.61)	
$fdi \cdot KF_{it}$					0.08
					(9.73)
$N*T$	420	420	420	420	420
Panel PP-stat	**-2.712**	**-3.247**	**-3.570**	**-3.233**	**-3.245**
Panel ADF-stat	-1.610	**-2.921**	**-4.333**	**-2.552**	**-3.602**
Group PP-stat	**-2.598**	**-3.444**	**-3.805**	**-3.841**	**-4.091**
Group ADF-stat	-1.442	**-4.028**	**-5.590**	**-4.411**	**-5.931**

Notes:

(1) The estimations are based on panel data for the 21 countries for the period 1971-1990. T-ratios in parenthesis. Bold numbers indicate rejection of the null of no cointegration in the panel cointegration tests.

(2) All equations include unreported country specific fixed effects.

(3) The maximum lag for the truncation window chosen was 4.

Table 3. Export function G7 countries. Panel estimation using FMOLS.

	(i)	(ii)	(iii)	(iv)	(v)
Y^F_{it}	1.75	1.46	1.66	1.50	1.65
	(62.56)	(9.44)	(14.46)	(11.29)	(12.07)
RER_{it}	-0.31	-0.31	-0.30	-0.34	-0.31
	(-12.47)	(-12.71)	(-16.64)	(-17.65)	(-13.73)
KH_{it}		0.08	2.26	1.98	0.21
		(2.18)	(9.69)	(8.05)	(7.02)
KF_{it}			-2.15		
			(-9.98)		
$m{\cdot}KF_{it}$				0.03	
				(0.40)	
$fdi{\cdot}KF_{it}$					-0.21
					(0.31)
$N{*}T$	140	140	140	140	140
Panel PP-stat	**-1.871**	**-1.698**	**-2.020**	-1.224	-1.195
Panel ADF-stat	-0.510	**-1.741**	**-2.287**	**-1.968**	-0.891
Group PP-stat	**-2.131**	**-1.652**	**-1.665**	**-2.084**	**-1.828**
Group ADF-stat	-0.690	**-1.843**	**-2.848**	**-2.156**	**-2.883**

Notes:

(1) The estimations are based on panel data for the G7 countries for the period 1971-1990. T-ratios in parenthesis. Bold numbers indicate rejection of the null of no cointegration in the panel cointegration tests.

(2) All equations include unreported country specific fixed effects.

(3) The maximum lag for the truncation window chosen was 4.

Table 4. Export function non-G7 countries. Panel estimation using FMOLS.

	(i)	(ii)	(iii)	(iv)	(v)
Y^F_{it}	1.73	1.20	1.72	0.83	1.29
	(63.77)	(23.57)	(22.90)	(17.67)	(25.94)
RER_{it}	-0.23	-0.24	-0.36	-0.32	-0.24
	(-8.14)	(-13.93)	(-22.92)	(-13.59)	(-17.96)
KH_{it}		0.25	0.14	0.24	0.15
		(4.89)	(3.28)	(5.36)	(3.07)
KF_{it}			0.28		
			(2.26)		
$m \cdot KF_{it}$				0.05	
				(5.93)	
$fdi \cdot KF_{it}$					0.04
					(6.95)
$N*T$	280	280	280	280	280
Panel PP-stat	**-1.997**	**-2.843**	**-2.949**	**-3.223**	**-3.263**
Panel ADF-stat	-1.560	**-2.878**	**-3.702**	**-3.359**	**-4.059**
Group PP-stat	**-1.674**	**-3.064**	**-3.482**	**-3.231**	**-3.717**
Group ADF-stat	-1.279	**-4.338**	**-4.832**	**-4.535**	**-5.225**

Notes:

(1) The estimations are based on panel data for the non-G7 countries for the period 1971-1990. T-ratios in parenthesis. Bold numbers indicate rejection of the null of no cointegration in the panel cointegration tests.

(2) All equations include unreported country specific fixed effects.

(3) The maximum lag for the truncation window chosen was 4.