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Technology Spillovers and Trade: Empirical Evidence for the G7 Industrial Countries

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Technology Spillovers and Trade: Empirical Evidence for the G7 Industrial Countries

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Abstract: The paper tests a model of trade in manufacturing products of major G7 countries for the period 1974-1990. Earlier studies demonstrated that market shares are a function of relative export prices (unit export values) and a proxy for the comparative technological advantage (share of international R&D expenditures or patent counts). The present paper extends this approach by including an indicator of R&D spillovers in addition to direct R&D expenditures and other variables. The indicator for inter-industry flows of R&D spillovers is based on input-output matrices of patents using cross-classification of Canadian patents (PATDAT) according to the most likely 2 digit SIC industry of manufacture and use of the patented invention. The preliminary results suggest that technology spillovers received by an exporting country industry (sector) are rarely a significant determinant of its share of EEC imports.

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Introduction

The new international trade literature broaded traditional trade models by formally recognizing that export performance in oligopolistic and monopolistic industries also depends on non-price competition. Invention, innovation, technology transfer, product differentiation and technological rivalry were included among the main determinants of export flow evolution (Posner,1961; Krugman, 1979; Brander and Spencer, 1982).

The relationship between technology and foreign trade composition and evolution has been the focus of empirical studies well before empirical insights were formalized and integrated in the "new" trade theory. The first studies examined the contemporaneous cross-section association between technology factor and export performance (for a survey of this literature see Soete, 1981).

Hanel (1976) cast the problem in a comparative static framework. His model uses changes in price and technological competitiveness to explain changes in a country's share of international export markets not explained by export territorial and/or industrial composition (i.e. the residual, "competitive effect " identified by constant market share analysis). The share of international export markets was measured by the change in unit value of manufacturing exports, and the changes in price and technological competitiveness by the change in share of total R&D expenditures across all countries in the sample. Even though the low number of observations did not allow robust empirical estimates to be obtained, regression results nevertheless suggest that variation in export market shares is associated with changes in price and R&D competitiveness.

A recent study by Magnier and Toujas-Bernate (1994) explored the relationship between export market share and price competitiveness. This study showed that the growth of export market share of industrialized countries cannot be explained satisfactorily by the evolution of price competitiveness alone. For instance, Japan's growing export market share from 1979 to 1987 has been accompanied by a rise in relative export prices, i.e. by decreasing price competitiveness. Their model uses relative price, share of R&D expenditures and investment rate to explain export market share ratio (exports to the OECD market) of five major industrialized countries by country/industry. The latter two explanatory variables represent supply factors, while the demand side effect is shown by the relative prices. The economic model is very similar to Hanel's (1976), although the availability of a richer database made it possible to use more sophisticated econometric methods than those possible in the 1970s. The empirical findings of their study appear to be quite robust and indicate that supply factors do indeed matter. The variation of OECD export market share is associated positively with both demand and supply factors, i.e. with relative prices on one hand and with relative investment rate and R&D effort on the other. The adjustment of export market shares takes time; the estimated long run effect is more than twice as large as the current year effect. As expected, there are significant inter-industry differences in R&D elasticity-R&D-intensive sectors displaying a larger effect of R&D on export share than sectors performing less R&D.

We admit that our approach has the major shortcoming of not considering technological externalities between industrial sectors. We suggest that "a consistent improvement would be to use technology flow matrices between industries…".

Firms generate new technologies and their behaviour is determined by national environments as well as by increasingly global competition. The endogenous character of innovation means that the process is rooted within each country or region. However, technology is a non-rival good and in many cases its creators and owners cannot exclude others from making unauthorized use of it. These spillovers of technological knowledge explain why social returns to innovation typically exceed private returns. Grossman and Helpman (1991) integrated domestic and international knowledge spillovers in their theoretical model of international trade. Empirical evidence of the effect of technological externalities on trade is limited. More often, international trade and/or international investment is considered as the carrier of international spillovers of knowledge and new technology. The first empirical study that looked at the association of technology spillovers and trade shares is Ioannidis and Schreyer's (1997). They use the input-output flow of R&D incorporated in intermediate goods and investment as a proxy for inter-industry technology flows. They did not find any evidence to corroborate their hypothesis that that R&D incorporated in intermediate and investment goods has an effect on export competitiveness. Their results indicate that an increase in industry's R&D effort is positively associated with an increased export competitiveness. The relationship is particularly important and significant in R&D-intensive industries.

The main objective of this paper is to attempt to better measure the contribution of R&D to export performance, by refining R&D indicators and adding inter-industry technology flows to the set of explanatory variables of relative export share. Another important distinctive feature of the present paper is our belief that exports competing in the same market should be studied to correctly test the export market share model. Hence, we will use the share of exports to the EEC rather than to all OECD countries as did Magnier and Toujas-Bernate. We recognize that over the period under study, the EEC was far from being the ideal market for this purpose. Exports to the EEC by non- member countries were certainly affected by changes in the EEC's commercial and industrial policies over time. However, we believe that considering exports to the EEC only, rather than to all OECD countries, brings us one one step closer to a meaningful market definition.

Another distinctive element of our study is that it includes the G7 group of exporting countries, because we have added Canada and Italy to the original G5 countries (the United States, Japan, United Kingdom, Germany and France) and included observations for an additional three years.

The empirical part of the paper presents the specification of the model, construction of the variables, including technology spillover indicators, a brief discussion of econometric specifications and preliminary results of the relative export market share model.

An economic model of export market shares

The economic model relating the export share of a country /industry to a series of demand and supply factors (the latter also including technology spillovers) is an extension of Hanel (1976) and Magnier-Toujas-Bernate (1994). Since the latter paper discusses the issue of price and non-price competitiveness thororoughly, our paper will focus on indicators of technology effort and their spillovers.

The export market share ratio MSX_{mj} for country m in industry j is a function of a set of demand and supply factors F_{mj} , where relative prices represent the demand side, and supply side factors are represented by indicators of relative technology effort and investment.[1] In reality, both country and industry parameters vary so that the ideal approach would be to specify the function (1) for each country and industry pair independently. We have not done this because of the limited number of periods for which data is available. One way to make the model tractable is to impose restrictions on coefficients so that each elasticity is a sum of an average effect (β, a country-specific effect (β_m), and an industry-specific effect (β_j).

$$MSX_{mj} = \alpha_{mj} + (\beta + \beta_m + \beta_j)\, F_{mj} \quad \text{with } \Sigma_m \beta_m = \Sigma_j \beta_j = 0 \qquad (1)$$

$$F_{mj} = f\,(P_{mj}/\Sigma_m P_{mj}\ ,\ IN_{mj}/\Sigma_m IN_{mj}\ ,\ RD_{mj}/\Sigma_m RD_{mj})$$

where the summation sign includes the other six countries. Relative prices are represented by $P_{mj}/\Sigma_m P_{mj}$, relative investment/value added by $IN_{mj}/\Sigma_m IN_{mj}$, and relative R&D expenditures by $RD_{mj}/\Sigma_m RD_{mj}$.

The model does not take explicitly consider other determinants of export performance other than those captured in the three indicators. Since the model is tested using time series, we assume that variation over time of other factors not included in the model is relatively small compared to variation in price, investment and technology indicators.

In theory export shares adjust to a long run target MSXij*. In reality they adjust only partially with a certain adjustment speed. The adjustment mechanism will be specified in the empirical section and its estimation will yield the short-term and long-term response (elasticities) of the relative export market share to changes in the predetermined variables.

Technology indicators and empirical measurement of technology spillovers

The rationale for using an R&D indicator as a proxy for the effect of innovations on the relative export market share rests on the following assumption: an industry *j* in a country *m* that increases its R&D expenditures relative to its competitors[2] will innovate and the export of new and improved products will increase its share of the export market at unchanged or even higher relative prices. In order to be able to deliver new and improved products, the innovating industry is likely to be compelled to expand its production capacity; this is expected to be reflected in the increase of the relative investment rate. Thus the technology and investment indicators are proxies for two closely related supply-side determinants of export performance.

Previous studies used total R&D expenditures as a proxy for the export-enhancing effect of research and development. This approach can be improved on at least two counts. First, instead of relying solely on R&D (an indicator of input in the innovation process), it is desirable to consider R&D process outputs. Second, previous studies used total R&D expenditures[3] as a proxy for the creation of new and/or improved products that ultimately lead to enhanced export performance. Since in some industry sectors a significant part of research and development activity aims at discovering and introducing process innovations, using total R&D expenditures as a proxy for improved product innovation certainly introduces some measurement error. In industries where a large portion of R&D is spent on production process improvements, a successful process innovation should presumably lead to lower prices. Thus the effect of the portion of R&D that resulted in improved production process should in principle already be included in the relative price variable. On the one hand, using a more specific indicator of product-improving R&D should improve empirical test precision, if indeed the R&D indicator of R&D accounts for the supply side effect not already included in the relative price. One of the contributions of the present paper is to propose and test more precise indicators that consider an industry’s own product-oriented R&D activity.

The innovation process is a combination of learning, absorbing and creating new industrial knowledge. Inventors, researchers and engineers and managers are learning from their colleagues, competitors, and also from scientific and technological advances even in seemingly unrelated areas. This is so because creators of new technology are unable to perfectly control and appropriate the new information they have created. Thus an unknown fraction of new technology "leaks out" and becomes available to those able to use it to their own benefit.[4] This is Griliches' (1979) knowledge spillover that occurs in what we shall call the technology space.

The technology space should not be confused with the economic space. The former is defined in terms of scientific and technological information, the latter in terms of production and sales of goods and services. The technology space is described by patent classification, the economic space by industrial classification and standard international trade classification (for the international trade of goods). We have had to combine information from these three types of classification systems, which certainly introduces an unknown margin of measurement error in our empirical analysis.

When inter-industry flows of technology spillovers are considered, it is possible and useful to make a conceptual distinction between the creation and the use of own technology and the use of technology received from other sectors. The following section presents the construction of technology indicators used in the present study.

Indicators of creation of own and use of received technology

In the present study, spillovers[5] are estimated using a combination of information on R&D expenditures and patent statistics. This has the advantage of combining information on the inputs and outputs of the innovation process. On the other hand, both R&D and patent counts have several shortcomings of their own (Pavitt K, 1985), Griliches (1989, 1990). We have assumed that Canadian patents issued to firms from the G7 countries are representative of their type and direction of R&D activity. This is a very strong hypothesis involving an unknown margin of error. We use the PATDAT database in spite of its obvious shortcomings, because it is the only available source of information of this type; other researchers have used it for the same reason (Kortum & Putnam, 1997). Following the work of ((Scherer F.M., 1982)), (Englander Steven A., 1988), (Hanel, 1994) and (Hanel, 2000), we created matrices estimating inter-industry flows of technology as being proportional to patent-weighted R&D expenditures for the G7 countries (United States, Japan, United Kingdom, Germany, France and Italy). In order to eliminate short-term variation, the technology flow matrices were constructed for three periods, 1978-81, 1982-85 and 1986-1989.

The distribution of R&D used by industry *j* in country *m* is estimated from the matrix of patents awarded in Canada to business patentees from each of the G7 countries. There are seven such "national" matrices, one for each country. The elements of each national patent matrix $[P_{ijm}]$ indicate the number of Canadian patents issued to firms from country *m*. The subscript *i* indicates the industry that is most likely to manufacture the patented invention, according to the best judgement of Canadian Patent Office experts. The subscript *j* indicates the industry most likely to use it, and *m* denotes the country of origin of the firm holding the patent. Using the information from the national patent matrix we calculate the patent output coefficient p_{ijm} for each country m.

$$p_{ijm} = \frac{P_{ijm}}{\sum_j P_{ijm}}$$

The patent output coefficient p_{ijm} is then used to distribute R&D expenditures of that country across user industries j in the following way. We first estimate the portion of R&D that is related to creating new and/or improved products. The product-related R&D expenditures of each manufacturing industry *i* are then distributed over the user industries in proportion to the patent output coefficient. Formally, $PR_{ijm}=[R_{im}.p_{ijm}]$, where PR_{im} is the product-related R&D

expenditure by industry *i* in country *m*. The resulting matrix $[PR_{ijm}]$ represents technology flows–inter-industry spillovers-from industry *i* to industry *j* in country *m*.

These national input-output matrices of inter-industry flows are then used to construct the following indicators of R&D activity and the inter-industry spillovers within each country (the country subscript is omitted here to simplify notation):

Own product-oriented R&D activity – the portion of R&D expenditures of industry *j* allocated to product innovations, PR_j
Received product-oriented R&D – The sum of product-oriented R&D done by other manufacturing industries *i* potentially used by industry *j*, $\sum_i PR_{ij}$. This is the measure of spillovers deemed to be received and used by industry j for developing new and improved products
Total product-oriented R&D used by industry *j*, equals the sum of own and received product-oriented R&D, $PR_j+\sum_i PR_{ij}$

We recognize that the proposed indicators of spillovers are far from being a perfect measure of technology flows. In reality, technological knowledge spills over not only between industries in the same country but also between firms in the same industry (intra-industry spillovers) and between countries as well. Because international trade, along with international investment and the resulting production of multinational firms, is one of the principal carriers of international spillovers, it appears impossible to use the existing proxies for international spillovers in the context of a study attempting to explain international trade. Another aspect not taken properly into account by the proposed indicators is an appropriate measure of the so-called productivity spillovers (Griliches, 1979). These represent purchases of inputs at a price below the real cost of the new technology.[6]

An econometric model

Since one of our objectives is to replicate and then to expand the results of Magnier and Toujas-Bernate (1994), we have tried to follow their econometric procedure as closely as possible given the often cursory description of their approach.

The empirical model is a partial adjustment procedure that allows estimation of long-run adjustment to the target export market share MSX* according to the following specification allowing for industry- and country-specific effects.

$$MSX_{mj\,(t)} - MSX_{mj\,(t-1)} = \mu\,(MSX_{mj(t)}^{*} - MSX_{mj(t-1)}) \qquad (2)$$

We experimented with five models and their variants. The first four replicate equations are estimated by M&T-B, the last includes technology spillovers and is estimated in several variants (subscript t left out for simplicity). Only the results of the last two specifications are presented.

(i) $$MSX_{mj}^{*} = a_{mj}\,P_{mj} + u_{mit}$$

(ii) $$MSX_{mj}^{*} = a_{mj}\,P_{mj} + b_{mj}\,IN_{mj} + u_{mit}$$

(iii) $MSX_{mj}^* = a_{mj} P_{mj} + c_{mj} RD_{mj} + u_{mit}$

(iv) $MSX_{mj}^* = a_{mj} P_{mj} + b_{mj} IN_{mj} + c_{mj} RD_{mj} + u_{mit}$

(v) $MSX_{mj}^* = a_{mj} P_{mj} + b_{mj} IN_{mj} + d_{mj} ROWN_{mj} + e_{mj} RREC_{mj} + u_{mit}$

Where m and j are respectively country and industry indexes, P is the relative price, IN relative fixed investment, RD relative total R&D expenditures, ROWN relative expenditures for own product-oriented R&D and RREC an indicator of relative R&D spillovers received from other industries.

The estimation method

All variables were transformed in logarithms. Since we have seven countries, 19 industries and 17 annual observations, we used pooled cross-section time-series methods. This type of data suffers from heteroskedascity between cross-section units and autoregression in the time series. In order to eliminate both heteroskedascity and autocorrelation, we used a cross-sectionally heteroskedastic and time-wise autoregressive generalized linear regression model introduced by Parks (1967), specifies according to Kmenta (1986; ch. 12) and implemented by Shazam (1997, version 8) software. The model assumes heteroskedasticity $E(\epsilon_{it}^2)=\sigma_i^2$, cross-section independence $E(\epsilon_{it}\,\epsilon_{jt})= 0$, and autoregression $\epsilon_{it} = \rho_{i,}\, \epsilon_{i\,t-1} + v_{it}$

To reduce the problem created by the larger number of cross-section units (19 industries) than periods (17), we used Kmenta's approach for estimating the generalized least square (GLS), constraining the values of ρ_i in the (–1, 1) interval.

All variables are expressed as log deviations from their temporal mean value. This means that levels remain unexplained and only dynamic conclusions can be drawn. Since we have seven countries and 19 industries of very different sizes, OLS would introduce a heteroskedascity bias. To eliminate this bias, we use the feasible generalized least squares statistical model, a standard two-step approach for situations involving heteroskedasticity. The actual implementation allows for two alternative specifications. The first is a dummy variable model which replicates Magnier and Toujas-Bernate's (1994) approach. In the first step the OLS estimates generate the variance of each cross-section group σ_{ij} which is then used to weight each observation of the particular cross-section unit (country, industry or sector and the country-industry couple depending on the specification). In this specification most of the autocorrelation is taken care of by including the lagged (-1) dependent variable. As in M&T-B, the average speed of adjustment μ =0.35 is held constant and is very close to the estimated average coefficient for the whole sample.

The second specification is a cross-sectional heteroskedastic and time-wise autoregressive generalized linear regression model introduced by Parks(1967), specified according to Kmenta (1986; ch. 12) and implemented by Shazam (1997, version 8) software. The model assumes heteroskedasticity $E(\epsilon_{it}^2)=\sigma_i^2$, cross-section independence $E(\epsilon_{it}\,\epsilon_{jt})= 0$ for $i \uparrow j$, and autoregression $\epsilon_{it} = \rho_{i,}\, \epsilon_{i\,t-1} + v_{it}$

Since the observations include countries belonging to different trading groups and operating under different competitive conditions and innovation systems, the autocorrelation may vary from one cross-section group to another. In this case it is preferable to use a specific autocorrelation parameter ρ_i for each individual group i.

The set of explanatory variables includes the lagged dependent variable $MSX_{mj\ (t-1)}$, which is correlated with the disturbance term, leading to an inconsistent estimator of ρ_i. A consistent estimator may be obtained by restricting the value of the parameter ρ_i to the interval -1 to +1 (Kmenta, 1985, p.621). This option is also helpful to reduce the problem created by the larger number of cross-section groups than periods, encountered when the model is estimated for the 133 country-industry couples and the individual industries (19) across countries, while the number of periods is only 17.

Results

We have estimated the average elasticities of all 133 country-industry cross-section couples using Kmenta's method. The results are presented in Table 1. They show that the average long-term price elasticity (-1.14) has the expected sign. The elasticity of the export market share to relative investment shows that in the long term a capacity expansion is closely associated with an improved export market share. Both elasticities are close to those estimated by M&T-B for G5 export shares of the total OECD market (-1.17 and 0.19 respectively). In contrast to their study, the elasticity of the export market share to total research and development spending of a national industry relative to its foreign competitors is less robust in the present study. The estimated elasticity is positive but not different from zero at the conventional 5% level. When the relative share of total R&D expenditures is replaced by the relative shares of received and own product-oriented R&D, the average effect of received R&D on export share is negative while the effect of industry's own R&D is positive and statistically more significant. Thus on average, R&D spillovers received from other industries do not appear to enhance share in the EEC market.[7]

Several reasons may explain why estimates of export share elasticity to relative R&D expenditures in the present study are weaker and less robust than those obtained by M & T-B:

1. The present sample includes two countries (Canada and Italy) that were not included in the M & T-B study.
2. The period of observations is not identical.
3. The present study focused on exports to the EEC, while M & T-B's study looked at the total OECD market.

Estimates by technology sector and by industry

Previous research suggests that competitive conditions and technological opportunities vary between industries. In order to make more sense of the industry-specific results, we sub-divided industries into three groups according to Robson et al's (1988) typology of technology sectors. The *core sector* includes industries supplying technology to the rest of economy. In general, these are industries with a high ratio of R&D expenditures to value added. However, R&D-intensive industries that do not generate significant technology spillovers for other industries are not included (e.g. aerospace and petroleum refining industries are not in the core sector, but in the secondary sector). Industries in the *secondary sector* are less prominent creators and suppliers of technology spillovers and use a non-negligible amount of spillovers from the core sector. Remaining industries are grouped in the “other” sector. They contribute little technology to others and depend on technology created and "supplied" by firms included in the upstream core and secondary sector.[8]

The unequal number of industries included in each technology sector made it impossible to use the Shazam pool routine to estimate the GLS with a correction for both heteroskedascity and autocorrelation. We therefore estimated the dummy variable variant of the GLS model, transforming observations of each industry sector by $_{ij}$ (where i, j are technology sectors) to eliminate the heteroskedascity bias. The estimated equations display a very low autocorrelation coefficient (rho=0.01), suggesting that autocorrelation is negligible.

The estimated coefficients of observations by technology sectors are presented in Table 2. The table shows estimates of two equations with sector-specific slope dummy variables. The first equation relates the relative export share to the relative price, investment and total R&D expenditure in each sector across the seven countries. The estimated coefficients show that as we move from the high technology core sector to the low technology "other" sector, the estimated elasticities are changing. Estimated price elasticities are negative in all three sectors. Contrary to theoretical expectations, the high tech core sector displays the highest price elasticity and the least R&D-intensive "other" sector the lowest one. Elasticity of export shares to relative investment is highest in the "other" sector and lowest in the secondary sector.

The relationship between the relative EEC export market share and R&D is more statistically more significant and the elasticity higher in the secondary versus the high technology core sector. This is undoubtedly caused by the classification, which includes the aircraft industry (with the highest R&D elasticity) in the secondary rather than the core technology sector. Results show that we cannot reject the hypothesis that there is no statistical association between a national industry's share of total R&D expenditures of its competitors and the market share of G7 exports to the EEC in core and "other" sectors. In contrast, the hypothesis of no relationship between changes in the export market share and in R&D is rejected at the conventional 5% level.

Taking into account the received and own product-related R&D sheds additional light on the complex relationship between export market share and technology indicators. The EEC export share is positively related to technology received from other sectors only in "other" industries. In contrast, received R&D does not enhance export share market in the two other technology sectors.

Industry estimates

Industry-specific elasticities were estimated by pooling industry observations across countries and performing a GLS with correction of heteroskedasticity and autocorrelation. The estimated coefficients are presented in Table 3, where industries are arranged according to decreasing intensity of R&D/Va. The results show important variability of all estimated coefficients. More often than not, R&D elasticity is not statistically significant and the number of industries with a positive statistically significant R&D elasticity exceeds those with a negative one by only a weak margin. As the regression coefficient of the lagged dependant variable Share(-1) shows, the speed of adjustment, initially constrained to $\mu = 0.35$ for all observations, does not fit well for several industries (cf. deviations of the reg. coefficient of the Share(-1) variable from 1-0.35=0.65). Unexpected results include the negative estimates of R&D elasticities for such high tech industries as pharmaceuticals and electronics & communications equipment and the positive price elasticity of non-ferrous metals.

Estimates by country

Country-specific elasticity estimates complete the preliminary analysis (Table 4). Price elasticities for all seven countries are negative. Export shares of non-EEC members (Canada, US and Japan) are more elastic to relative price differences than those of EEC member states. With the exception of Japan, the elasticity of export share to relative investment is positive. Only the two technological giants, the US and Japan, display a positive and significant association between the variation of their share of the EEC market and relative R&D. On the other hand, R&D spillovers received from other industries might contribute marginally to the competitiveness of Germany and the UK in the EEC.

Price elasticities of EEC export market share estimated for the member states are notably lower than elasticities of their share of total OECD exports as estimated by Magnier and Toujas-Bernate (1994).

Other results

In addition to the above results, we experimented with two additional R&D proxies, own product-related R&D and the sum of own product-related R&D and product-related R&D received from other industries. The results were only marginally different from those presented above. Another series of experiments were run for a sample restricted to G5 countries (countries included in M & T-B sample). We did not, however, recalculate the shares for the 5 countries. Thus the shares are for G7 countries excluding observations for Canada and Italy. We wanted to find out whether excluding the two countries with the lowest R&D intensity from the estimating sample would result in higher values of estimated R&D elasticities, as one would expect. There was a marginal increase in some R&D elasticities, but the improvement was very modest and estimates for the G5 sample were not significantly different than from those for G7 sample.

Conclusions

Preliminary estimates of the relationship between the change in the relative share of exports to the EEC market and the changes in relative price, R&D and investment indicators suggest that:

- On average, changes in relative prices, investment and R&D and the lagged export share explain about 50% of total variance in EEC export shares.
- The estimated elasticities, especially those for R&D variables, vary significantly among technology sectors and manufacturing industry groups. The positive association between indicators changes in relative R&D effort and export share is strongest in R&D-intensive industries. It disappears or even becomes negative in many low tech industries.
- However, there two important exceptions in the high technology industries-pharmaceuticals and electronics & communications equipment. Since both industries were heavily regulated in each EEC country, their failure to conform to the pattern displayed by other high-tech industries is likely the result of regulation-related interventionist policies protecting national markets against foreign competition, especially non-EEC members.
- Productivity differences are the cornerstone of the international trade theory. Given the strong empirical evidence of the nexus between inter-industry spillovers of R&D and productivity growth, it is surprising that we found so little evidence of a positive relationship between R&D spillovers and export shares. Technology spillovers enhance export market share only in the low-tech industries belonging to the “other” sector.
- Only the two technological giants, the US and Japan, display a positive and significant association between the variation of their share of the EEC market and their own R&D expenditures. On the other hand, R&D spillovers received from other industries might contribute marginally to the competitiveness of Germany and the UK in the EEC.
- The country results suggest that to increase their share of the EEC export market, exports of non-member countries have to rely more on price and R&D competitiveness than intra-community exports of member states.

- Our estimates of the average price and investment elasticity of EEC export share are very similar to price and investment elasticities of total OECD export shares as estimated by Magnier and Toujas-Bernate(1994). In contrast, our estimates of R&D elasticities of EEC export share are smaller and less statistically significant. Because we cannot control all possible causes of this difference, we are left with an intriguing question for further research: whether the less robust relationship between R&D performance and export share is caused by export competition peculiarities in the EEC market or whether results cast doubt on the validity of the tested hypothesis.

Reference List

1. Englander S. et al. (1988). Recherche-developpement, innovation et flechissement de al productivite totale des facteurs. *Revue economique de l'OCDE No.11*.

2. Griliches Z. (1989). Patents: Recent trends and puzzles. *Brooking papers: Microeconomics* 1989, pp.291-336

3. Griliches Zvi. (1979). Issues in Assessing the Contribution of Research and Development to Productivity Growth. *Bell Journal of Economics*, 10(1), 92-116.

4. Grossman, G. and Helpman, E.(1992). *Innovation and growth in the global economy*. MIT Press, Cambridge, Mass

5. Hanel, P. (2000). R&D, inter-industry and international spillovers of technology and the total factor productivity growth of manufacturing industries in Canada, 1974-1989. Forthcoming *Economic Systems Research, (*September)

6. Hanel, P. (1994). Inter-industry flows of technology: an analysis of the Canadian patent matrix and input-output matrix for 1978-1989. *Technovation*, 14(8), 529-548.

7. Hanel, P. (1982). L'évolution de la compétitivité technologique, 1963-1976, *Revue d'économie industrielle*, No.19, 65-89

8. Hanel, P.(1976). The change of manufacturing exports as a function of R&D and price changes, in *Rentabilité de la recherche et industrielle et besoins de progrès technique.* Actes du colloque D.G.R.S.T., Paris, 14 et 15 juin 1976, Centre National de la Recherche Scientifique.

9. Ioannidis and Schreyer's (1997). Déterminants technologiques et non-technologiques de l'accroissement des parts de marché à l'exportation , *Revue économique de l'OCDE*, no.28, 1, 188-227

10. Kmenta, J. (1986). *Elements of Econometrics*, 2nd Edition, Macmillan

11. Kortum, S., & Putnam, J. (1997). Assigning Patents to Industries: Tests of the Yale Technology Concorrdance. *Economic System Research*, *9,* (2), 161-175.

12. Krugman, P.(1979). A model of innovation, technology transfer and the world distribution of income. *Journal of Political Economy*, vol.87.

13. Magnier, A. and Toujas-Bernate, J. (1994). Technology and trade: Empirical evidences for the major five industrialized countries. *Weltwitschaftliches Archiv*, Vol.130, 494-519.

14. Mairesse J. and Mohnen, P. (1995). *Research & development and productivity. A survey of the econometric literature*. Montreal: Universite de Quebec à Montreal, Dépt. d'économique,

15. Parks, R.W. (1967). Efficient Estimation of a System of Regression Equations when Disturbances are both Serially and Cotemporaneously Correlated. *Journal of the Amercian Statistical Association,* Vol. 62, 500-509

16. Pavitt K. (1985). Patent Statistics as Indicators of Innovative Activities: Possibilities and Problems. *Scientometrics vol 7 No.1-2 Page 77-99,* Science policy research unit University of Sussex (UK).

17. Posner, M.(1961). International trade and technical change. *Oxford Economic Papers,* vol.13.

18. Robson, M., Townsend, J., & Pavitt K. (1988). Sectoral patterns of production and use of innovations in the UK: 1945-1983. *Research Policy,* 17, 1-14.

19. Scherer F.M. (1982). Inter-Industry Technology Flows and Productivity Growth. *Review of Economics and Statistics,* vol.64,(nov.) 627-634.

20. *Shazam, User's Reference Manual Version* 8.0, (1997) McGraw Hill

21. Soete, L. (1981). A general test of technological gap theory, *Weltwirtschaftliches Archiv*, Vol, 117, 638-660.

Appendix

Definitions of variables and data sources

The estimates use data on manufacturing industries of the G7 industrialized countries (USA, Japan, United Kingdom, Germany, France Italy and Canada).The sample is composed of 19 industries and covers the period 1974-1990.

The trade data were kindly provided by the French Institute National de la Statistique et Études Économiques (INSEE). The R&D expenditures, gross fixed capital formation and value added are from the OECD databases ANBERD and STAN respectively. The Canadian patent PATDAT database was used to construct the R&D spillover data.

- **Export volume market share is defined as**: MSXij: Export volume (exports in constant 1980 US$) market share ratio computed as exports of each country's industry to European Economic Community (EEC 12) divided by the exports of the other six countries to the same market (i=country, j= industry) . Source: INSEE.

- **R&D indicators** (see the detailed description in the text) are relative shares of the respective country-industry indicator: Rij: Share of R&D expenditures (converted by purchasing power parity in $US) computed as the ratio of R&D expenditures by a country's industry divided by R&D expenditures of the same industry of other six countries. The share of various R&D spillover indicators are computed in the same way. Data on R&D expenditures are available for period 1973-1990. In order to smooth the year to year fluctuations, R&D shares are averaged over the preceding three years. $R_t = R_{t-1}^{0.3} R_{t-2}^{0.4} R_{t-3}^{0.3}$. In order to limit the loss of observations by smoothing, the first and second period are treated as follows: $R_{74} = R_{73}$ and $R_{75} = R_{74}^{0.4} R_{73}^{0.6}$.

Source: the ANBERD data base (OECD) and PATDAT data base (Canada)

- INij: Rate of investment, i.e. gross fixed capital formation/ value added in current prices, divided by the weighted average investment rate of the other six countries (weighted by export (volume) to the EEC), smoothed over the three last years.

$IN_t = IN_{t-1}^{0.3}\ IN_{t-2}^{0.4}\ IN_{t-3}^{0.3}$. Relative investment rate: $IN_{mj} = IN_{mj} / \propto_{m=1,7} w_{mj} . INmj$,

Where w_{mj} the export share (volume) of the country's industry relative to the other six countries.
Source: OECD STAN database

- $P_{mj:}$ Price competitiveness indicator, i.e. the unit export value of the country's industry divided by the unit export value of the other six countries (weighted by their respective export volume shares). $P_{mj} = VU_{mj} / \propto_{m=1,7} wmj.VU_{mj}$

VU is the unit value of exports**,** w_{mj} the export share (volume) of the country's industry relative to the other six countries. Source: tabulation by INSEE

Table 1: Estimated coefficients for all groups.

	Price	Invest.	R&D total	R&D rec.	R&D own	Share(-1)	R2
133 groups	-1,136[a]	0,304[a]	0,017			0,6[a]	0
(- " -)	-1,148[a]	0,303		-0,024[d]	0,044[b]	0,6[a]	0

Notes: Pooled 133, different ρ for each group (-1≤ ρ ≤ 1). Common SHARE(-1)
t-student significant at level 0,01=a; 0,05=b; 0,1=c and 0,15=d.

Table 2 : Estimated coefficients by technology sectors.

Sector	Price	Invest.	R&D total	R&D rec.	R&D own	Share(-1)
Core	-1,5[a]	0,53[a]	0,03			0,66[a] *
(- "-)	-1,5[a]	0,53[a]		0,004	0,01	
Secondary	-1,47[a]	0,10[a]	0,15[b]			
(- "-)	-1,45[a]	0,11[a]		-0,11[b]	0,23[a]	
Other	-0,74[a]	0,73[a]	-0,03			
(- "-)	-0,76[a]	0,73[a]		0,13[a]	-0,14[a]	

Notes: Dummy variables specification GLS, common SHARE(-1)
t-student significant at level 0,01=a ; 0,05=b; 0,1=c and 0,15=d.
1 st equation : R2 adj= 0510, DW=1,97; 2 nd equation : R2 adj=0,514

Table 3 : Results by industry.

Industry	R&D/Va%	Price	Investment	R&d Total	R&D rec.	R&d own	Share(-1)
Aerospace	41,8	-1,41[a]	0,73 [a]	0,55 [a]			0,59 [a]
Aerospace	(- "-)	-1,39[a]	0,79 [a]		-0,12	0,51 [a]	0,63 [a]
Computers & office	21,5	-1,98 [a]	1,24 [a]	0,37 [b]			0,35 [a]
Computers & office	(- "-)	-2,03 [a]	1,32 [a]		0,29 [d]	0,21	0,32 [a]
Electronics & com	20,3	-1,48 [a]	0,42 [a]	-0,89 [b]			0,60 [a]
Electronics & com	(- "-)	-1,59 [a]	0,37 [a]		0,06	-0,91 [b]	0,59 [a]
Pharmaceuticals	18,6	-0,60b	0,47 [a]	-1,14 [a]			0,26 [a]
Pharmaceuticals	(- "-)	-0,58c	0,68 [b]		0,65 [b]	-1,44 [a]	0,16 [a]
Instruments	12,5	-1,34 [a]	0,40	0,07			0,34 [a]
Instruments	(- "-)	-1,5 [a]	0,46		0,04	0,13	0,32 [a]
Motor vehicles	11,1	-0,39	0,20	0,41			0,75 [a]
Motor vehicles	(- "-)	-0,29	0,26		-0,05	0,26	0,76 [a]
Industrial chemicals	9,4	-0,49	0,09	-0,015			0,63 [a]
Industrial chemicals	(- "-)	-0,68	0,31		0,25 [b]	-0,26 [b]	0,44 [a]
El. Machinery	9,3	-1,50 [a]	0,19	0,13			0,59 [a]
El. Machinery	(- "-)	-1,53 [a]	0,18		0,014	0,13	0,59 [a]
Petroleum refining	6,4	-1,17 [a]	0,65 [a]	-0,38 [b]			0,45 [a]
Petroleum refining	(- "-)	-1,09 [a]	0,65 [a]		-0,06	-0,05	0,47 [a]
Non el. Machinery	4,6	-2,09 [a]	0,79 [a]	0,32 [c]			0,46 [a]
Non el. Machinery	(- "-)	-2,19	0,79 [a]		-0,02	0,28	0,46 [a]
Rubber & plastics	3,7	-0,39	0,034	0,06			0,61 [a]
Rubber & plastics	(- "-)	-0,36	0,02		0,07	0,01	0,55 [a]
Non-ferrous metals	3,7	-1,21b	0,02	0,28 [c]			0,54 [a]
Non-ferrous metals	(- "-)	-1,61 [a]	0,08		0,01	0,12	0,47 [a]
Ferrous metals	2,7	-2,5 [a]	-0,16	-0,17 [d]			0,665 [a]
Ferrous metals	(- "-)	-2,72 [a]	-0,14		0,06	-0,15	0,62 [a]
Stone, glass & cerm	2,7	-2,14 [a]	0,27	-0,11			0,60 [a]
Stone, glass & cerm	(- "-)	-2,25 [a]	0,32		0,02	-0,13	0,59 [a]
Metal products	1,5	-1,38b	-0,18	0,10			0,69 [a]
Metal products	(- "-)	-1,32b	0,05		-0,16	0,12	0,64 [a]
Food, bev & tobacco	1,0	-0,72	1,58a	0,09			0,44 [a]
Food, bev & tobacco	(- "-)	-0,69	1,89a		0,21	0,06	0,40 [a]
Paper & pulp	0,8	-0,52	0,33	0,05			0,81 [a]
Paper & pulp	(- "-)	-0,34	0,22		-0,12	0,27	0,75 [a]
Textile & clothing	0,7	-0,48	0,33	-0,05			0,70 [a]
Textile & clothing	(- "-)	-0,45	0,37		0,05	0,08	0,67 [a]
Wood & furniture	0,3	-1,82b	1,11a	0,07			0,71 [a]
Wood & furniture	(- "-)	-1,93b	1,21a		0,12	-0,03	0,65 [a]

t-student significant at level 0,01=a, 0,05=b, 0,1=c and 0,15=d

1 st equation : R2 (Buse)= 0,557, DW=1,881 ; 2 nd equation : R2 (Buse) = 0,536, DW=1,906.

Table 4 : Estimated coefficient by country

Country	Price	Investment	R&D total	R&D rec.	R&D own	Share(-1)
USA	-1,95 [a]	0,62 [a]	0,30 [a]			0,43 [a]
(- "-)	-1,97 [a]	0,64 [a]		0,20	0,19	0,52 [a]
Japan	-1,10 [a]	-0,34 [d]	0,39b			0,79 [a]
(- "-)	-1,21 [a]	-0,22		-0,17	0,71 [a]	0,80 [a]
UK	-1,18 [a]	0,313 [a]	-0,05 [d]			0,71 [a]
(- "-)	-1,23 [a]	0,33 [a]		0,10 [d]	-0,16 [b]	0,70 [a]
Italy	-0,98 [a]	0,22 [b]	0,05 [d]			0,61 [a]
(- "-)	-0,98 [a]	0,21 [b]		-0,02	0,06 [d]	0,61 [a]
France	-0,11 [a]	0,39 [a]	0,09			0,39 [a]
(- "-)	-0,09	0,40 [a]		-0,02	0,02	0,38 [a]
Germany	-0,61 [a]	0,48 [a]	-0,03			0,59 [a]
(- "-)	-0,55 [a] *	0,51 [a]		0,17 [b]	-0,07	0,59 [a]
Canada	-2,59 [a]	0,55 [d]	-0,52 [c]			0,43 [a]
(- "-)	-2,63 [a]	0,60 [a]		0,06	-0,66 [b]	0,41 [a]

t-student significant at level 0,01=a,0,05=b, 0,1=c and 0,15=d.
1 st equation: R2 (Buse) = 0,5082, DW=1,978, 2 nd equation : R2 adj= 0,517, DW=1,975

Notes

[1] We use Magnier and Toujas-Bernate (1994) specification and symbols with the exception that in the present paper the symbol k denotes the country. The need for this change in notation becomes clear in the next section where we present the construction of inter-industry spillover indicators.

[2] The indicator of technological competitiveness measured as a variation of the a country's industry share relative to the sum of R&D expenditures of other countries in the given industry, was introduced and applied to OECD countries by Hanel (1982).

[3] This was due to the data constraint. The internationally comparable R&D statistics do not provide any details on the breakdown of R&D by main objective.

[4] In order to be able to benefit from the scientific and technological advances of others, firms have to invest in basic and applied research in order to learn and/or to adopt -to imitate- new technology created by their competitors or by researchers in unrelated areas. Thus even if new technology were made available free of charge, there still is a non-negligible learning cost to firms wanting to adopt and use it.

[5] Measurement of technology spillovers has been in the forefront of empirical research on determinants of the growth of multifactor productivity and on the private and social returns on investment in R&D. For a recent survey see (Mairesse et Mohnen, 1995) and Griliches (1999)

[6] The best example is the productivity enhancing effect of purchases of new generations of computers at a steadily decreasing price/performance ratio.

[7] An alternative estimation by a dummy-variable GLS model which weighted all 133 country-industry group observations by σij only (i.e. did not include the correction for autocorrelation which is included in the reported pool estimates) gave regression coefficients of the same order of magnitude for the price and investment variables, and the same sign but statistically less significant estimates for the R&D variables compared to those presented in Table 1.

[8] The composition of sectors is as follows: Core (chemicals, pharmaceuticals, non-el. machinery, computers and office machines, radio, TV& electronic and communication eqpt., professional goods. Secondary (petroleum refining, rubber & plastics, stone, clay and glass, ferrous and non-ferrous metals, fabricated metal products, el. machinery, motor vehicles and aerospace). Other (food, beverage and tobacco, textile, apparel & leather, wood and pulp and paper products)

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