Technology and economic inequality effects on international trade

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Resumen

Desde hace décadas, numerosos trabajos empíricos apoyan la hipótesis de que la tecnología juega un papel determinante en el comercio. En este documento se emplea una perspectiva diferente, tratando de analizar los efectos de las desigualdades tecnológicas y económicas sobre las desigualdades en el comercio internacional. Los fundamentos teóricos de este trabajo se encuentran en el enfoque del *gap tecnológico*. En el estudio se analizan ocho países europeos y trece ramas manufactureras, en el período temporal 1995-2002. Para el análisis se emplea un modelo de datos de panel, siendo la unidad de análisis de sección cruzada la distancia euclídea entre países en cada rama de actividad. Dicha distancia se emplea como aproximación a la desigualdad entre países en cada industria. Se observa que las desigualdades tecnológicas y económicas afectan a las desigualdades comerciales y que los efectos varían en función del contenido tecnológico de cada rama de actividad.

Palabras clave: desigualdad tecnología, desigualdad comercial, distancia euclídea, contenido tecnológico.

Abstract

The notion that technology plays a key role in explaining trade performed was supported in the last decades by many empirical studies. In this paper we use a different perspective trying to analyse the effects of technology and economic inequalities on international trade inequalities. The theoretical framework where we built our empirical analysis is the technological gap aproach. We considered eight European countries and 13 manufacture industries in the time period 1995-2002. We made a panel data model with a cross-sectional unit of analysis: the Euclidean distance among countries in each industry. We considered the Euclidian distance as a proxy of inequality among countries in each industry. We observed that technology and economic inequalities affect trade inequality and that the effect depends on the technological contend of each industry.

Key words: Technology inequality, trade inequality, Euclidean distance, technological contend.

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1. Introduction

Over time the economic analysis has studied the main determinants of international trade based primarily, on the endowment theories and more recently on the technological views. Most of the studies have emphasized the role of technological innovation in order to explain the export and import dynamics of countries and industries. However, in very few cases these works have taken into account the uneven distribution of the factors that explain the evolution of competitiveness, which is the international and sectoral inequality. This is due to two main shortcomings: first, the way in which the technological gap between countries and industries may be measured and second the lack of a consensus about the framework on which to build up the analysis.

In the work we are carrying out the theoretical framework selected is the technology gap approach given the advantages related to the flexibility in introducing some issues like the organisational and institutional aspects –e.g. value added distribution at industrial level-.

Due to the outlined problems, some contributions -that have been developed in parallel, although more intensively as since the beginning of the 80's- have tried to explain trade factors from different points of view, although linked in one way or another to the consideration that technology is a crucial factor. However they do not generally take into account the inequality in the distribution of the technology and other kind of advantages. Even at the risk of being extremely simplistic, these approaches can be summarized as follows:

1. Trade models based on the product life-cycle theory, upheld by the renowned Vernon (1966) study, tilt towards focusing more on supply factors. Emphasis is made on companies' behaviour with regard to innovation and for how firms face risks from openness to other markets and from their own innovation, -see Graham (1979)-.

2. Intraindustrial trade models based on economies of scale and differentiation of products, analyzing trade in contexts of imperfect competition –Glejser, Jaquemin and Petit (1980)-, while is true that at the begining the emphasis was not set on aspects relatives to technology.

3. The "new theory" of international trade, emphasizing the importance of innovative activities, within imperfect competitiveness models on trade and economic growth, Grossman and Helpman (1991). These models use the steady state concept in the analysis of differences in technological activities of the economies in an adequate way. However, they seem unable to explain the changes related to trade and innovation across countries in the same way. They take into account the North-South innovative behaviour as a proxy for the technology and economic inequality.

As can be seen from this compressed summary, an inadequate treatment of some aspects explaining international trade has been provided, mainly due to three reasons. The first one, refers to the existing dynamics in the trade-technology relationship and without considering the factors indicating the temporary development of variables, which needs a suitable theoretical framework. The second, has to do with technology itself, since from its conception a completely different commercial behaviour arises according to the approach chosen. Finally, the consideration of other sources of inequality is very weak and mainly accounted for by the existing differences in wages.

These matters led to considering changing factors jointly over time, so that changes in trade are closely linked to tecnological distances between industries and countries as well as in changes in wages or investment at country and sectoral level –Kugler (2002)-. Indeed, setting the existence of different dynamics in economic and trade growth –Barcenilla and López-Pueyo (2000)- leads one to reflect on the role of technical change as a factor that affects growth –along with others- therefore, also affecting its notable importance concerning aspects linked to convergence. In this context, the development of convergence/divergence patterns between countries over time implies the existence of differences in the functions of aggregate production of countries and therefore in the technology supporting such production[1] functions.

2. Technological inequality

The joint consideration of these differences in growth, together with a conceptualization of technology as something dynamic and changing over time, lead to an *evolutionary* theoretical approach. In other words, if one assumes that technology inequality is one of the key factors that explain countries and sectors trading patterns, only an explanation of the realtionship between trade and technology with features inherent to the latter will be suitable, i.e., one that does not consider it as something given but as an ever-changing process having its own "laws" and that feedback[2] generates, in turn, virtuous circles and external effects in the rest of the economy.

Along the same line, Posner's pioneering paper (1961) draws up a relationship between temporary advantages generated by a sector through technological know-how, with the largest trading competitiveness. Posner defines dynamic economies of scale through the decrease of unit costs over time and observes that these can be due to three factors: general technical progress, accumulated experience by companies and the development of new methods regardless of previous experience. Thus, a country obtains a better trade performance than their competitors by generating new products and processes. This is the essence of the *technology gap theory* followed in the next pages. The reasons for choosing this approach can be given in terms of the capacity to reflect in a dynamic way the trade-technology relationship, the possibility of including different variables of technology itself -as will be discussed subsequently-, the role given to the mechanism of generation and diffusion of technology innovations and the capacity to include the inequality or existing technological and economic distances between industries and countries in the explanation of trade patterns.

A realistic vision of the functioning of the economic world implies admitting the coexistence of companies, sectors and countries characterized by differences in its technological and economic *performance* in relation to the technological frontier. Therefore, the existing distance between the point in which an economy is positioned with respect to the frontier defines the technology *gap*, i.e., the degree of technological asymmetry, that from a dynamic point of view is due to technology innovation as a mechanism for creating asymmetries and to technology diffusion as a mechanism for reducing asymmetries or for convergence, see for this purpose, Dosi, Pavitt and Soete (1990).

This fact involves admitting the existence of different technological *paradigms*[3] and *paths,* therefore of the possibility of discontinuities generating differences on technological and economic levels –technological inequalities- of sectors and countries. However, as has been mentioned, the diffusion and imitation reduce the technology gap, hence the attained advantages are temporary and lead to the continuing search for new products and processes to maintain the leadership or reduce the distance from the technology frontier. This statement creates certain contradiction as regards postulates concerning the product life-cycle theory, since innovations on standarized products are not taken into account, therefore –according to Wakelin (1997)- it gives the impression of technology stability with products that follow a well defined development path.

The way in which discontinuities as well as convergence/divergence processes arises, that is tos ay, the technology gap development, is bound up with the characteristics of each country and sector. There are a number of factors that contribute to changes in the gap. First, the *national system of innovation structure*, considering different aspects that build it up, such as the existing interrelations between the economic and social agents of the system. Second, sector's dynamics which has been called *technological regimes*, related to the different combinations of concentration and stability of innovation activities, the

[1] See Fagerberg (1994).

[2] Features of technology innovation have been profusely included in evolutionary literature and are related to accumulation, the partial appropriation of its results, its tacitness and specific character -i.e., only partially public-, different sources of generation, ranging from the most formal as R&D to the most informal as learning by doing, and the risk it involves. A great number of these concepts can be seen in Dosi (1988), et.al.

[3] For a detailed analysis of these concepts see Nelson and Winter (1977) and Sahal (1981).

emergence of innovation undertakings, its innovation size and the degree of technological[4] opportunities. Third, scientific and technological policies as well as other economic policies –such us industrial or trade policies-, from different perspectives its effects on incentives and risks that companies undertake concerning innovation, as well as the country's economic scenario can be either a lead or a lag factor of innovative dynamics and of the absortion of knowledge capacity[5]. Lastly, innovations demand, for new processes and products demand implies a further pressure on agents in order to innovate or imitate, showing a trend to closing the gap in countries more distant from the technological frontier, although it is similarly notable incentive for more developed countries.

This fact raises the issue of the effects on the convergence across countries of similar technological development and the high degree of integration –as is the case of some countries of the EU-, or what is the same, the decrease or even the ceasing of technological gaps. There are two viewpoints to analyse this matter. On the one hand, if one consider that a higher regional integration induces to improve the channels of technology transfer -together with the great significance of foreign direct investment as a paradigm-, it seems plausible that gaps are lower or even limited to the short run. However, from an evolutionary point of view due to the cumulative nature of technology –which shows its strong dependence on the past-, it can be expected that the maintenance of gaps even across countries of similar development or highly integrated.

In this paper, the second option is stated: technology is not easily transferable and its transfer includes costs usually very high. It also will be stated that the technology history of a country matters for its future possibilities and it restraints its learning capacity. Also technological opportunities vary across countries and sectors according to its national system of innovation, that is, the characteristics of a country have an effect on both its innovation or imitation possibilities and on its capacities to absorb new knowledge.

As has been pointed out by Cimoli (1988) and Cimoli and Soete (1992), technological asymmetry is the main explanatory factor of the specialisation patterns of countries and industries. However, it is not the only one. Prices and costs are still very important factors in the explanation of international competitiveness. In this sense, Amendola, Dosi and Papagni (1993) and Magnier and Toujas-Bernate (1994) and more recently, Barcenilla and Lopez-Pueyo (2000) and Fonfría et al. (2002) show that both variables affect the export share of USA, Japan and some European countries although their effect is not as strong as in the case of technology.

The inclusion of variables relative to production costs or to prices in the market tries to capture those aspects linked to traditional theories –non-technological- of international trade. It is necessary to underline the importance of this type of variables since –although its importance has declined throughout time and its effects are linked to the short run-they are competitiveness factors that discriminates in international markets. In fact, the international division of labour have changed certain countries in productive cores geared to practice multinational's strategies aimed at reducing costs and prices in order to compete in a profitable way in the markets[6].

Empirical literature has used three variables for explaining trade: wages, labour costs and prices. Along the same line, the work done by Dosi and Soete (1983), Soete and Verspagen (1994) and Wakelin (1998), state that wages are not very significant in explaining trade development, although there are notable sectoral differences that lead to think that the combination of various factors bears on the trade pattern, showing a different weighting, sometimes closer to Ricardo's behaviour and others to neo-technological behaviours in which technology is the key factor.

Very similar results are obtained from the other two variables –unit labour costs and prices- although nuances arise from considering the different level of sectoral breakdown.

[4] A theoretical as well as empirical analysis of these characteristics can be found in Orsenigo (1989), Malerba and Orsenigo (1995) and Fonfría and Granda (1999).

[5] Please note that both types of policies have been separated due that the effects on technological innovation of the former are direct while on the latter are not, or at least they are not geared to the same aim.

[6] Some well-known cases are those of companies belonging to textiles or computers sectors, which use asian countries as means of getting products of a medium-high quality at lower costs.

It is acceptable that the different significance of intraindustrial trade between countries as well as the consideration of bilateral flows or market shares globally guide differentiated results[7].

Investment on capital goods has also been used as a mean of measuring embodied technology, whether through gross fixed capital formation or taking into account capital-labour ratio –Soete (1987), Milberg and Houston (2005)-, indicating the intensity of the incorporated technology endowment by employment unit . Most of the studies have used the former indicator –Fagerberg (1988), Verspagen and Wakelin(1994),

Barcenilla and Montalvez (2000) and Fonfría et al. (2002), among others-, because of the two possible inerpretations from the demand side and the supply side. From the demand side, an increase of investment is linked to a positive evolution of the market share –as well as the domestic demand in most of the cases-. To the extent in which the capital formation requires foreign goods, it is expected to show a positive relationship with trade. From the supply side this variable captures the national supply capacity to respond to stimuli provoked by foreign and domestic demand –Barcenilla and Lopez-Pueyo (2000)-. In this case the sign could be negative. Nonetheless, the econometric results do not give a clear picture of the real effect of this variable on trade.

Table 1 includes a summary of some of the empirical studies and its outstanding features that have been stated broadly along the foregoing pages.

Table 1.- Factors explaining trade

AUTHORS	AIM	DEPENDENT VARIABLE	EXPLAINING FACTORS	CONCLUSIONS
Soete (1981)	To develop an international type of measurement for technology output in order to measure changes in international trade figures.	Exports share, revealed trade advantage, export to import ratio and exports/GDP	Patents, K/L, Population	Better results using market shares. Crucial role of patents while K/L performs poorly. Distance is an outstanding issue. In general, it does not affect natural resource-based industries
Dosi and Soete (1983)	To analyse technological differences between countries and its effect on international competitiveness.	Exports/population rate	Wages related to Value Added, K/L and patents per capita	International trade composition is explained by specific sectoral patterns of technology gaps/leads regardless of countries comparative advantages
Soete (1987)	To develop a technological output measurement linking it to other variables in order to measure trade performance.	Per capita exports and exports share	Patents, population, R&D, K/L, distance between countries	Patents and distance between countries are the most explanatory variables concerning trade performance

[7] See Amendola, Guerrieri and Padoan (1998), who use other variables for foreign trade quantification.

Fagerberg (1988)	To analyse an inter-sectoral competitiveness model which relates market share growth with three sets of factors: Competitiveness in technology, competitiveness in prices, competitiveness in capacity	GDP and market share	Labour costs, R&D expenditures and patents, investment, public consumption	Technology and capacity (investments) are key factors in explaining differences across countries in the long run in its market shares growth and its GDP. Competitiveness in prices plays a more limited role than the one usually assigned.
Magnier and Toujas-Bernate (1994)	Prices and Non-prices variables effect (R&D and GFCF) on market shares. Specific effects by country and sectors	Exports share	Exports prices, R&D expenditures, GFCF	Key role of R&D and GFCF variables in the development of market shares. Differences across countries and sectors, and its long run effects
Amendola, Dosi and Papagni (1993)	Short run and long run effects of technology changes and costs adjustment on international competitiveness of each country	Exports share	Patents share, capital goods investment and equipment, unit labour cost	Technology training and technology incorporated to capital have significant effects on trade in the long run; heterogeneity across countries revealing institutional and organisational variables of the country
Verspagen y Wakelin (1993)	To explain changes in bilateral trade from technology movements, investments, labour costs and exchange rates	Bilateral exports	Labour costs, R&D expenditures, investments, exchange rate	In general, trade shows a negative relation to wage costs, a positive relation to R&D and ambiguous to investment. Technology is a crucial determinant of trade even in low technology sectors
Soete and Verspagen (1994)	To study the relationship between technology specialisation, trade specialisation and growth, focusing on technology imitation	Revealed Trade Advantage	Wages, Investment /VA and Patents (RTA)	Patents are very significant in high-technology sectors. Wages are of less importance and investment ranks in between. Technology imitation leads to an increasing trade specialisation
Sánchez and Vicens (1994)	To explain costs and prices variables effects together with technology variables of the Spanish economy competitiveness	Market share growth in OECD	Prices, R&D expenditures, R&D efforts	Prices have a negative effect on competitiveness while technology has a positive one. In traditional sectors, technology has a positive as well as negative effect on leading edge-technology sectors
Amable and Verspagen (1995)	To analyze exports market shares determinants taking into consideration different factors of prices	Exports share	Labour costs, investments, patents share	Considerable impact of those variables that are not related to prices when determining competitiveness in the long run
Greenhalgh, et al. (1996)	To study trade figures of the United Kingdom taking into account wages, prices and technology (innovations and property rights)	Export to import ratio	Number of Innovations, patents, strikes, X/M Prices and unit exports value	Factors not related to prices are of considerable importance to explain trade performance. Technology innovation has a positive and more permanent impact than prices. Wide differences across sectors

Landesmann and Pfaffermayr (1997)	Exports demand system differentiating analysis by country of origin for two sectors	Exports share	Labour costs, R&D expenditures	The R&D effort has a positive effect on exports shares in industrialised countries (USA and the U.K) as well as on "catching-up" countries (Japan); R&D efforts has lower effects on other industrialised countries
Amendola el al. (1998)	To analyse how trade specialisation is determined by technology	Revealed Comparative Advantage and Contribution to Trade Balance Index	Patents	Patents explain a part of trade specialisation. There are three groups of countries: leaders, intermediate and small. Country's specific factors effect being of considerable importance
Wakelin (1998)	To analyse how bilateral trade across sectors and countries changes, sensitivity to figures stemmed from the innovation proxy	Bilateral Exports	Investment, wage costs, R&D expenditures and patents	Positive relation between innovation and bilateral trade either at aggregate level as well as for many sectors. The role of innovation on trade is bigger in net innovation production sectors than in net users
Grupp and Münt (1998)	To study international competitiveness changes through high-technology and leading-edge technology sectors, defining different patents scopes	Market share	Patents/ employment: : in USA, EPO, and (USA, Japan and the EU)	Technological output expressed through copyright is more significant in explaining trade of high-technology than leading-edge technology sectors. Highly important role of SIN
Barcenilla and Montavez (2000)	Analysis of Spanish foreign competitiveness determinants regarding the EU from a dynamic point of view	Exports share	Relative technological capacity, relative labour costs, fixed capital investment	The Spanish industry competes in costs and technology. The role of physical capital investment being of less significance. Technology is more important in medium-technology capacity sectors while costs are more important in lower technology content sectors
Barcenilla and Lopez-Pueyo (2000)	Analysis how technology affects trade and trade determines the evolution of growth	Export and import share	Technological payments, gross fixed capital formation, population, relative import prices, unit labour costs, GDP deflator, exchange rate	The only explanatory variable of the export share is technology. There is not a clear interpretation of the GKF.
Fonfría et al. (2002)	Analysis of the evolution of market share in to regions: EU and Latin America, including the role played by macroeconomic policies	Export share	R&D, investment unit labour costs, exchange rates, industrial policy, demand	There are very different effcts of the variables included in relation with the two export market considered, so policies must be different.

Milberg and Houston (2005)	Study the "social gap" including technological view, product cycle model approach and institutional variables	Export market share, import penetration, net foreign direct investment	Demand, RULC, R&D expenditure, K/L ratio, net union density, duration of strikescost of job lost, employment protection, social expenditure	R&D expndeing and union density seems to be the most relevant variables. Social expending and cooperative labour relations improve trade competitiveness.

Source: Fonfría et al. (2002) and own elaboration

Most of the studies on technology *gap*, consider market share as the most suitable variable to express trade development, yet other variables are also used as for example, cover rate, export/GDP percentage, revealed trade advantage or the contribution to the trade balance index. Other studies consider bilateral exports between countries thus comparing trade profits and losses between two countries (see Table 1).

Choosing the variable does not seem to be subject to theoretical criteria, beyond its own construction and meaning, provided that it reflects the exports relative magnitude of a country compared to another or to a specific area. In fact, even in the case that revealed trade advantages were considered –which indicate comparative advantages-, showing that it is a particular case for demonstrating absolute advantages in market conditions of perfect competitiveness, see Dosi, Pavitt and Soete (1990).

However, some authors have decided to use a number of trade indicators and the results do not seem to vary considerably (see, e.g., Soete (1981) and Amendola, Guerrieri and Padoan (1998)). In general, results point that market shares -both for its simple structure and interpretation, and for showing the capacity of penetration in other markets, i.e., the competitive capacity *ex post*-, is a suitable indicator, in particular for technology gap models. Nevertheless, the use of indicators such as the relationship between exports-GDP -indicator referred to the degree of openness-, does not seem to be especially suitable, because it does not show the capacity to compete in other markets[8].

[8] In fact, countries as the Netherlands or Belgium, considered small, have very high degree of trade openness due to their small size; this does not mean that they are more competitive than Germany of Japan that show lower degrees of openness.

3. The explanation of trade

As has been pointed out before, one of the most interesting contributions -from the point of view of the technology *gap* theory, tackled in great detail in terms of this kind of literature- is the recognition that the technological variable can be insufficient to account for all trade flows and also that other variables have to be taken into account. In this sense, some modifications of this framework may be very useful to analyse the effects of income and technology inequalities on international trade.

The original approach is based on technology, price and costs factors as main determinants of trade. Hence, a contribution of both types of variables seems to be the appropriate way to understand trade behaviour of countries and sectors. In this sense, Dosi, Pavitt and Soete (1990) have shown that absolute advantages based on technology, together with those advanges related to costs, can provide a wide range of sectoral situations in which the relative importance of each one of the two aspects varies considerably: "*Our hypothesis is thus absolute advantages dominate over competitive advantages as determinants of trade flows. Their dominance means that they account for most of the composition of trade flows by country and by commodity at each point in time. This dominance takes two forms. First, absolute advantages / disadvantages are the fundamental factors which explain sectoral and average competitiveness, and, thus, market shares. Second, they also define the boundaries of the universe within which cost-related adjustments take place*" (pp. 151).

These authors state the following relation:

$$X_{ij} = f(T_{ij}, C_{ij}, O_{ij}) \qquad (1)$$

In which: X_{ij} is the indicator of international competitiveness of sector i in country j; T_{ij} includes technology advantages/ disadvantages; C_{ij} includes costs differences -basically unit labour costs- and O_{ij} stands for industries ways of organization.

Regarding this last factor (O_{ij}), the difficulties in obtaining information have led to a lower treatment in empirical works, which have been focused on the use of different proxy variables relative to economies of scale, the differentiation of products and to some indicators of demand[9]. Nevertheless, it is necessary to consider its importance since the fact that the generation of innovation is very closed related to the structure of sectors[10] -according to Schumpeter's terms- and the effects of this latter clearly affect the foreign competitiveness of economies.

However, it is possible to extend and modify this framework to income and income distribution issues, including new explanatory variables in the equation. This enlargement of the approach has two positive aspects. Firstly, it takes into account the direct effect of inequality on the competitiveness of the countries. Secondly, this kind of variable includes to some extent institutional factors which differ among countries.

In general, the development of trade *performance* of each country in the long run is determined by the dynamics of those sets of variables in relation to the rest of the countries. Sectoral and each country specificity is determined, just as has been pointed out, by the system of innovation –expressed through technological distances among industries and countries- and through demand disparities accounted for by income inequality.

In short, technology gaps between countries imply the existence of an "average" *gap* of the country and the contribution to it from each sector. In other words, a country can gain market shares and lose them in particular sectors, therefore absolute advantage stemming from a higher technology has to be complemented with the vision of comparative advantage linked to the relative situation of each one of the sectors.

[9] See Caves (1981) and Bergstrand (1990).
[10] See Kamien and Schwart (1982).

From the demand side, the position of a country or sector relative to the others is measured by different indexes of distance expressing de degree of existing inequality.

From an evolutionary perspective, the dynamic equation (1) would be the following -Amendola, Dosi and Pagagni (1993)-:

$$X(t) - X(t\text{-}1) = f\,\{[E_i(t\text{-}1) - \hat{E}(t\text{-}1)\,]\,/\,\hat{E}(t\text{-}1)\} \qquad (2)$$

In which, $E_i(.)$ stands for the vector of variables affecting competitiveness -technology and income-, and $\hat{E}(.)$ stands for competitiveness average of the chosen countries.

The equation (2), does not imply to taking on any assumption related to equilibrium, so in essence, it is a model that could be called of dynamic change without balance. This formulation includes the foregoing comments on the existence of disparities in technical change and income and of constant movement affecting trade development.

4. Information and variables description

As it has been pointed out, the notion that technology plays a key role in explaining trade performance was supported in the last decades by many empirical studies. Some of them showed a strong linkage between technological innovation and international competitiveness at aggregate level (Fagerberg, 1988), other ones at the sectoral level (Soete, 1987, Dosi, Pavitt and Soete, 1990, Amendola, Guerrieri and Padoan, 1998). This empirical evidence points out the linkage between a country's technological capacity and its ability to penetrate foreign market.

In this paper we use a different perspective to analyse the relationship between technology and trade. We try to study in which sense the differences in technological capability affect trade inequality, at the sectoral level. As it was mentioned before, the theoretical framework where we built our empirical analysis is the technological gap approach, which remarks the fact that technology and costs gaps among countries and industries generate imbalances on trade performance. The accumulation of these differences along the time gives as a result the gap in trade and generates advantages and disadvantages among industries.

In the empirical analysis we considered eight European countries (Czech Republic, France, Germany, Italy, Norway, Poland, Spain and Sweden) and 13 manufacture industries following ISIC rev. 3 classification (see Table 2). The time period analysed is 1995-2002. We made a panel data model with a cross-sectional unit of analysis: the Euclidean distance among countries in each industry. We considered the Euclidian distance as a proxy of inequality among countries in each industry.

Table 2. Industrial classification

Description	ISIC Rev. 3	Technological classification
Food products, beverages and tobacco	15-16	Low-Tech
Textiles, textile products, leather and footwear	17-19	Low-tech
Wood and products of wood and cork	20	Low-tech
Pulp, paper and paper products	21	Low-tech
Coke, refined petroleum products and nuclear fuel	23	Medium-tech
Chemical and chemical products	24	High-tech
Rubber and plastic products	25	Medium-tech
Other non-metallic mineral products	26	Medium-tech
Basic metals and fabricated metal products	27-28	Medium-tech
Machinery and equipment, n.e.c.	29	High-tech
Electrical and optical equipment	30-33	High-tech
Transport equipment	34-35	High-tech
Manufacturing, n.e.c.	36	Low-tech

Note: The classification of manufacturing industries based on technology follows criteria held by:
High-tech: Included high-technology and medium-high-technology group according to OECD classification.

Medium-tech: Correspond to medium-low-technology group of OECD classification.
Low-tech correspond to low-technology group of OECD classification.

As dependent variable we considered export shares distance. The export share indicator is calculated as export of a certain industry for a given country as a percentage of exports of this industry for 23 selected OECD. Data come from OECD, STAN Indicators 2005 Database.

Following the theoretical approach chosen, as independent variables we considered the inequality existing among countries in different aspect of technological activity, labour cost and other aspect of economic structure. Concretely, we calculated the distance among R&D expenditures shares, investment intensity, labour compensation and value added. The R&D expenditure share indicator represent for each industry, the R&D expenditure for a given country relative to the R&D expenditures for 12 selected OECD countries. This variable gives an approximation to the disembodied technology. On the other side, embodied technology is calculated through the investment intensity that is calculated as the ratio of gross fixed capital formation in a certain industry to the value added in that industry.

The labour cost indicator is calculated as the ratio of labour compensation for a particular industry to the number engaged divided by the ratio of labour compensation for the total economy to the number of persons engaged for the total economy. Finally, the indicator of value added shows each industry's value added as a percentage of value added for the total economy. This indicator is a proxy of an important characteristic of the industries as is their relative size. All the data have been obtained from OECD STAN Indicators 2005 Database. (See Table 3).

In addition to explanatory variables we included country, industry and year dummies in the estimation. Country-fixed effects control for unobserved heterogeneity across countries. They reflect other country characteristics that influence on trade inequality such as cultural aspects, fiscal policy and other aspects of the national system of innovation. Industry-fixed effects considered permanent unobserved differences across industries and time dummies account for external shocks affecting trade.

Table 3. Variables description

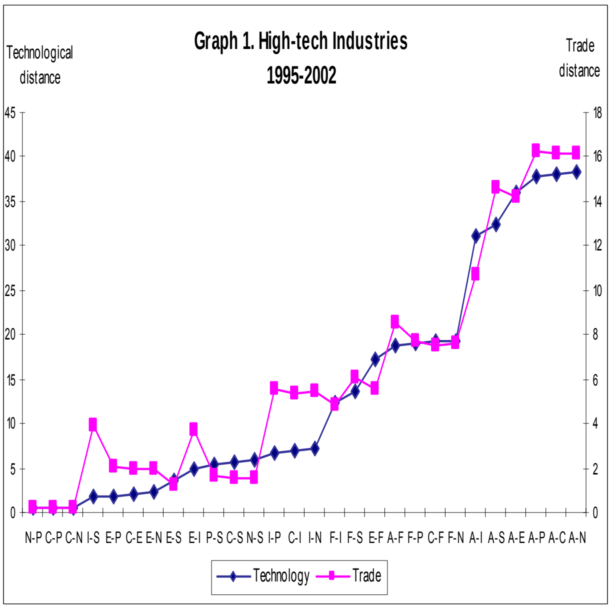
DEPENDENT VARIABLE:	
Export shares: $XS_{Ki} = \dfrac{Expo_{Ki}}{Expo_{OECDi}} * 100$	
INDEPENDENT VARIABLES:	
R&D expenditures shares: $RDS_{Ki} = \dfrac{R\&D_{Ki}}{R\&D_{OECDi}} * 100$	**Labour compensation:** $LC_{Ki} = \dfrac{LB_{Ki} / EMP_{Ki}}{LB_{Ktotal} / EMP_{Ktotal}} * 100$
Investment intensity: $INV_{Ki} = \dfrac{GFCF_{Ki}}{VA_{Ki}} * 100$	**Value added:** $VA_{Ki} = \dfrac{VA_{Ki}}{VA_{Ktotal}} * 100$
Cross-sectional unit of analysis: Euclidean distance among countries (k) in each industry (i).	

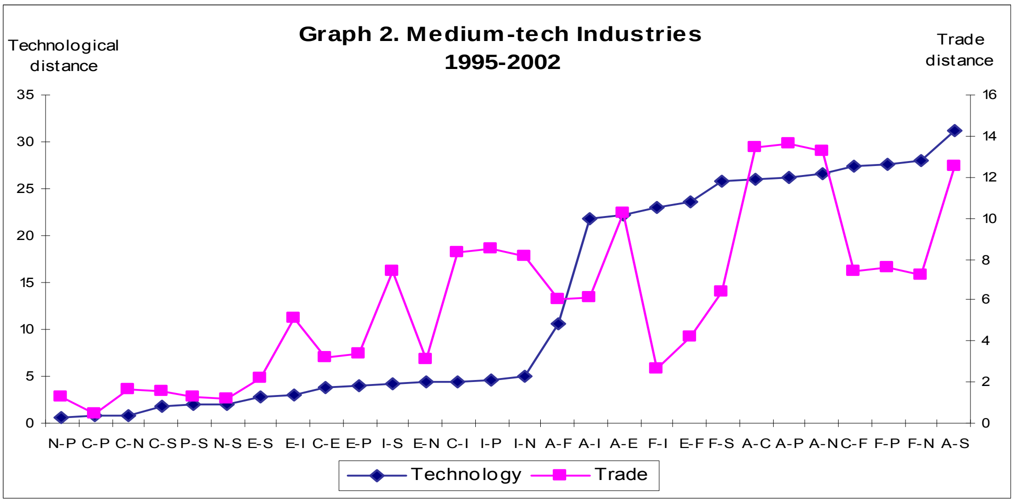
Source: OECD, STAN Indicators 2005.

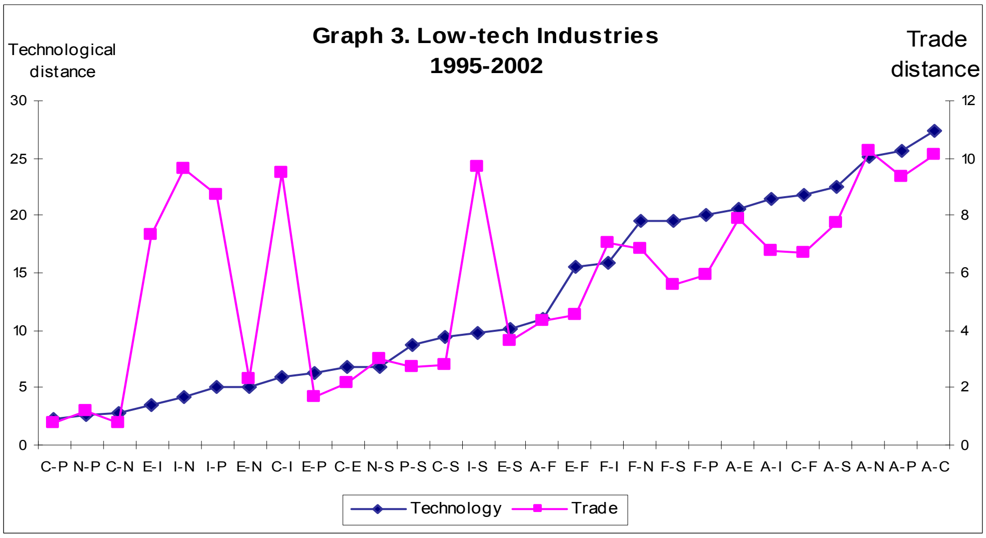
5. An approximation to the relationship between technological and trade inequality

Taking into account the technological contend of each sector according to OECD classification, we made a first approximation to the relationship between technology and trade inequality. Graphs 1 to 3 show technological and trade distances among countries in high, medium and low tech industries in time period 1995-2002.

Graph 1-3. Technological and trade inequality



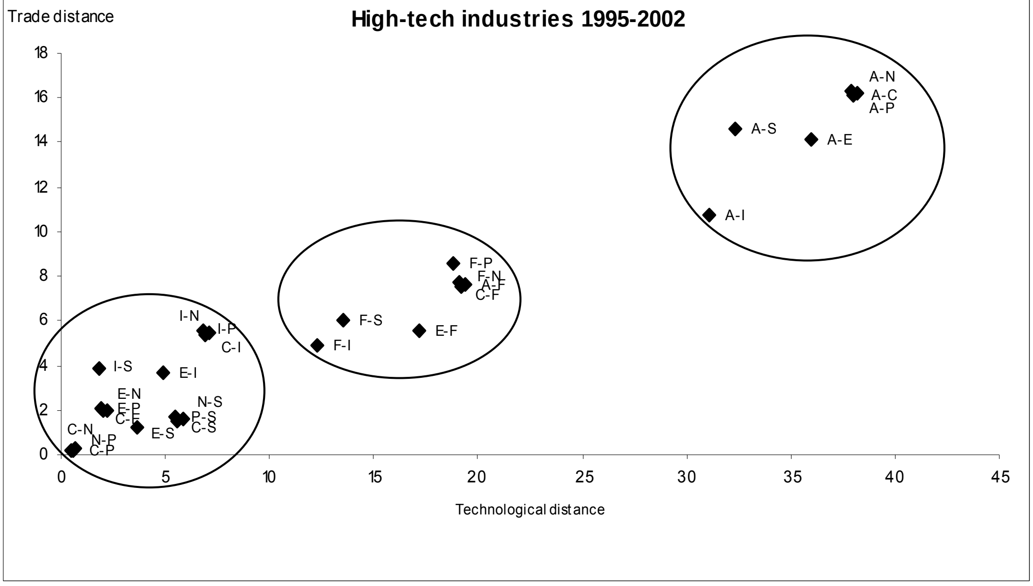




It can be observed that in high-tech industries there is a strong correlation between technology inequality and trade inequality, but the relationship is not very clear in medium and low tech industries. At the same time, it is in high-tech industries where it can be found the highest levels of technology and trade inequality.

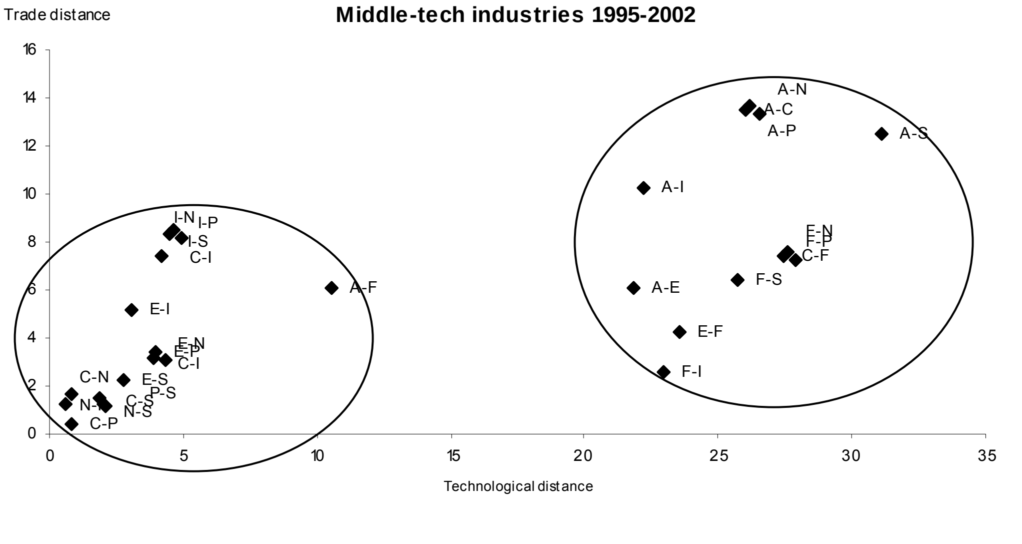
This first analysis suggests that the relationship between trade and technology inequality can follow different patterns depending on the technological contend of each sector. Following this idea we made cluster analyses trying to study the relationships between trade and technology inequality in high, medium and low tech industries. Graphs 4 to 6 shows the different clusters of countries obtained. In Graph 4 it can be observed again the strong correlation between trade and technology inequality in high-tech industries, with three very well different groups of countries. One of them is characterised by high technology and high trade inequality and includes the distances among Germany and the rest of countries except France, there is another cluster with middle distances in both variables. It includes the distances between France and the other countries and a third model with low distances in technology and trade. This group includes the distances among the other countries considered.

Graph 4. Technological and trade inequality
High-tech industries 1995-2002



Graph 5 shows two very different patterns. In medium-tech industries, it is technological distance that discriminates between groups. One cluster is characterised by high technology inequality, and here it is not relevant if trade distance is high or low, and in the other group technological distance is small, and although there are differences in trade distances, they are in general not very high.

Graph 5. Technological and trade inequality
Middle-tech industries 1995-2002



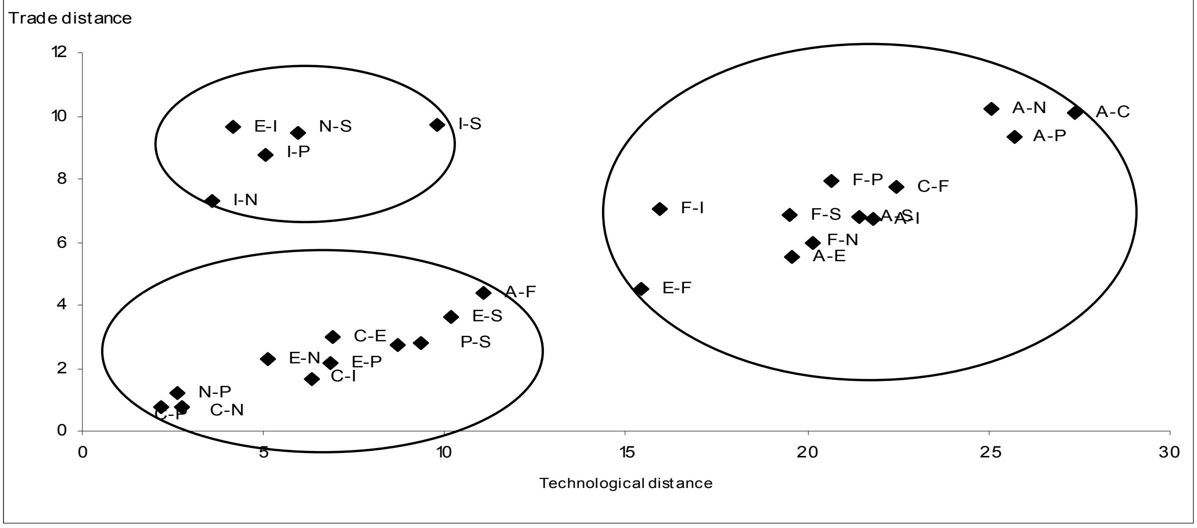
Graph 6 reflects the different groups that appear in low-tech industries. There is a group where technological distances and trade distances are very big and other where both kinds of distances are small. But there is a third group where trade distance is very high and technology inequality is small. This group include the distance among Italy and many others countries.

(Dist_Inv), and value added (Dist_VA). The empirical specification is the following:

$$Dist\_XS^{Kj}_{it} = f\,(Dist\_RD^{Kj}_{it}, Dist\_INV^{Kj}_{it}, Dist\_CL^{Kj}_{it}, Dist\_VA^{Kj}_{it})$$

Where k and j refer to countries, i industry and t time period.

Graph 6. Technological and trade inequality
Low-tech industries 1995-2002



In sum this first descriptive analysis let us know that the technological contend of each industry is an important aspect that affects the relationship between technology and trade inequality.

6. The econometric model

In this part of the study, we try to analyse the effect of technology and economic inequality on international trade. For this purpose, we made a panel data model where we considered, for each variable, the Euclidian distance among countries in each industry as a proxy of inequality. The econometric model we try to analyse has as dependent variable export shares distance (Dist_XS) and, following the theoretical approach chosen, as independent variables the inequality existing among countries in different aspect of technological activity, labour cost and other aspect of economic structure. Concretely, we calculated the distance among R&D expenditures shares (Dist_RDS), labour compensation (Dist_LC), investment intensity

Using the panel data elaborated, we made a first estimation where we analysed the effect of independent variables over export shares distance following a random effect model. It can be observed that R&D, labour compensation and value added inequalities have a positive and significant effect over export shares inequalities. These results show the important of diminish the technological and economic gap to reduce trade inequality, and corroborate, since a different perspective, what many previous empirical studies showed about the influence of technological activities over trade performance.

In a second random effect model we considered the technological contend of each sector according to OECD classification[11] and we

[11] The classification of manufacturing industries based on technology follows criteria held by OECD for manufacturing industries:

- High-tech: Included high-technology and medium-high-technology group according to OECD classification.
- Medium-tech: Correspond to medium-low-technology group of OECD classification.

analysed the effect of the interaction among independent variables and technological dummies over export share distances. The results show that the effect of differences in R&D expenditures over trade depends on the technological contend of each sector, being technology inequalities highest in high-tech industries, being also positive and significant the effect in medium-tech industries and negative in low-tech sectors. The sign of this last relationship may reflect that in low tech industries R&D is not the best indicator of their technological activities, being more important other more informal ways of doing innovations. The technological effect may be explained by investment intensity that shows a positive and significant effect over trade inequalities in low-tech industries. This is not very surprising because incorporated technology in this kind of industries is mainly standard.

The effect of labour cost inequalities over trade inequalities is positive and significant in high and middle tech industries and the effect of differences. Finally the effect of inequalities in value added on trade shares differences are significant in high-tech and low-tech industries.

Table 3. Random-effects GLS regressions

	Regression 1	Regression 2
DIST_RD	**0.0172 (0.004)*** **	
DIST_FBK	0.0009 (0.002)	
DIST_LC	**0.0091 (0.002)*** **	
DIST_VA	**0.1636 (0.057)*** **	
DIST_RD HT		**0.1445 (0.014)*** **
DIST_RD MT		**0.0183 (0.009)** **
DIST_RD LT		**-0.0113 (0.005)** **
DIST_FBK HT		0.0023 (0.004)
DIST_FBK MT		0.0000 (0.002)
DIST_FBK LT		**0.0074 (0.004)* **
DIST_LC HT		**0.0210 (0.004)*** **
DIST_LC MT		**0.0059 (0.003)** **
DIST_LC LT		0.0009 (.006)
DIST_VA HT		**0.2222 (0.079)*** **
DIST_VA MT		0.0647 (0.109)
DIST_VA LT		**0.1950 (0.097)** **
Constant	**5.5841 (0.247)*** **	**4.2825 (1.296)*** **
Time dummies		Yes
Industry dummies		Yes
Country dummies		Yes
Observations	2411	2411

Robust standard errors in parentheses.
* Significant at 10%
** Significant at 5%
*** Significant at 1%

- Low-tech correspond to low-technology group of OECD classification.

7. Main conclusions

This paper explores the effects of technology and economic inequality on international trade. The theoretical framework where we built our empirical analysis is the technological gap approach. The main difference with other works rests on the consideration of distances as a proxy of inequality.

In the empirical analysis we considered eight European countries and 13 manufacture industries in the time period 1995-2002. We made a panel data model with a cross-sectional unit of analysis: the Euclidean distance among countries in each industry and variable. We considered the Euclidian distance as a proxy of inequality among countries in each industry. As dependent variable we considered export shares distance and, following the theoretical approach chosen, as independent variables we considered the inequality existing among countries in different aspect of technological activity, labour cost and other aspect of economic structure.

We observed that technology inequalities affect trade inequalities and that the effects depend on the technological contend of each sector. Also the impact of inequalities in other economic variables depends on the technological contend of each industry. The impact of the technological gap over trade inequality is highest in high tech industries. These sectors are also affected by labour cost and value added inequalities. Trade inequalities in medium-tech industries are influenced by inequalities in technology and labour costs. In low tech industries, inequalities in value added and investment have a positive and significant effect on trade inequalities. The last regression shows a negative effect of technology inequality on trade. We think that a plausible explanation of this is that R&D is not very relevant for competition in low-tech industries because in these sectors technology follows more informal ways different than R&D.

These results and the way in which the problem has been approached may give some ideas for the application of policy measures. In this sense, it is important for politicians to take into account the technological characteristics of each industry, its *Sectoral System of Innovation*, in order to evaluate the effect of economic and technological policies on trade performance.

If the objective is to be more competititive in trade, it is important to diminish distances among countries in their technology, costs and investments. In this sense, it is very useful to reinforce the links between international trade and technological efforts through technological policies oriented to generate and exploit new knowledge in an international context. At the same time, it is necessary to make the correct selection of the industries which can play the role of "spreaders" of horizontal technologies.

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