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Agricultural and food trade in European Union countries, 1963-2000: a gravity equation approach

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ABSTRACT

The proliferation of regional trade agreements in the last decades of the 20th century has intensified the debate about the different processes of regional integration. This study contributes to this debate by analysing the principal determinants of the growth in trade flows of the countries making up the European Union. The work analyses EU agri-food trade from a disaggregated perspective, by products, imports and exports, from 1963 to 2000. An extended gravity equation model is estimated employing Prais-Weistein estimation and fixed effects in order to improve on the results reported in previous studies. The results of the present study show that in EU countries the growth of per capita income stimulated exports and reduced imports. Specifically, its exports were positively influenced by the presence of the home market effect, while its imports were strongly influenced by the effects of the liberalisation of intra-EU trade, as also occurred in the case of intra-EU trade flows.

Keywords: International Agricultural Trade, Economic History of the European Union, Gravity equation

RESUMEN

La proliferación de acuerdos regionales de comercio en las últimas décadas del siglo XX ha intensificado el debate sobre los diferentes procesos de integración regional. Este estudio contribuye a este debate analizando los principales determinantes del crecimiento de los flujos de comercio de los países integrantes de la Unión Europea. El trabajo analiza el comercio agro-alimentario de la UE desde una perspectiva desagregada, por productos y diferenciando exportaciones e importaciones, desde 1963 hasta el año 2000. Se estima una ecuación de gravedad ampliada empleando el método Prais-Weinstein y efectos fijos, para mejorar los resultados de otros estudios previos. Los nuestros muestran que en los países de la UE el crecimiento de las exportaciones estuvo positivamente influenciado por la presencia del efecto de mercado domestico, mientras sus importaciones estuvieron fuertemente influenciadas por los efectos de liberalización commercial del comercio intra-UE, lo que ocurrió también en el caso de los flujos de esta naturaleza

Palabras clave: Comercio internacional agroalimentario, Historia Económica de la Unión Europea, Ecuación de gravedad

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1. Introduction

The second half of the XX century witnessed a dramatic return to international economic integration, known as the second globalisation. However, this new process of market integration was far removed from the pattern of complementarity between North and South developed throughout the first globalisation. Both total trade and trade in agricultural products and food have become progressively concentrated on the exchange of goods among developed countries (Hertel et al. 1999). Nations which traditionally were more dependent upon the export of agricultural products and food saw their market share fall, while that of the more developed countries increased. In this latter group the position of Europe was striking, as the principal protagonist of significant changes in the regional distribution of international trade in agricultural products and food.

It is clear that these substantial changes may be explained by the successful liberalisation of regional exchanges through various types of Regional Trade Agreements[1]. In particular, the European Economic Community, subsequently the European Union[2], to which countries of "Old Europe" have been progressively incorporated, was especially successful in liberalising the exchange of agricultural products and food among its members.

In contrast to regional liberalisation, it is also striking that this was a period in which the industrialised nations protected and supported their agriculture more than any other sector (Lindert 1991, Tyres and Anderson 1992, Diaz-Bonilla and Tin 2002, Diaz-Bonilla and Reca 2002 and Aksoy 2005). Specifically, the countries of Western Europe, following wartime and postwar shortages, made a secure food supply both a priority and an important argument for the development of the Common Agricultural Policy (CAP). Its implementation, in combination with access to new technologies, produced some of the most far-reaching changes in agricultural trade in the second half of the XX century.

The abovementioned factors i.e. the elimination of trade barriers among the EU member states and the implementation of the CAP, produced two crucial effects: the achievement of European self-sufficiency in food and an intensive integration of European markets. On the one hand, Europe left behind its traditional position as a net importer of agricultural products and food, becoming instead a net exporter. On the other, it significantly increased the degree to which its agriculture was integrated[3].

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[1] As examples, see Dell'Aquila et al. (1999) or Diao et al. (1999), who demonstrate the extraordinary upsurge in intra-regional trade in various geographical areas.

[2] Hereafter we shall use the term European Union (EU) for all those institutions which preceded it.

[3] The symmetrical index of the relative openness of EU agricultural trade displays values close or exceeding 0.50 throughout the period, showing that EU regional integration was far higher that that of the rest of the World (Pinilla and Serrano 2009: 295-296).

Obviously, market proximity or the important cultural and historical ties among the European countries explain their greater degree of initial integration. However, integration increased after the mid-1980s, as new countries joined the European Union. This significant acceleration may have been related to the incorporation of countries from peripheral Europe and to the increase in protectionism which took place in this period (Krueger et al. 1988, Tyres and Anderson 1992, Diaz-Bonilla and Reca 2002). Subsequently, from 1995 onwards, protectionism fell, coinciding with the implementation of the liberalising agreements reached in the Uruguay Round of the GATT and the effects of the reform of the CAP.

Given this historical context, the objective of our study is to analyse the determinants of the evolution of EU agricultural trade flows. Special attention will be paid to analysing the process of integration of its agricultural markets and the causes of the rise in intra-regional trade. Moreover, a study will be made of the success of the EU in achieving self-sufficiency in food i.e. the factors which caused it to become a net exporter of agricultural products and food will be analysed.

The methodology employed consists of using different gravity models to explain EU agricultural trade flows. The first and most general of these include both import and export flows. The second and third include, respectively, only the EU flows of agricultural exports or imports. The final model includes intra-EU agricultural trade flows.

In order to be able to study the subject more deeply from a more disaggregated perspective, an analysis will be performed of the role played by the different product groups which comprise agricultural trade, in both the abovementioned process of integration and the achievement of self-supply. To this end, trade in agricultural products and food has been broken down into four product groups.

It should be emphasised that our objective is to fill the void left by earlier studies. Very few have concentrated specifically on agricultural trade, while those which have done so lack the long-term perspective we adopt[4]. Furthermore, none of them has employed an analysis as highly disaggregated by product group as the present study[5].

Our results show that European agricultural trade in the period under study was progressively concentrated among economies with a broad market size; the growth of per

[4] Numerous studies have analysed, using gravity equations, the determinants of total EU trade [see, for example, Badinger and Breuss (2004)], but very few have dealt with the issue of agricultural trade. Those which have done so [Koo *et al.,* (2006), Fidrrmuc (2004) and Cho *et al.,* (2002)] do not, however, employ such a long time period as that studied here. Nevertheless, mention should be made of the work of Vollrath (1998), employing an alternative methodological approach which does take the time dimension into account.

[5] A similar study, for North American trade, may be consulted in Jayasinghe and Sarker (2004).

capita income stimulated exports and reduced imports, while the liberalisation of EU internal markets was decisive in encouraging intra-regional trade.

In addition, this more disaggregated analysis of EU agricultural trade demonstrates that its exports were positively influenced by the presence of the home market effect, characteristic of a pattern of intra-industrial trade, associated with the surge in the agricultural supply capacity of the EU, while its imports were strongly influenced by the effects of the liberalisation of intra-EU trade, as also occurred in the case of intra-EU trade flows.

The following research study is divided into four sections, followed by its conclusions. The first section studies the most important antecedents and elements of European trade in agricultural products and food. The second section presents the theoretical framework of the augmented version of the gravity equation employed in the empirical analysis. The third describes the sources and data required for its performance. Lastly, the most important results obtained by the study are presented, divided into four sections. The first of these shows the determinants of European agricultural trade from a general perspective. The second and third analyse the differences between the patterns of EU exports and imports. Finally, the fourth section lists the principal determinants of the upsurge in intra-EU trade.

2. Antecedents: European protagonism in the agricultural products and food trade

World agrifood trade grew at an extraordinary pace in the second half of the 20th century, expanding at an average annual rate of 4.0%. Growth was especially fast until the economic crisis of 1973 (annual rate of 4.6%), whereafter it slowed to 3.5% in the period to the year 2000. In any event, the rate was faster than the average 3.7% achieved in the second half of the 19th century (Serrano and Pinilla 2009a).

Is it in this context, that the agrifood trade of the EU countries grew rapidly in this period although the pace of exports was considerably higher than that of imports. The strong growth in exports in the first sub-period was concentrated especially in the years from 1967 onwards (except the difficult period of the 1970s crisis from 1973-75), after the customs union had been completed and the CAP fully implemented. It seems reasonable to suppose that these policies caused a strong expansion of both output and European exports (Serrano and Pinilla 2010).

Throughout the second half of the 20th century, the European share of worldwide exports of agricultural products and food tended to increase and, as the table 1 shows, this rise played a fundamental role in the strong increase in intra-EU trade, which in the final

stages of the period accounted for almost a third of worldwide exports of agricultural products and food.

Table 1 European share (%) of World agricultural products and food trade (in 1980 US dollars)

Imports	1959-66	1966-73	1973-80	1980-87	1987-94	1994-00
Europe	58.48	58.23	57.18	53.9	53.86	47.69
Intra-EU	17.4	21.8	24.5	27.2	30.2	28.3
Europe, excl. intra-EU	41.1	36.5	32.6	26.7	23.5	19.4
Rest of the world	41.53	41.76	42.81	46.1	46.23	52.31
Exports	1959-66	1966-73	1973-80	1980-87	1987-94	1994-00
Europe	31.43	36.32	39.67	41.45	46.31	44.28
Intra-EU	17.1	21.2	23.9	27.1	29.7	26.8
Europe, excl. intra-EU	14.3	15.1	15.8	14.4	16.3	17.4
Rest of the world	68.56	63.68	60.32	58.54	53.99	55.73

Source: Authors' compilation, on the basis of FAO (1947-2000) and FAOSTAT (2004).
Europe includes trade from the USSR and, after 1991, trade from Russia and the ex-Soviet economies. EU is the EU-15.

On the imports side, a considerable long-term fall is observable in European imports, which dropped from 58.48% of total worldwide imports in the period 1959-66 to 47.69% in 1994-2000, and for all product categories, except for tropical products (e.g. coffee, cocoa), which were hardly cultivated in Europe.

Thus, as is well known, not only was the desired self-sufficiency achieved but also, even early on, European countries became net exporters of agricultural products (Thorbeche and Condliffe 1963, Pinilla and Serrano 2009). A priori, technological advances, together with the CAP, permitted the EU to achieve self-sufficiency in numerous bulk products and even to rapidly increase its exports. On the one hand, technological progress radically transformed European agriculture, substantially increasing its levels of productivity. The advances made in chemical fertilisers, animal genetics and animal feed, increased mechanisation and even robotics and information technology allowed the European farming sector to achieve levels of productivity similar to those of other industries, and to overtake those of manufacturing industry (Hayami and Ruttan 1985). These innovations produced a spectacular increase in European agricultural production, in products such as cereals, oilseeds, sugar or meat.

On the other hand, the CAP stimulated this process. Through its complex institutional framework, it created a highly interventionist and distorted market. In the words of García-Delgado and García-Grande (2005), agricultural policy has basically been a

pricing policy aimed at achieving self-sufficiency in food within the EU, resulting in a spectacular increase in production (producing substantial surpluses and considerable financial costs) and severely distorting the international markets.

We shall not undertake a detailed analysis of the effects of such sectorial policies, upon which many studies have concentrated [6]. Briefly, the first period of the CAP (1960-1972), via subsidies and pricing policies, concentrated essentially on products in which Europe specialised (cereals, oilseeds, dairy products and meat) and the sugar sector.

Subsequently, the model was extended to other products, such as those in which the Mediterranean countries specialised (fruit, vegetables, olive oil, wine, rice and tobacco). Thus, by the 1980s a protectionist network had been constructed, affecting a large number of products and providing substantial incentives to increase European agricultural production and productivity.

Consequently, the EU generated considerable surpluses in the 1980s. The levels of self-supply of sugar, wheat and milk, to give three important examples, were approximately 140%, 124% and 118%, respectively, causing stocks to be accumulated and serious financial problems in the heart of the EU. The solution adopted to dispose of these surpluses was to place them on the international markets (García-Delgado and García-Grande 2005). The ratio of agricultural exports to imports for the EU-15 countries increased sharply over the four decades examined. If the value of their exports was 41% of imports in 1961, by 1993 this had risen to almost 100%, finally achieved in 2000 (Pinilla and Serrano 2009).

The alarming increase in the part of the budget allocated to the CAP, in addition to international pressure and discontent, produced tentative proposals for the restructuring of the model. The Uruguay Round of the GATT laid the foundations for the beginning of a gradual process of liberalisation of international agricultural trade and a set of common norms aimed at abolishing the state subsidies which distorted international agricultural trade. The reform of the CAP in 1992 should be understood in this context[7].

Lastly, before beginning the empirical analysis, we shall comment briefly on the composition of EU agricultural trade. The evolution of this structure between 1961 and 2000 shows that changes were not especially far-reaching. The agrifood trade of the EU in 1961 was already basically made up of high value and processed products (70% of total flows), and the share of these goods has since increased by a further five percentage points. In comparison with the composition of world trade, the differences are significant, since goods

[6] For a detailed analysis of the CAP's intervention mechanisms and their effects, see Gardner (1996) and García-Delgado and García-Grande (2005), among others.

[7] The USA and the Cairns Group (the group of agro-exporting countries) were deeply dissatisfied with the CAP; in the Uruguay Round, they insisted that the EU reduce its level of agricultural protection and, most particularly, its subsidised exports.

of this kind accounted for only 37% of the world total at the beginning of the period (Pinilla and Serrano 2009). While this share rose considerably until the year 2000, when it reached 54%, the difference with EU agrifood trade remains significant (Serrano and Pinilla 2009b and 2010). The most developed countries were already preferentially trading relatively high income elasticity foodstuffs and agricultural products at the beginning of the 1960s, and that these goods were frequently subject to industrial transformation.

With regard to imports, the share of high value foods and processed agricultural products increased at the expense of bulk products . The composition of exports displays the increasing specialisation, throughout the period, in high-value and processed foods which had begun at the start of the century (Aparicio et al. 2009).

In this light, it seems reasonable to suppose that the EU countries were already very well positioned to benefit from the customs union and later the single market before economic integration took place and the CAP was implemented. Their level of development and specialization in high value added products provided additional advantages over non-EU competitor countries that often specialized in the low-growth bulk and plantation products[8].

3. The theoretical framework of gravity models

The initial applications of the gravity model, developed by Tinbergen (1962) and Pöyhönen (1963) and employed in the study of the determinants of international trade, lacked a theoretical basis. Subsequently, the success of this approach in explaining international trade patterns caused economists to formally develop its theoretical foundations (Anderson 1979, Helpman and Krugman 1985 or Bergstrand 1985 and 1989).

More recently, the empirical validations of gravity equations, such as those performed by Helpman (1987), Hummels and Levinsohn (1995), Fontagné, Freudenberg and Péridy (1998) and Evenett and Kéller (2002), have concluded that such equations can be derived from different theoretical models. An eclectic vision of trade determinants which includes, complementarily, the Hecksher-Ohlin models and the models of trade with increasing returns, permits gravity equations to be more satisfactorily reconciled with the theoretical models.

In all such models, the gravity equation is derived from a general equilibrium model in which incomes (Y_i , Y_j) are interpreted as the market size of countries and are positively associated with the evolution of trade. The distance between countries has a negative influence, and is used as a proxy for transport costs (D_i). In other words, these

[8] This was the case, for example, of the Latin American countries, traditional producers of low-growth, low-income elasticity goods (Serrano and Pinilla, 2008).

models explain exchanges between two countries as a function directly proportional to their "volume" (national income) and inversely proportional to the "distance" between them. Given the similarity between this equation and that which describes gravitational force in Newtonian physics, equations of this type have been termed "gravity models" (Deardorff 1984).

Their most commonly employed functional form, applying logarithms, is:

$$ln\ X_{ij} = \beta_1 + \beta_2\ ln(Y_i) + \beta_3\ ln(Y_j) + \beta_4\ lnDist_{ij} + \varepsilon_t \qquad (1)$$

In the initial approach of the gravity equation, $\boldsymbol{X_{ij}}$ represents the volume of trade flows between two countries. $\boldsymbol{Y_{ij}}$, as stated earlier, is the market size of the countries, which is usually proxied by its income (Gross Domestic Product, GDP) or population. It is even more interesting to interpret this variable separately, since this shows that a country's potential to supply (export) its products depends upon its size, as measured by GDP, while foreign demand for those products depends upon the GDP of the importing country. That is to say, the potential supply and demand of trade partners can be measured by their respective GDP (Jacobo 2005).

Following the work of Feenstra et al. (1998, 2001, 2004), these variables may also be used to analyse the degree of adaptation of different goods to intra-industrial trade. This theoretical framework of the gravity equation provides a method for the verification of the home market effect (or reverse home market effect) for different sector trade flows. According to these authors, in the case of differentiated products (manufactures), exports are more sensitive to changes in the income of the exporting country than variations in that of the importing country; this has been termed the home market effect, and occurs in situations of increasing returns to scale and product differentiation. Krugman (1980) argues that when countries trade, that which has a wider market will produce a greater number of differentiated products, since it will attract more companies and will become a net exporter of differentiated products.

With regard to the products comprising agricultural trade, their exchange is more sensitive to the income of the importing country than to domestic income. On this point, studies such as Feenstra et al. (1998) and Fidrmuc (2004) have shown that agricultural trade fits within the framework of models characteristic of homogeneous products, whose theoretical basis is easier to reconcile with reciprocal dumping models. That is to say, price discrimination between the domestic market and international markets leads to trade in the same product between countries, in both directions[9].

[9] Trade takes place because companies perceive greater demand elasticity in the international market than in the domestic market.

As stated earlier, the geographical distance between countries is usually seen as an obstacle to trade. Various studies have discussed this argument, since logistical infrastructure differs greatly among countries; they therefore propose weighting the geographical distance between countries on the basis of their economic strength, income or population (Rose 2000). These variables are expected to display a positive sign, since when two neighbouring countries are remote from alternative markets, their reciprocal trade increases.

In addition to the economic size of countries and the distance between them, gravity equations usually include GDP per capita. Predictably, there is more reciprocal trade between the more developed countries. According to Bergstrand (1989), the inclusion of GDP in the model permits us, moreover, to characterise trade in different types of goods. On the one hand, the exporting country's per capita income coefficient may be considered as a proxy of its factor endowment; this coefficient is positive in the case of capital-intensive goods and negative for labour-intensive products. On the other hand, the importing country's per capita income coefficient characterises types of goods and has a positive sign for normal goods and a negative one for inferior goods.

The vast majority of studies also employ other multiple variables simultaneously. Some examples are geographical proximity (if the countries share a border) or cultural proximity (the existence of historical or cultural ties between trade partners, such as a colonial relationship or the use of the same language). A positive sign is to be expected for the coefficient of all these variables.

With regard to the institutional context, the specification of the gravity equation has been refined in many studies, to take into account the factors which may limit trade. Surprisingly, few studies have introduced trade policies into the gravity equation. Their incorporation into the model is difficult, due to the limited or non-existent availability of data. However, many studies have introduced dummy variables to analyse the effects of both the regional liberalisation produced by the proliferation of Regional Trade Agreements (RTAs)[10] and the multilateral liberalisation of international markets.

In our case, in addition to the traditional variables described above, three others have been considered, in order to analyse the effects of trade creation and diversion which may have been caused by the process of integration of the European Union. Following the studies by Aitken (1973) and Pelzman (1977), the model incorporates a dummy variable (C_EU) to analyse the gross effects upon trade creation produced by regional economic integration. In other words, it shows to what extent inter-country trade among EU members is higher than it (hypothetically) should be under normal circumstances, and a positive sign is to be expected.

[10]See, for example, Frankel (1997), Frankel and Wei (1993), Bayoumi and Eichengreen (1993) or Sapir (1997)

Following the methodology proposed by Frankel and Wei (1993), Frankel et al. (1995) and Endoh (1999), two new dummy variables (D1_EU and D2_EU) have been introduced, in order to distinguish between the effects of trade creation and trade diversion. The former reflects any effect of trade diversion upon the structure of EU exports, while the latter represents the results of trade diversion upon import flows. A negative and statistically significant sign of the coefficient of these variables would indicate, in the first case, that EU integration caused its member countries to redirect their exports towards countries within that region and, in the second case, that they diverted imports from non-member countries, replacing them by products from within the EU.

With regard to multilateral market liberalisation, gravity models also include dummy variables to explore the effects of membership of free trade organisations. Rose (2004) provides a particularly useful study of this theme, estimating the effect upon trade of the General Agreement on Tariffs and Trade (GATT) rounds. The result, and therefore the sign of this variable, is unclear. Surprisingly, Rose did not find that adherence to GATT substantially affected trade.

Lastly, some studies, such as Cho et al. (1998) and Rose (2000), also include different measures of the volatility of bilateral exchange rates, in order to examine the impact of exchange rate uncertainty upon trade flows; its coefficient is expected to display a negative sign. In other words, exchange rate instability leads to lower trade growth between two countries.

4. Data and estimations: bilateral trade flows

We shall estimate different gravity models, using data for bilateral trade flows provided by the United Nations Statistics Division in its UN-COMTRADE database (2003). Adopting the Standard International Trade Classification System (SITC, Revision 2), export flows by volume between 1963 and 2000 have been reconstructed for total EU agricultural trade and for the following product groups: bulk products, plantation products, processed and high-value foods and, lastly, other processed agricultural products[11].

The sample includes trade flows among 13 countries which were EU members at the end of the period, and trade flows between these countries and a further 27 exporting and importing nations (representative of different economic regions) for both total agricultural trade and the four above-mentioned product groups[12].

[11] Trade in bulk products (041-045.Bulk cereals, 00.Live animals, 22.Oilseeds, 26.Textile fibres); trade in plantation products (06.Sugar, 07.Coffee, tea, cacao); trade in processed and high-value foods (01.Meat and prepared meat, 02.Dairy products and eggs, 04.Processed cereals, 05.Fruit and vegetables, 08. Cattle feed, 09. Other foods); and, lastly, Other processed agricultural products (11.Drinks, 12.Tobacco, 41.Animal fats, 42.Vegetable oils, 43.Processed oils).

[12] EU: Austria, Germany, Belgium-Luxembourg (aggregation of the two countries), Denmark, Finland, France, Greece, Italy, Ireland, the Netherlands, Portugal, Spain and the United Kingdom.

The database cited has been separated into four types of balanced panels[13]. The first comprises the set of export and import flows in which EU member states intervened (the complete panel, with 29,640 observations). The second panel lists the export flows of EU member states, or 19,266 observations (38 years x 13 x 40). The third is composed of the import flows of EU member states, which in this case amount to 16,302 observations[14] (38 years x 13 x 34). The final panel shows EU intra-regional trade flows (5,928 observations i.e. 38 years x 13 countries of origin x 12 countries of destination).

The present study proposes an eclectic version of the gravity equation, using the variables included in earlier research, although the models proposed by Feentra *et al*., (1998) and Rose (2000,2004) provide its principal foundation. Its functional form, applying logarithms, is:

$$\begin{aligned} ln\, X_{ij} &= \beta_1 + \beta_2\, ln(Y_i) + \beta_3\, ln(Y_j) + \beta_4\, ln(Ypcp_i) + \beta_5\, ln(Ypcp_j) + \\ &+ \beta_6\, lnDist_{ij} + \beta_7\, lnExcvol_{ij} + \beta_8\, lnRem_{ij} + \beta_9\, Border_{ij} + \\ &+ \beta_{10}\, Lang_{ij} + \beta_{11} C\_EU_{ij} + \beta_{12} D_1\_EU_{ij} + \beta_{13} D_2\_EU_{ij} + \\ &+ \beta_{14}\ GATT_{ij} + \varepsilon_t \end{aligned} \qquad (2)$$

$\boldsymbol{X_{ij}}$ represents agricultural exports flows, by volume, from country i to country j, in 1985 US dollars, deflated by their respective price index in order to obtain volume series; $\boldsymbol{Y_i}$ $\boldsymbol{Y_j}$ is the real GDP of both the exporting and importing country, in 1985 US dollars (WDI CD-ROM 2004); $\boldsymbol{Ypcp_i}$ $\boldsymbol{Ypcp_j}$ is the GDP per capita of both the exporting and importing country, in 1985 US dollars (WDI CD-ROM 2004); $\boldsymbol{Dist_{ij}}$ is the distance between the capitals of the exporting and importing countries; $\boldsymbol{Excvol_{ij}}$ is an indicator of exchange rate volatility, expressed as the standard deviation of the first difference of the natural logarithm of the nominal bilateral exchange rate, in the 10 years prior to period t (WDI cd-rom 2004); $\boldsymbol{Border_{ij}}$ is a dummy variable which takes the value of 1 if the countries have a common border and 0 if not ; $\boldsymbol{Lang_{ij}}$ is a dummy variable which takes the value of 1 if the countries have a common language and 0 if not; $\boldsymbol{Rem_{ij}}$ is the relative distance (Rose, 2000); $\boldsymbol{GATT_{ij}}$ is a dummy variable which takes the value of 1 if the two countries adhere to GATT and 0 if not; $\boldsymbol{C\_EU_{i\,j}}$ is a dummy variable which takes the value of 1 if the two countries are members of the EU and 0 if not. Lastly, $\boldsymbol{D_1\_EU_{ij}}$ and $\boldsymbol{D_2\_EU_{ij}}$ are dummy variables which take the value of 1 if the export/import is undertaken with a non-EU member state and 0 in the opposite case.

Rest of the world: **Africa** (Algeria, Ivory Coast, Egypt, Morocco, Nigeria, Sudan), **Asia** (China, India, Indonesia, Israel, Japan, Malaysia, Saudi Arabia) **North America** (Canada, Mexico, United States) **Latin America** (Argentina, Brazil, Chile, Colombia, Ecuador, Nicaragua, Peru, Uruguay), **Oceania** (Australia, New Zealand) and Norway

[13] To obtain a balanced panel (required for some estimation methods), trade flows with a value of 0 were replaced by a minimum trade volume ($100).

[14] In order to achieve a balanced panel, and due to the shortcomings of the data, exports from China, the Ivory Coast, Nigeria, Sudan, Saudi Arabia and Uruguay were eliminated.

5. Results: the gravity equation and agricultural trade of the European Union

Our intention here is to overcome the limitations of previous studies which, as we stated earlier, only take into account the variations between the units of observation (cross-section analysis). The present study also considers the temporal variations within the units of observation, while the use of panel data increases the efficiency of the estimators and significantly reduces the potential problems caused by the omission of variables (Hsiao 1986). From this perspective, three types of panel data estimation are proposed: the first is the estimation of ordinary least squares (OLS) using the pooled panel, while the second and third take the temporal variation into account by including random effects and fixed effects, respectively, in the model.

To determine which of the three models is most efficient in the estimation of the gravity equation, we firstly employ the Breuch-Pagan LM test for random effects, which permits us to choose between OLS estimation of the pooled panel and estimation with random effects. Following the application of the latter, it is concluded that the random effects are significant, and it is therefore preferable to use the random effects estimation instead of that of the pooled panel. Furthermore, to demonstrate that the inclusion of fixed effects is a more appropriate method than previous approaches, various tests were performed. Firstly, the F-test (Greene 2000) of the significance of the fixed effects indicated that their estimations are better than when the OLS estimation of the pooled panel is employed. Secondly, the Hausman test demonstrated that the estimators of random effects and fixed effects differ substantially and that the fixed effects model better explains the sources of variation; it is therefore more appropriate than the random effects model[15].

Here, it should be emphasised that, even when we modelled temporal and spatial heterogeneity, our model, according to Wald test (Greene 2000) poses problems of heteroskedascity and, according to the Wooldridge test, there also exist problems of autocorrelation. Lastly, the Breusch-Pagan test, employed to identify problems of contemporaneous correlation in the residuals in fixed also confirms the need to correct this problem. The problems described were resolved by estimating the Panel-Corrected Standard Errors (PCSE)[16].

5.1. Determinants of European Union agricultural trade

The models appear to function correctly for both total agricultural trade and for the different groups considered; they are all capable of explaining a large percentage of the variations in EU agricultural trade flows. As is typical in the gravity equation, rich countries,

[15] This result is typically repeated in each of the studies which analyse trade using the data panel methodology. To give one example, Feenstra (2004) states that fixed effects estimation is the method which produces the most consistent estimation.

[16] Beck and Katz (1995) demonstrate that the standard errors of PCSE are more precise than those of FGLS (Feasible Generalised Least Squares, the alternative method to jointly resolve the problems mentioned).

with broad markets and belonging, in this case, to the EU, traded more between themselves. Column 1 of Table 2 shows the coefficients of the more aggregated analysis i.e. that which analyses the determinants of the evolution of EU trade in agricultural products and food. At first sight, the results of the coefficients (*Yi Yj)* for market size show a positive and statistically significant effect in the case of the country of destination, and a negative and statistically significant effect for the country of origin.

The first result is related to the growth, both intra- and extra-EU, of the demand for imports of agricultural products and food. The second is related, as we shall see below, to the limited supply capacity of developing countries, whose food consumption rose notably in the last forty years of the XX century, due to a permanently increasing population. The combination of the two effects largely explains the progressive concentration of exchanges in countries with a large market size, as is the case of most EU member states.

Table 2 Gravity equation results: EU trade in agricultural products and food

	EU agricultural trade			EU exports			EU imports			Intra-EU trade		
Ln X_{ij}	PCSE-ef.	FE	RE	PCSE-ef.	FE	RE	PCSE-ef.	FE	RE	PCSE-ef.	FE	RE
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
lnY_i	-1.105***	-0.874***	0.510***	1.875**	1.915***	1.149***	-0.842**	-0.452***	0.373***	-0.659	-0.938***	0.722***
lnY_j	2.048***	1.847***	1.175***	1.764***	1.574***	0.909***	1.614***	1.145***	1.093***	3.105***	3.270***	1.065***
$lnYpcp_i$	2.045***	2.091***	0.412***	-1.112	-0.713**	0.503***	1.844***	1.640***	0.536***	1.291*	2.042***	0.323***
$lnYpcp_j$	-0.777***	-0.828***	-0.027	-0.406	-0.460***	0.114**	-0.683	-0.657*	-0.601***	-0.183**	-2.503***	-0.190**
$lnExcvol_{ij}$	0.006	-0.024***	-0.029***	0.015	-0.002	0.007	-0.003	-0.050***	-0.076***	0.003	-0.038***	-0.039***
$lnDist_{ij}$			-0.656***			-1.223***			-0.103			-0.988***
$lnRem_i$	-0.006	-0.001	0.024***	0.004	0.021*	0.004	0.017*	0.012	0.036**	-0.003	0.007	0.019**
$Border_{ij}$			-0.094			-0.909*			0.785**			-0.105
$Lang_{ij}$			1.404***			1.281***			1.256***			0.501
C_EU_{ij}	0.138**	0.532***	0.750***	0.125	0.272***	0.301***	0.128*	0.723***	0.957***	0.278***	0.517***	0.583***
$D_1\_EU_{ij}$	-0.024	0.105***	0.314***	-0.003	-0.034	0.098**	-0.139*	0.107	0.199***	…	…	…
$D_2\_EU_{ij}$	-0.023	-0.170***	-0.387***	…	…	…	-0.033	-0.043	-0.100**	0.031	-0.023	0.011
$Gatt_{62\text{-}94\ ij}$	0.055	0.231***	0.178***	0.060	0.370***	0.384***	0.057	0.120*	0.044	0.002	0.384***	0.394***
$Gatt_{94\text{-}00\ ij}$	0.107	0.263***	0.189***	0.030	0.203***	0.232***	0.186	0.403***	0.260***	0.023	0.389***	0.392***
Constant	-0.050	-21.06***	-25.63***	-0.068	-63.55***	-33.48***	-0.045	-9.964	-19.67***	-0.15	-39.26***	-23.61***
Number of observations	29.640	29.640	29.640	19.266	19.266	19.266	16.302	16.302	16.302	5.928	5.928	5.928
Adjusted R^2		0.220	0.452		0.309	0.614		0.157	0.475		0.628	0.725

Note: PCSE-Ef: Prais-Winsten regression with panel-corrected standard errors (PCSE) and fixed effects. FE estimation, including fixed effects and RE with random effects. Columns 1-3, total flows involving EU countries. Columns 4-6, export flows of EU countries. Columns 7-9, import flows of EU countries. Columns 10-12, total intra-EU flows. All variables in logarithms, except binary variables (such as common border/language and different RTAs) Standard errors are given in parentheses. ***, ** and * denote statistical significance of 1%, 5% and 10%, respectively.

With regard to the effects of increased per capita income upon trade flows, on the one hand the negative sign of the importing country is striking. This effect is due to agricultural goods being necessity goods, as we saw earlier (Bergstran 1985); this becomes even clearer when we observe the coefficient of the variable upon bulk agricultural products i.e. those whose income elasticity of demand is lowest (see Table 3). On the other hand, its effects upon the exporting country display the opposite sign; in other words, development had a positive effect upon a country's agricultural exports. This result may be related, according to the interpretation made by Bersgrand (1989), to technical progress in agriculture. When comparing product types, it should be underlined that the effect was once more greater for the bulk products group, perhaps because this group, composed principally of cereal grains and oilseeds, took greatest advantage of the technical advances produced by the green revolution.

Consequently, as European per capita income rose in the second half of the XX century, the demand for imported agricultural products fell, while technical progress caused exports to rise, at the same time as Europe's share of worldwide exports of agricultural products and food increased dramatically and its share of imports fell.

Furthermore, EU membership intensified intra-regional flows. A novel and important aspect of the present study is that, contrary to expectations, no effect of the diversion of trade to third countries was found. Although their signs are negative, as expected, neither $D_1\_EU_{ij}$ (which reflects the effects of trade diversion upon export flows) nor $D_2\_EU_{ij}$ (which reflects the effects of trade diversion upon import flows) are statistically significant[17]. Thus, it would appear that the decrease in the relative importance of EU imports was due more to the considerable degree of self-sufficiency attained than to the institutional effects of trade diversion.

The sole exception is to be found in the analysis disaggregated by product type, and specifically for the plantation products group. The negative and statistically significant sign of $D_1\_EU_{ij}$ implies that trade diversion effects existed, related to the exports of EU countries, which were redirected to the EU market. This is logical, if we take into account that the internal European market paid higher prices than the international market; a case in point was the sugar sector.

[17] It was impossible to compare this result with those obtained by previous studies for European agricultural trade flows, since some analyse this aspect for other time periods while others only take into account specific regional cases. However, our long-term vision found results different to those of Koo et al. (2006), for a cross-section analysis in 1999.

Table 3 Gravity equation results: EU agricultural trade by product category

	EU agricultural trade				EU exports				EU imports				Intra-EU trade			
Ln X_{ij}	Bulk	Plant.	Food	Proc.	Bulk	Plant.	Food	Proc.	Bulk	Plant.	Food	Proc.	Bulk	Plant.	Food	Proc.
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
lnY_i	-3.616***	-0.544	-0.556	-0.770**	1.205	-1.451	1.903**	-1.301	-3.164***	-0.979**	-0.643*	-0.153	2.700**	0.392	-0.115	-0.887
lnY_j	2.463***	1.234***	1.806***	0.698***	2.167***	0.775***	1.783***	0.467**	0.515	3.541***	1.141	1.488*	1.825	4.606***	3.655***	3.070***
$lnYpcp_i$	4.422***	1.714***	1.500***	1.988***	-0.891	3.352***	-1.293	2.805***	4.240***	1.819***	1.654***	1.362***	-2.092	0.775	1.619*	2.361**
$lnYpcp_j$	-1.149***	0.868***	-0.264	1.027***	-0.727**	1.222***	-0.171	1.380***	0.422	-1.184	0.408	-0.465	-1.091	-2.278*	-1.875**	-2.041**
$lnExcvol_{ij}$	-0.044**	-0.006	0.018	0.009	-0.014	-0.011	0.039*	0.017	-0.048	-0.015	-0.008	-0.005	0.007	-0.032	0.010	-0.016
$lnDist_{ij}$																
$lnRem_i$	-0.031**	0.019	-0.001	0.022	-0.007	0.010	0.010	0.016	-0.026	0.002	0.015	0.013	-0.028	-0.018	-0.001	-0.003
$Border_{ij}$																
$Lang_{ij}$																
C_EU_{ij}	0.197*	0.172*	0.152*	0.045	0.152	0.095	0.116	-0.023	0.287**	0.253**	0.187*	0.182	0.523***	0.430**	0.295***	0.206*
$D_1\_EU_{ij}$	0.054	-0.141**	-0.075	-0.079	0.060	-0.170**	-0.101	-0.109	0.019	-0.051	-0.119	-0.086	0.313**	0.207	-0.008	-0.001
$D_2\_EU_{ij}$	0.009	-0.027	0.004	0.030					0.054	0.083	0.059	0.112	…	…	…	…
$Gatt_{62\text{-}94\ ij}$	-0.060	0.038	0.037	0.105	0.025	0.009	0.061	0.167	-0.190	0.076	0.018	0.073	-0.180	-0.083	0.112	0.378*
$Gatt_{94\text{-}00\ ij}$	0.054	0.196	0.131	0.232*	0.046	0.081	0.081	0.199	-0.049	0.165	0.165	0.260	-0.324	-0.323	0.178	0.380
Constant	-0.007	0.003	-0.027	-0.076	-0.078	0.077	-0.012	-0.075	0.065	-0.135	-0.069	-0.147	-0.017	-0.158	-0.260	-0.484*
No. of observ.	29.640	29.640	29.640	29.640	19.266	19.266	19.266	19.266	16.302	16.302	16.302	16.302	5.928	5.928	5.928	5.928

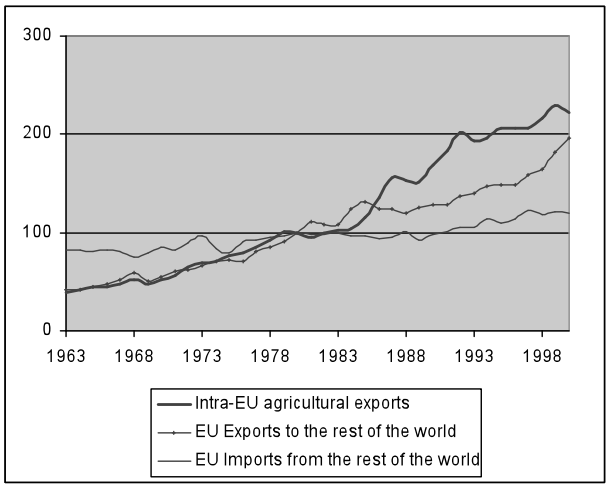
Note: The above are estimations of the gravity equation with panel-corrected standard errors and fixed effects (PCSE-Ef). Columns 1-4, total flows involving EU countries. Columns 5-8, export flows of EU countries. Columns 9-12, import flows of EU countries. Column 13-16, total intra-EU flows. Bulk: bulk agricultural products, Plant.: plantation products. Food: high-value and processed food. Proc.: processed products. All variables in logarithms, except binary variables (such as common border/language and different RTAs). Standard errors are given in parentheses. ***,** and * denote statistical significance of 1%, 5% and 10%, respectively.

To conclude, the results show the lack of influence of adherence to GATT, by EU countries and their trading partners, upon trade (see the variables $Gatt_{62\text{-}94\ ij}$ and $Gatt_{94\text{-}00\ ij}$ in Tables 2 and 3). To a certain extent, this result demonstrates that the degree of liberalisation of intra-EU agricultural trade was already very high. Consequently, the mild multilateral liberalisation implemented following the Uruguay Round had no expensive effect upon the trade of EU member states.

5.2. Determinants of European Union agricultural exports

The results of the gravity equation for EU export flows, both intra- and extra-EU, show good behaviour i.e. all the variables display the sign expected and adequately explain trade flow variations. Nevertheless, the results of the PCSE-Ef estimation (Column 4, Table 2) show how the evolution of EU exports, when an aggregated analysis is performed, is explained solely by increases in the income of the countries of both origin and destination *(Yi Yj)*.

Graph 1 Evolution of EU agricultural trade flows: Intra-EU trade and trade with the rest of the world *(Index numbers, 1980=100)*



Source: Authors' compilation, on the basis of UN-COMTRADE (2003)

An important question is the positive influence of the growth of domestic income upon European exports of agricultural products; the increase in the GDP of EU member states had a highly expansive effect (greater than unity) upon their export capacity[18]. This

[18] Gardner (1996) has shown how price maintenance policies have produced incentives to expand production. This process produced a considerable increase in surpluses, which were placed on the international markets as export restitutions.

result is related to factors already mentioned, such as the upsurge of European agricultural production, the increase in surpluses or the stagnation of the European food consumption level (Graph 1 shows the extraordinary increase in the exports of EU agricultural products).

Moreover, it should be noted that this result is similar to that which Feenstra *et al.,* (1998) and Fidrmurc (2004) present for manufacturing trade. It must be remembered that, as differentiated products, the exports of this sector were more sensitive to changes in the income of the exporting country than to variations in that of the importing country; this has been called the "home market effect". Thus, this result implies that EU agricultural exports were, in part, intra-industry trade.

As Table 3 shows, this effect upon aggregate EU agricultural exports was due to the group of processed and high-value foods (see Column 7, variable Y_i). It is important to remember that this group was responsible for the bulk of EU exports, and furthermore accentuated its trade specialisation[19].

The remaining product groups displayed, in line with Feenstra et al. (1998) and Fidrmurc (2004), a trade pattern of reciprocal dumping; this is a common response to the problem of the increase in EU surpluses (such as those of bulk agricultural products), which are placed on international markets at prices lower than those of the EU internal market.

At institutional level, the coefficient of the variable which measures trade creation (C_EU_{ij}) had, surprisingly, no effect upon the evolution of European exports, whether aggregated or disaggregated by product type. This result confirms those of Diao et al. (1999) and Dell'aquila et al. (1999), namely that European exports were already concentrated among EU member states. Furthermore, despite the fact that the coefficient of the variable $D1\_EU_{ij,}$, which measures the effect of trade diversion (i.e. exports previously sent to extra-EU countries redirected to other intra-EU destinations), displays a negative sign, this is not statistically significant with regard to aggregate agricultural trade. As stated earlier, the plantation products group (sugar sector) is the exception to this rule.

[19] As is well known, there exists a trend to increasingly concentrate the commercialisation of processed agricultural products in the developed world (Dayton and Henderson 1992). Furthermore, as McCorriston and Sheldon (1998) emphasise, the EU member states became increasingly predominant exporters of processed products.

5.3. Determinants of European Union agricultural imports

Column 7 of Table 2 offers the principal results for total EU imports. As in the previous analysis, increased income in the country of destination (in this case, EU member states), strongly and positively influenced trade growth. However, the opposite sign is displayed in the case of the income of the exporting country i.e. exports decreased in line with market size increase in the country of origin. This result is typical for developing countries, which in the second half of the last century underwent rapid population growth, which reduced their export capacity (Serrano and Pinilla 2008). Columns 9-12 of Table 3 show that demographic increases principally affected bulk agricultural products, the growth of demand for which was greatest in the least developed countries.

The second factor which stimulated the growth of EU imports is related to the liberalisation which took place in the EU. In contrast to the description given above of EU exports, in this case there is evidence of trade creation (see the dummy variable C_EU_{ij}). Specifically, this result was returned for the group of products in which European agriculture was traditionally less specialised i.e. bulk products and plantation products (sugar). High-value and processed foods also formed part of this trade expansion effect, although to a lesser extent. To summarise, the upsurge in European production was directed towards its liberalised internal markets.

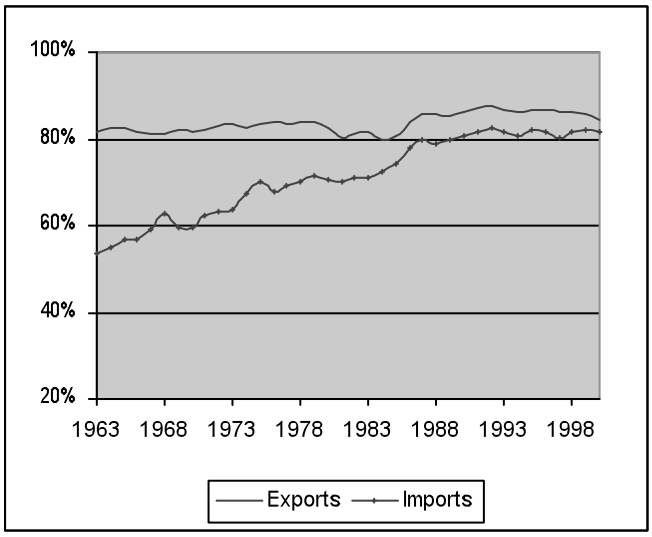
As Graph 2 shows, on the side of imports, the increase in the share of intra-regional trade with regard to total EU agricultural trade (using the countries included in the sample) was considerable. On the imports side, the increase in intra-regional trade was considerable; at the beginning of the 1960s this figure scarcely exceeded 50%, but at the end of the study period was over 80%[20].

Perhaps unexpectedly, the structure of EU imports displayed no trade diversion effects. Thus, the reduction in the relative importance of the EU with regard to total worldwide imports is mainly a result of its capacity for self-supply (due to the institutional network and technical progress)[21].

[20] Their evolution coincides with the results produced by Diao et al., (1999) for total worldwide and EU agricultural trade.

[21] The few studies which have focused specifically on this aspect reach no consensus. While Koo et al. (2004) find no trade diversion effects for trade flows in 1999; Vollrath (1998) does find such effects, applying a methodology different to that of the gravity equation.

Graph 2 Intra-regional trade percentage of total EU agricultural trade (trade flows of the present study sample)



Source: Authors' compilation, on the basis of UN-COMTRADE (2003). N.B: this is a representation solely of the countries in our sample.

It should nevertheless be emphasised that the dummy variable $D_1\_EU_{ij}$ represents trade diversion effects when exports are from European countries which had not yet joined the EU. By way of example, the incorporation of the United Kingdom in 1973 produced a diversion of imports from countries such as Spain, which were not yet members of the EU (see Graph 2).

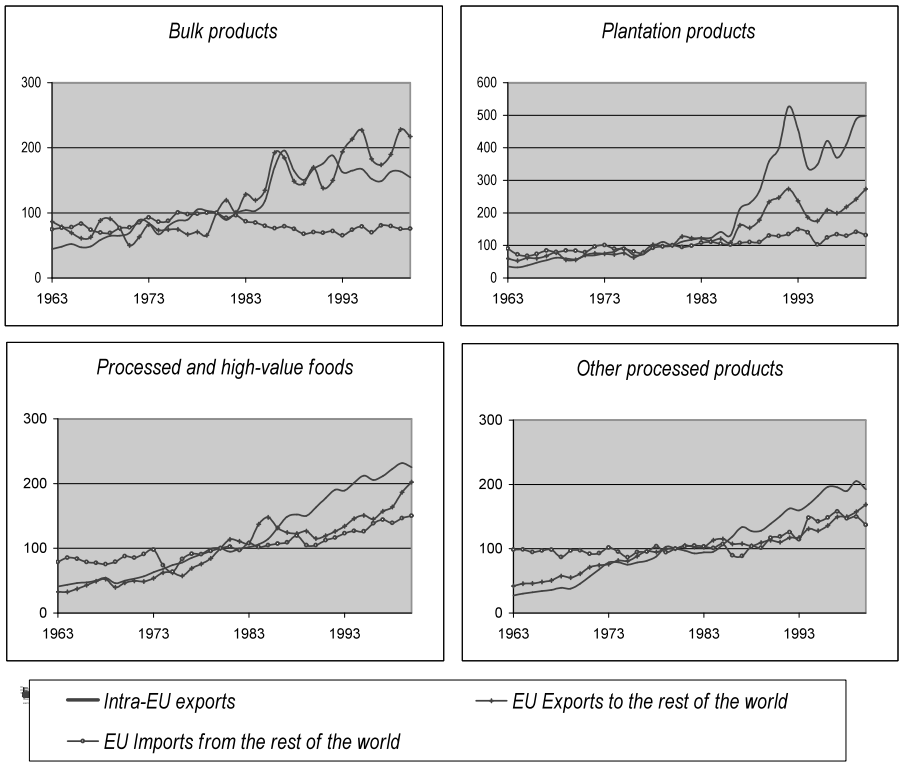
5.4. Determinants of intra-European Union agricultural trade

Lastly, this section analyses the results provided by the gravity model which study the determinants of intra-EU trade. The following set of graphs shows that its growth was exceptional, as mentioned earlier. This was true, furthermore, for all the product categories considered, including those which in earlier periods depended on the importation of products from other regions.

With regard to the empirical analysis, it is striking how well the models perform, compared to the models proposed for agricultural trade in previous models (see the adjusted R^2 in Table 2, Columns 6 and 11). Column 10 of Table 2 displays both the coefficients and the significance of the variables of the method selected; these are very similar to the results of the general analysis of EU agricultural trade. Consequently, only the most notable results are described here.

Starting with the results of the coefficients (*Yi Yj*), which refer to the market size of both the country of origin and the country of destination of exports, the positive effect upon trade of market size increase in the importing country is striking. In this case, what is significant is that the coefficient is far higher than that of previous estimations. We believe that this result may be closely related to the liberalisation of the EU market for agricultural products and food. It should be remembered that this is one of the few examples of trade which was liberalised for a large part of the study period. As Table 3 shows, this process was especially significant in the case of plantation products, followed by processed and high-value foods and the group of other processed products.

Graph 3 Evolution of EU agricultural trade flows, by product group: intra-EU trade and trade with the rest of the world. *(Index numbers, 1980 = 100)*



Source: Authors' compilation, on the basis of UN-COMTRADE (2004).

Secondly, and as was foreseeable, the dummy variable included in the model to capture the effects of EU trade creation displays a positive and statistically significant sign. At the disaggregated level, its effects were wider-reaching for the group of products in which European agriculture was less specialised i.e. bulk products and plantation products; this is a strong reflection of the considerable degree of isolation from the international

market, as we showed with the estimation of the coefficient of nominal protection of the EU.

6. Conclusions

The present study has focused on the analysis of the determinants of EU agricultural trade in the bulk of the second half of the XX century, paying special attention to the process of integration of European agriculture and the achievement of self-sufficiency. To this end, the study has applied different gravity models for agricultural trade flows. The first (and most general) includes both import and export flows, the second only takes into account EU agricultural export flows, the third is comprised of EU agricultural import flows and the fourth consists of intra-EU agricultural trade flows.

We believe that the analysis performed is innovative and may help us to understand one of the most controversial aspects of the process of EU integration. Very few studies have focused specifically on trade in this type of products, and those which have done so lack the long-term perspective we present. Moreover, none of them have employed an analysis as highly disaggregated by product group as ours.

The results of the different gravity models provide important conclusions with regard to the objective proposed in the introduction to the present study i.e. the study of the determinants of EU agricultural trade flows in the period 1963-2000.

Firstly, the increase in such flows was principally stimulated by income growth in the importing country, by the growth of per capita income in the exporting country and, particularly in this case, by the trade creation effects produced by the implementation of the EU; however, this increase was hindered by the negative income demand elasticity of the importing country.

These results confirm the general opinion that agricultural trade in this period became progressively concentrated among economies of large market size; their exports increased and their imports fell in line with their rising incomes. Lastly, as in the case of the EU, their intra-regional trade accelerated as a result of the liberalisation of their internal markets.

A more detailed vision is provided by the results of the more highly disaggregated analysis of EU agricultural trade. It is clear that EU exports were positively influenced by the home market effect, characteristic of a pattern of intra-industrial trade associated with the growing concentration of the international agrifood industry within the EU. By contrast, EU imports were stimulated by the effects of intra-EU trade liberalisation, especially for those products traditionally imported by European countries

and for those whose production increased significantly. It must be emphasised that the present study has found that third countries suffered no significant effects of trade diversion. In fact, our results show that the growth in the market size of the exporting country restricted exports, due more to the dynamic of population growth in the less developed countries than the construction of the EU.

The first conclusion reached is that the increase in the supply capacity of EU agriculture was reflected in a considerable increase in its level of exports. Secondly, it seems clear that the development of the EU enormously affected the growth of imports from the countries joining it, while an increasing percentage of their imports came from their new EU partners. Lastly, the slow growth of imports from third countries was mainly a result of the increases in demand in the less developed economies and the growing agricultural self-sufficiency of the EU.

Finally, the analysis of intra-EU trade flows for agricultural products and food shows, firstly, that the EU was responsible for a far-reaching integration of trade in agricultural products. Thus, the dummy variable which measures the effects of EU membership shows that trade in all types of agricultural products was significantly stimulated. Secondly, intra-EU agricultural trade increased principally as a result of the growth in the market size of the importing countries. In this case, it is especially significant that the coefficient is far higher than that displayed in the first three models, which also represented trade flows with non-EU members. We believe that this greater effect in the case of intra-EU flows may be closely related to the fact that this was one of the few examples of a liberalised agricultural market for a large part of the second half of the XX century.

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