An Analysis of the Trade Patterns of Olive-Oil in the European Union

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Abstract

In this paper we examine the factors that affect the trade of olive-oil within the 28 member-countries of the European Union. We do this by applying the gravity model of trade, which is regarded by many as the most appropriate tool for the analysis of factors affecting trade. The empirical study is based on data collected on unidirectional trade volumes of olive-oil of the European Union member states for a period of 16 years (from 2000 until 2015). We perform Pooled OLS, Fixed and Random Effects regressions, implementing one-way, two-way and dyadic clustering on our data. After performing the relevant F-test and ***Hausman*** *test we find that the Fixed Effects method is the most efficient one and see that, as expected, an increase in the price of olive-oil has a negative result on quantities traded whereas an increase in the per capita GDP of either the exporter or the importer has a positive effect.*

Keywords: gravity model, trade, olive-oil, European Union

JEL Codes: C33, F11, F15

Introduction

Within the European Union we find the world's four largest producers and exporters of olive-oil, namely Spain, Italy, Greece and Portugal. They account for the 70% of world production and approximately 95% of production of olive-oil within the European Union. Similar analogies apply on exports of olive oil: they account for more than 75% and more than 95% of exports of olive-oil worldwide and within the European Union, respectively.

Olive-oil has always been an important element of the diet of the Mediterranean countries and due to extensive promotional campaigns sponsored by the European Union and others, the benefits of a diet that contains olive-oil have spread over the world. This has resulted in an increase of olive-oil consumption in countries other than the traditional olive-oil producing Mediterranean countries. Production of olive-oil is important to the rural economies of these countries as approximately 5% of their agricultural areas is devoted to the cultivation of olive trees and approximately 2.5 million people (growers, cooperatives, pressing mills, blenders, refiners, exporting companies) are involved in the supply chain of olive-oil in the European Union.

Olive-tree plantations in Spain are mainly focused on the production of olives, in Greece they mainly produce olives for the extraction of olive-oil and in Italy both types are almost equally met. The largest factor of input costs is labor, where 43% to 57% of total cost in represented by family labor (e.g. in Greece, which has compared to Spain and Italy, mostly small plantations, family labor is major input) and 10% to 17% concerns wages. It is therefore important to analyze the trade patterns of this specific agricultural commodity as well as the factors that affect the unidirectional volumes of its trade within the European Union.

Theories explaining incentives and patterns of trade can be traced back to the 19th century, with Ricardo's theory of comparative advantage being one of the first ones trying to give an explanation as to how trade among two countries could benefit both of them. Regarding the post WWII growth of trade, most theories that have tried to provide an explanation have mainly based their arguments on the liberalization of trade (by means of agreements like the GATT, which was signed in 1947 by 23 nations, and the creation of unions like the EEC in the late 50's by six countries, namely France, West Germany, Italy, the Netherlands, Belgium and Luxembourg) or the reduction of transportation costs thanks to the improvement of technology.

In the early 60's, Tinbergen (1962) and Pöyhönen (1963), independently developed the *gravity model of trade*, a tool that has been widely used ever since by many due to its great empirical success, in order to measure the effect of various factors on trade in general or on trade of a specific commodity. Since agriculture is an important part of many economies, many studies have focused their interest on studying factors that affect agricultural trade, rather that overall trade. Moreover, many economists have argued that the gravity model gives clear results and makes better predictions if applied to data regarding a specific sector or even a specific commodity. The rationale behind this argument is that when the gravity model is used on aggregate trade data, it is forced to estimate one coefficient for each variable that fits all sectors. But if each sector is examined separately the deviations from the single coefficient might be quite large.

Mainly two factors have been in the center of attention regarding agricultural trade: tariff and non-tariff barriers and various regional trade agreements formed by countries in order to by-pass those barriers together with the abandonment of the *Bretton Woods* system and the adaption of a floating exchange rate system. There has been a lot of dispute around these and many economists have pointed out that they should be examined not on an aggregate level, but per sector separately since there are many claims that agriculture might be the most sensitive of all sectors. Therefore many studies have been conducted which measure the effects of above mentioned factors specifically on agricultural trade or even a specific commodity, like for example the study of Cho *et al.*, (2002) who find that the effect of exchange rate volatility is quite larger for agricultural trade than aggregate trade for the G-10 countries, Chen *et al.*, (2008) who find that Chinese exports of spinach are affected by *Sanitary and Phyto-Sanitary* (SPS) standards even more than agricultural trade as a whole, etc.

The paper is organized as follows: in Section 2 the gravity model of trade and its theoretical foundations are presented. In section 3 we review some empirical studies that have implemented the gravity model on agricultural trade or on specific agricultural commodities. In section 4 we present our model, the data we used, we analyze the econometric specifications of the methods we have applied and discuss our empirical results. Section 5 outlines our main conclusions.

Theoretical Model

The gravity model of trade was first developed, independently, by Tinbergen (1962) and Pöyhönen (1963). It takes the following basic form:

$$X_{ij} = b_0 Y_i^{b_1} Y_j^{b_2} D_{ij}^{b_3} u_{ij} \tag{1}$$

where X_{ij} indicates the amount traded between countries *i* and *j*, $Y_{i(j)}$ is each country's GDP, D_{ij} denotes the distance between countries *i* and *j* and u_{ij} is the usual random term.

It takes its name due to the resemblance it bares with *Newton's* classical law of gravity, stating, in its simplest form, that trade among two countries is proportional to their economic size and inversely proportional to the distance (serving as a proxy for transport costs) between their economic centers (usually considered to be a country's capital city). The model can be further extended by adding various dummy variables to check for other factors that may be facilitating or resisting trade (e.g. free trade agreement areas, common currency countries, adjacent countries, variables indicating level of infrastructure as a cost-reducing factor, protectionism measures, common language, relationship between countries that increases trade disproportionately like being a country's colony in the past, etc).

In 1966, Linnemann added population in the equation, as an additional measure of the country size (besides GDP) in what is called the augmented gravity model. In some other cases, the GDP per capita has been used instead which can be regarded as a proxy to the capital/labor ratio in the exporting country and which also allows for non-homothetic preferences in the importing country (Bergstrand, 1989).

Bergstrand (1985) shows that the common specification of the gravity model

$$PX_{ij} = b_0 (Y_i)^{b_1} (Y_j)^{b_2} (D_{ij})^{b_3} (A_{ij})^{b_4} u_{ij} \tag{2}$$

where PX_{ij} is the dollar value of the traded quantity between countries *i* and *j*, and A_{ij} is anything aiding or impeding trade between *i* and *j* and u_{ij} a log-normally distributed error term, can be derived by combing a utility function and a production function, under some simple assumptions.

Bergstrand (1989) extends his 1985 work and combines an inverse market demand curve for a specific product and the supply curve of that industry, which allows for relative factor-endowment differences (following upon the idea of the *Heckscher-Ohlin* model) and non-homothetic tastes across markets (following upon the *Linder* hypothesis, that says that countries with similar GDPs will have similar demands). This resulted in the following *augmented* gravity equation:

$$\begin{aligned} PX_{Aij} = {} & \delta^{(\gamma^A+1)/(\gamma^A+\sigma^A)} (Y_i^K)^{(\sigma^A-1)/(\gamma^A+\sigma^A)} \times (\beta_{KA}\beta_{LB} - \beta_{KB}\beta_{LA})^{-1} \\ & \times \left[\beta_{LB} - \beta_{KB} (K_i^* / L_i^*)^{-1} \right]^{(\sigma^A-1)/(\gamma^A+\sigma^A)} \times (Y_j)^{(\gamma^A+1)/(\gamma^A+\sigma^A)} \times (1 - y_j^{-1})^{(\gamma^A+1)/(\gamma^A+\sigma^A)} \\ & \times C_{Aij}^{-(\sigma^A-1)(1+\gamma^A)/(\gamma^A+\sigma^A)} \times T_{Aij}^{-\sigma^A(\gamma^A+1)/(\gamma^A+\sigma^A)} \\ & \times E_{ij}^{\sigma^A(\gamma^A+1)/(\gamma^A+\sigma^A)} \times \left\{ \left[\sum_n (P_{Ain} / C_{Ain})^{1+\gamma^A} \right]^{1/(1+\gamma^A)} \right\}^{-\gamma^A(\sigma^A-1)/(\gamma^A+\sigma^A)} \end{aligned}$$

$$\times\left\{\left[\sum_n (P_{Anj}T_{Anj})/E_{nj}\right]^{1-\sigma^A}\right\}^{-(\gamma^A+1)/(\gamma^A+\sigma^A)} \tag{3}$$

where PX_{Aij} is the value of the flow from country i to country j in industry A, b's are the constant requirements for the production of one unit, Y_i^K is country's i output in terms of capital and $K_i^*(L_i^*)$ is country i's capital (labor) stock used up for set up expenses, P_{Aij} is the *f.o.b.* (free on board-buyer pays for transportation costs) price of good h of industry a ($a=A,B$) exported from country n to country j, E_{nj} denotes the exchange rate of country's n currency in j's currency, C_{Ain} are the transport costs to ship output of industry A from country i to country n and T_{Anj} is the one plus tariff on goods in industry A.

Another attempt to establish a theoretical foundation for the gravity model was provided by Deardorff (1995) based on the *Heckscher-Ohlin* model. He looks for the gravity equations from two different aspects: a world of frictionless trade, where imported and domestic goods should have the same price and therefore consumers should be indifferent to both of them and a world were trade costs and barriers do exist. The *Heckscher-Ohlin* model assumes no costs of trade and there for, in case no *Factor Intensity Reversals* (FIR) occur, allows for *Price Factor Equalization* (PFE). Deardorff (1995) first derives the simple frictionless gravity equation which would hold if trade had no costs and preferences were homothetic and identical:

$$T_{ij} = \frac{Y_i Y_j}{Y^w} \tag{4}$$

where T_{ij} denotes the value of exports from country i to country j and $Y_{i(j)}^{(w)}$ is the respective income of countries i, j and the world.

In case of differentiated preferences the equation takes the following form:

$$T_{ij} = \frac{Y_i Y_j}{Y^w}\left(1+\sum_k \lambda_k \tilde{a}_{ik}\tilde{b}_{jk}\right) \tag{5}$$

where λ_k denotes the fraction of the world income from the production of good k, $\tilde{a}_{ik}$ is the proportional deviation of share of income country i derives from producing good k, $\tilde{b}_{ik}$ is the proportional deviation of share of income that country j spends on good k. This second equation allows for an overview of how trade would increase or decrease relevant to the simple equation in case the exporting country over- or under-produces good k and the importing country over- or under-consumes good k.

In the second case Deardorff (1995) presumes that all international trade bares costs of transportation (although the equation also holds in the case of frictionless trade) and where every country produces and exports a different good. Costs of trade can be estimated either on an *f.o.b.* basis or a *c.i.f.* basis (cost-insurance-freight, seller pays for transportation). For the *c.i.f.* case, things are quite simple, the equation would again be:

$$T_{ij}^{c.i.f.} = \frac{Y_i Y_j}{Y^w} \tag{6}$$

Bilateral trade with *f.o.b.* costs could be estimated by the following equation:

$$T_{ij}^{fob} = \frac{Y_i Y_j}{Y^w} \frac{1}{t_{ij}} \left[\frac{\rho_{ij}^{1-\sigma}}{\sum_h \theta_h \rho_{ih}^{1-\sigma}} \right] \tag{7}$$

where θ_h denotes the share of all countries' share of world income except country j, ρ_{ij} is the relative distance among the pair of countries given by $\rho_{ij} = t_{ij} / \delta_j^s$, where t_{ij} is the transport factor (transport costs - assumed to be in the iceberg form plus one) between countries i and j and δ_j^s is the average distance from suppliers. This equation relates the amount traded between countries i and j to their relative distance, saying that if the relative distance among i and j is the same as the average of the distance of all demanders from country i, then the *c.i.f.* exports will be equal to those under frictionless trade and *f.o.b.* exports will be reduced by the transport factor (transport costs plus 1) from country i to j. It also shows that in case of reduction of the transport factor, then trade among countries further apart will increase and that of countries closer to each other will decrease, because they will lose their advantage relative to the remoter countries (Deardorff, 1995).

Review of Major Empirical Studies

Dascal *et al.*, (2002) analyzed wine trade flows within EU. They apply an augmented gravity model to panel data from the first 12 countries of the European Union for the period 1989-1997. They derive two gravity models, one for exports and one for imported quantities so as to determine factors that affect trade in both directions. To do this, they use a country's remoteness variable constructed by the distance between the two trading countries, weighted by the share of the exporter's (or importer's respectively for each model) GDP to the sum of GDP of all countries for that year. The intuition behind this is that further (remoter) a country is, then the larger its economy the more it will trade. They find a positive relationship between the exporting (importing) country's GDP per capita and exports (imports) of wine, remoteness of a country had a positive effect on exports and a negative effect on imports. The EU dummy variable has a positive sign for both imports and exports, indicating that the integration of the countries of the European Union has had an overall positive effect on both imports and exports.

Cho *et al.*, (2002) estimated a gravity model in order to check whether exchange rate volatility has a greater negative effect on agricultural trade than on any other sector or not. To do so, they gather panel data from the G-10 countries (namely Belgium, Canada, France, Germany, Italy, Japan, the Netherlands, Switzerland, the UK and the USA), which account for almost half of international trade on agricultural products, covering the period from 1974 until 1995. They group trade into five distinct sectors: total exports, machinery, chemicals, other manufacturing and agriculture. The variable of interest in this study is the exchange rate variability and there for they use two measures to capture the effect: the first one is based on the most common method of the standard deviation of the first differences in the exchange rate over a period of ten years and a measure proposed by Perée and Steinherr (1989) based on the minimums and maximums of the exchange rate adjusted by the levels of last year weighted by some kind of "equilibrium" exchange rate. They regress both models using both Random and Fixed Effects models and their results indicate that indeed exchange rate volatility has a larger negative effect on agricultural trade compared either with total trade or with the individual sectors.

Kandilov (2008) building on the paper by Cho *et al.*, (2002) examines if this result is also true when extending the developed countries group to 23. His hypothesis, that Cho *et al.*, (2002) results are restricted only to the G-10 group is confirmed, as indeed this time the effect is smaller. He offers some evidence to support his explanation posing that the G-10 countries apply various policies (namely exports and domestic subsidies) which seem to follow a similar temporal variation with exchange rate volatility. His hypothesis is further confirmed when he extends his sample even further so as to include exports of developed countries (he uses unidirectional data) to developed, emerging and developing countries, where the negative effect almost becomes negligible. Finally, he also finds that when focusing on exports of developing countries, the effect of exchange rate volatility on exports of agricultural products is negative but small and close to that of aggregate exports.

Sheldon *et al.*, (2013) take the ideas of Cho *et al.* (2002) and Kandilov (2008) focusing on the fresh fruit and vegetables sector. A point frequently discussed regarding exchange rate volatility and agricultural trade is if one should focus on short-term or long-term volatility. Some authors argue that the effects of volatility in the short-term can easily be soften by hedging and risk management instruments while, Vianne and de Vries (1992) suggest that even so, the risk of exchange rate volatility still negatively affects trade in the short run. In order to examine their hypothesis Sheldon *et al.*, (2013) gather bilateral trade data from 26 countries (which represent 80% of US bilateral fresh fruit trade) from 1976 until 1999 and bilateral trade regarding fresh vegetables from 9 countries (representing 80 - 90% of US bilateral fresh vegetables trade) for the period from 1976 until 2006. Using two different specifications to measure exchange rate volatility their results reveal that uncertainty has a negative effect on bilateral trade and that trade with Latin American countries accounts for most of this impact.

In a different empirical context Grant and Lambert (2008), motivated by conflicting empirical evidence, investigated the effects of Regional Trade Agreements (RTAs) on the trade of agricultural products. They point out that the majority of these studies focus on how RTAs affect trade, without distinguishing between agricultural and non-agricultural products. Using the gravity equation they test three hypotheses: first, if the increase in members' trade is larger for agricultural than for non-agricultural products, second, if the effect of the RTA takes place immediately after being signed or if it occurs over time and third, if the effect of all RTAs is the same or if it depends on the extent of agricultural trade liberalization. Using different empirical specifications for their model, they found evidence of their first hypothesis as indeed RTA's have increased trade on agricultural products by more than for non-agricultural products (on average 72% and 27% respectively). Regarding the second hypothesis, they find that the *phase-in* period also plays an important role. They check this for up to three four-years' lags and find that after a twelve years *phase-in*, agricultural trade has increased by 149%, while non-agricultural trade has increased by less than half of that (namely 63%). Finally, they argue that indeed one has to distinguish among the RTAs. For example, they find that after twelve years of *phase-in*, agricultural trade of EU members has increased by 400% while for members of the NAFTA/CUSTA the corresponding increase was only 137%.

Chen *et al.*, (2008) using a modified gravity model they analyzed the negative effects that non-tariff barriers may have on China's exports of agricultural products. According to Chen *et al.* (2008) the fact that many developed countries have resorted to the implementation of SPS standards at stricter levels for pesticides and veterinary antibiotics than those dictated by the FAO, may have caused damage to the developing countries' comparative advantage they usually tend to have on agricultural production. In their gravity model they use instead of exporter's GDP, the total quantity produced of the commodity exported and they have added a measure of the maximum residual limit (MRL) of the pesticide Chlorpyrifos (for vegetables) or the veterinary antibiotic Oxytetracycline for fish and aquatic products and a measure for any tariffs imposed by the importing country. They run two commodity groups regressions (namely vegetables and fish and aquatic products) and three commodity-specific regressions (garlic, onions and spinach). The results of the regressions indicate that indeed stricter measures have a negative effect on exports of vegetables. Regarding fish and aquatic products, again the regression indicates a positive relationship between the level of strictness (the higher the level the less the maximum residual limit is) and exports.

Kavallari *et al.*, (2011) analyzed which factors affect imports of olive-oil from the main producing Mediterranean countries (both members of the EU and not) into the EU's two main consumers, namely the UK and Germany. In this context, they enrich the typical gravity model with many variables in order to check if factors like the number of immigrants of the main producing countries living in Germany or the UK, if the exporting countries are members of the EU, if the exporting countries receive a large flow of tourists from Germany or the UK, if the importing countries buy directly from the producers or if there are a lot of mediators involved, etc. affect trade. They find that the EU membership or the Mediterranean Partnership has the highest impact. Imports of olive-oil are also positively affected by the absence of middle-mans, *i.e.*, if the importing countries buy directly from the producing ones and even more if they import bulk olive-oil, meaning that labeled olive-oil is less likely to be imported. This is explained by the fact that importing bulk olive-oil allows for the importing country to reap a larger part of the profits. Also trade is positively affected by tourism flows from the importing countries into the producing ones.

Finally, Ferro *et al.*, (2014) use the gravity model of trade to estimate the effects of Sanitary and Phyto-Sanitary (SPS) and Technical Barriers to Trade (TBT) agreements on the volumes of trade of agricultural products. Ferro *et al.*, (2014) faced three main difficulties regarding the quantification and normalization of the information and data they collected. Firstly that the aforementioned agreements develop two aspects of restrictiveness: one regarding the number of regulations per product and another regarding how strict these regulations are. Secondly the fact that all countries do not choose to regulate the same pesticide for each product, creating a heterogeneity of pesticides and thirdly how to interpret the data regarding the pesticides that are not regulated, given the fact that the value of zero would imply that a pesticide is completely banned from the importing country. To address these issues they created a restrictiveness index for each country for each product for each year. Their results indicate that indeed, on average, product standards affect trade negatively, meaning that if an exporter can choose between two countries, *ceteris paribus*, he will export to the country that has lower product standards. The additional costs inquired by an exporter so as to be able to meet up with the standards are regarded as sunk fixed costs and are consistent with the model proposed by Helpman *et al.*, (2008). Also, product standards seem to have a larger negative effect on exporters from low income countries, who seem to face greater difficulties in exporting to countries where standards are more strict.

In table 5 some basic findings of selected studies dealing with agricultural trade using the gravity model are presented.

A Gravity Model for Olive-Oil

Econometric model

As posed at the outset, the goal of this study is to measure which effects make trade of olive-oil within the European Union more easy or difficult. For doing so, we performed regressions with the three most commonly used methods for a gravity model using panel data (*i.e.*, Pooled OLS, Fixed Effects and Random Effects). The F-test and the Hausman test indicated the FE method produces the most efficient and consistent results. This outcome is consistent with both the intuition behind the model and literature regarding proper econometric specifications of the gravity model.

Panel data used to estimate gravity models consist out of many country-pairs examined over an extended period of time. Both the Random Effects and Fixed Effects models, assume that there are individual-specific time-invariant effects that are random. The main difference lies in the fact that Fixed Effects allow for the independent variables to be correlated with this individual-specific effect, where as Random Effects do not allow for such correlation. Specifically, given the following simple gravity model specification:

$$y_{ijt} = x'_{ijt}b + u_{ijt}$$

where u_{ijt} is the composite error and is equal to $a_{ij}+e_{ij}$ with a_{ij} being the unobserved heterogeneity term and e_{ijt} being the idiosyncratic error. Under the Fixed effects model assumptions, correlation between the independent regressors and the unobserved heterogeneity term is allowed for, *i.e.*, $Cov(a_i,x_{ijt})\neq 0$, where as the Random Effects model imposes the more strict assumption of $Cov(u_i,x_{ijt})=0$ which consequently implies that $Cov(a_i,x_{ijt})=0$.

The gravity model's most common regressors are each country' s GDP and we intuitively assume that there will be country-specific unobserved effects that will affect this independent variable (like historical or geographical factors which are unique, time-invariant and unobservable for each country and political factors which are also unobservable) and thus correlation between those factors and the independent variables cannot be equal to zero. Therefore we assume that only the Fixed Effects model will give consistent estimates. Egger (2000) also points out that due to the fact that the gravity model is usually not applied on a randomly selected sample of countries but rather on an ex-ante predetermined exhaustive set of countries (like in our case all the countries of the European Union) the FEM would probably be the most appropriate method.

The problem that arises with the FE method being the appropriate one, is that coefficients of time-invariant variables cannot be estimated, since they are dropped out of the model due to collinearity. This means that we cannot calculate a coefficient for distance, which is time-invariant for each country-pair. To solve this problem, we formed an other equation, using a remoteness variable to replace distance. The remoteness variable (used also by Dascal *et al.*, (2012)) is constructed by multiplying the distance between the country pair by the per capita GDP of the exporter divided by the sum of all the per capita GDPs of the 28 countries for that year:

$$R_{ij} = \text{distance}_{ij} \times \frac{GDP_{it}}{\sum_{i=1}^{28} GDP_{it}} \tag{8}$$

Since remoteness is no longer a time-invariant regressor, FE produces the relevant coefficient. We have also included two dummy variables in our model to assess if being a member of the Eurozone effects the volumes of olive-oil traded.

The model, in its log-linearized form is the following:

$$X_{ijt} = a_0 + a_1 \ln P + a_2 \ln GDP_{it} + a_3 \ln GDP_{jt} + a_4 \ln R_{ijt} + a_5 DE_i + a_6 DE_j + u_{ijt} \tag{9}$$

where X_{ijt} is the natural logarithm of quantity exported from country i to country j at time t, P is the price in constant terms of olive-oil, $GDP_{i(j)}$ is constant per capita GDP of the exporter and importer respectively at time t, R_{ijt} is the remoteness variable, as described above, $DE_{i(j)}$ is a dummy variable taking the value of 1 if the exporter, or importer respectively, is a member of the eurozone and 0 otherwise and u_{ijt} is the composite error term, consisting of the time invariant fixed effect a_{ij} and the idiosyncratic error e_{ijt}.

Data

We have collected panel data on unidirectional trade quantities among the 28 countries constituting the European Union till 2015, over a period of 16 years (from 2000 until 2015). Using panel data for gravity models has become a standard practice over the last years due to their advantages, some of which are: they allow for country-specific effects which may be correlated with some of the variables of the model and may also be unobservable; they offer information over a period of time for each country pair allowing for the identification of the role of the overall business cycle (Egger, 2000). Data on trade (quantity and values), GDP, population and deflators were all collected from EUROSTAT. Distance between the capital cities, which we regard as the economic centers of the country pairs, are measured in kilometers. This data created a panel of 4,068 observations on 474 unique trading pairs.

Empirical Results

Initially we estimated equation (9) by Pooled OLS. We also checked for serial autocorrelation of the errors on all lags of the dependent variable and confirmed that there is indeed a high degree of autocorrelation amongst the error terms. Specifically, regarding the pattern of the error correlation of data such as the ones used for the estimation of a gravity model, where the individual consists of a pair of countries, this can be a quite complicated one. As Cameron *et al.*, (2008) and Cameron and Miller (2014) point out, errors might be correlated not only amongst all observations sharing a common exporter

Table 1: *Parameter Estimates of the Pooled Effects Model*

Variable	No Clustering		One-Way Country Pairs		One-Way Exporter		Two-Way Exporter-Importer		Dyadic Clustering	
	Estimate	St. Error	Estimate	St. Error	Estimate	St. Error	Estimate	St. Error	Estimate	St. Error
Olive – Oil Price	-2.277	0.083**	-2.277	0.1660**	-2.277	0.202**	-2.277	0.259**	-2.277	0.246**
GDP of exporter	-1.138	0.098**	-1.138	0.231**	-1.138	0.433**	-1.138	0.448**	-1.138	0.432**
GDP of importer	1.107	0.064**	1.107	0.178**	1.107	0.186**	1.107	0.242**	1.107	0.244**
Countries' Remoteness	0.363	0.027**	0.363	0.068**	0.363	0.157**	0.363	0.163**	0.363	0.142**
Eurozone Member – Exporter	2.105	0.102**	2.105	0.247**	2.105	0.392**	2.015	0.432**	2.105	0.507**
Importer	-0.561	0.091	-0.561	0.253	-0.561	0.187	-0.561	0.258	-0.561	0.135
Constant	1.079	1.009	1.079	2.334	1.079	3.791	1.079	3.753	1.079	3.516

*and ** indicate statistical significance at the 10 and 5 per cent level, respectively.

Table 2: *Parameter Estimates of the Fixed Effects Model*

Variable	No Clustering		One-Way Country Pairs		One-Way Exporter		One-Way Importer		Two-Way Exp-Imp	
	Estimate	St. Error	Estimate	St. Error	Estimate	St. Error	Estimate	St. Error	Estimate	St. Error
Olive-Oil Price	-1.500	0.055**	-1.500	0.097**	-1.500	0.098**	-1.500	0.088**	-1.500	0.086**
GDP of exporter	5.606	0.604**	5.606	1.072**	5.606	1.333**	5.606	1.223**	5.606	1.416**
GDP of importer	1.908	0.253**	1.908	0.468**	1.908	0.594**	1.908	0.550**	1.908	0.643**
Countries' Remoteness	-5.290	0.626**	-5.290	1.031**	-5.290	1.464**	-5.290	1.039**	-5.290	1.429**
Eurozone member:										
Exporter	-0.084	0.158	-0.084	0.208	-0.084	0.246	-0.084	0.194	-0.084	0.226
Importer	0.185	0.103*	0.185	0.188	0.185	0.170	0.185	0.340	0.185	0.322
Constant	-43.61	3.808	-43.61	6.632	-43.61	8.900	-43.61	7.826	–	–

* and ** indicate statistical significance at the 10 and 5 per cent level, respectively.

Table 3: *Parameter Estimates of the Random Effects Model*

Variable	No Clustering		One-Way Country Pairs		One-Way Exporter	
	Estimate	St. Error	Estimate	St. Error	Estimate	St. Error
Olive-Oil Price	-1.570	0.055**	-1.570	0.091**	-1.570	0.096**
GDP of exporter	0.105	0.192	0.105	0.226	0.105	0.444
GDP of importer	1.354	0.130**	1.354	0.171**	1.354	0.242**
Countries' Remoteness	0.304	0.070**	0.304	0.076**	0.304	0.214
Eurozone member:						
Exporter	0.690	0.138**	0.690	0.177**	0.690	0.315**
Importer	0.226	0.098**	0.226	0.169	0.226	0.136*
Constant	-4.576	1.975	-4.576	2.510	-4.576	4.497

Standard errors are in parentheses * and ** indicate statistical significance at the 10 and 5 per cent level, respectively.

or importer, but also with all observations that have any of the two components in common regardless of the fact if it is the exporter or the importer. For example errors for the exports of Greece to Italy may not only be correlated with all other errors of exports from Greece or imports to Italy but also with all other errors of exports from Italy and imports to Greece. This would best be checked for by performing the Pooled OLS regression with dyadic (the term used by Cameron and Miller, 2014) clustering.

The typical Pooled OLS regression assumes no error correlation. Adding the one-way cluster-robust option on country-pairs only sets the elements of the diagonal of the variance-covariance matrix different to zero. One-way cluster-robust inference on exporter will set different to zero also the error correlation of the country-pairs that have a common exporters. The two-way clustering is a substantial progress, as it sets also the error correlation of individuals that have either the exporter or the improper in common as different to zero. Optimally, we would like to be able to also perform cluster-robust inference with dyadic clustering checking for all individuals that have either element of the country-pair in common, regardless if it is the exporter or the importer. We performed dyadic clustering on the Pooled OLS model only using Cameron and Miller (2014) approach.

Taking all above under consideration, we performed the Pooled OLS regression under the following specifications: simple Pooled OLS without cluster-robust errors, one-way clustering on country pairs, on exporter and on importer, two-way clustering on importer and exporter and dyadic clustering. Afterwards we also regressed equation (9) using FE and RE methods. Again due to the high correlation of the errors we performed cluster-robust regressions for both methods: for the FE method we perform cluster-robust estimations for one-way clustering on country-pairs, exporter, importer and two-way clustering on both importer and exporter and for the RE method we performed three regressions: no clustering, one-way clustering on country-pairs and on exporter.

Afterwards we performed the F-test between Pooled OLS and FE without clustering and Hausman test between FE and RE methods without clustering (results are presented in table 4), both of which indicated that, as was expected, the coefficients estimated with the FE method are the only ones that are consistent. The large difference between

Table 4: *Test Results Regarding Choice of Method*

Specification	F-Test	Hausman Test
Log of quantity exported from country i to j	$F_{(473, 3588)} = 31.77$ (F sign.: 0.0000)	$\chi_{(6)}^2 = 255.98$ (Sign.: 0.0000)

Table 5: *Results of Similar Studies*

Study	GDP_{it}	GDP_{jt}	R_{ijt}
Cheng et al. (2008)			
Vegetables	-	0.82**	-
Garlic	-	0.32**	-
Onions	-	0.37**	-
Spinach	-	0.83**	-
Fish Products	-	1.02**	-
Grant & Lambert (2008)			
Agricultural			
No time or country FE	0.34**	0.50**	-
Time but no country FE	0.37**	0.52**	-
Time and bilateral pair FE	0.06**	0.32**	-
Bilateral Pair and Country-by-pair FE	1.00	1.00	-
Non-Agricultural			
No time or Country FE	0.78**	0.69**	-
Time but no Country FE	0.79**	0.70**	-
Time and bilateral pair FE	0.22**	0.37**	-
Dascal et al. (2002)			
Exports			
Pooled OLS	1.540**	0.760**	0.369***
FE	0.169**	0.339**	0.040**
RE	0.686**	0.687**	0.183**
Imports			
Pooled OLS	1.996**	-0.119**	0.652**
FE	0.143**	0.532**	-0.399**
RE	1.923**	0.023	0.609**
Kavallari et al. (2011)			
Aggregate (UK & Germany)	3.286**	-0.997	-
Country-Specific			
Germany	4.943**	-2.640*	-
UK	6.052**	-4.309	-

* and ** indicate statistical significance at the 10 and 5 per cent level, respectively

the Pooled OLS and FE estimators confirms our initial assumption that the effect of the unobserved heterogeneity is very strong and the variance of the unobserved term is very large. This can be explained due to the fact that our group of countries, the 28 countries of the European Union, contain both the world's largest exporters of olive oil but also countries that barely export olive-oil. Results of all regressions are presented in table 1 for the Pooled OLS, in table 2 for the FE method and table 3 for the RE method.

Regarding the choice of the most appropriate method of clustering on the FE method, we see that indeed clustering provides a better estimation of the standard error. Clustering on individuals, i.e. country-pairs, does not suffice. This was expected since we assume that errors within a group, like for example exporters, will better check for the error correlation pattern. There for clustering over exporters and two-way clustering over exporters and importers produce the best results.

Coefficients produced with the FE method all have the expected sings and are in accordance with coefficients found in the gravity model literature. In the log-linearized model, coefficients are interpreted as elasticities. We see that 1% increase of the price of olive-oil will cause a decrease of 1.5% in quantities exported. An increase in GDP of the exporter has a positive effect on exports, as the signs of the coefficients of the per capita GDP of the exporter and of remoteness are positive. The positive sign of a_2 indicates that a production-driven increase in income will also increase exports. The negative sign of the remoteness factor, which substitutes for the negative effect of distance among two countries, is in accordance with the literature of the gravity model, implying that as distance between two countries gets larger, transportation costs increase making the product more expensive. The coefficient of the exporter's GDP also has a positive sign, implying an increase in the demand of imported olive-oil as income in the importing country rises.

The two dummy variables, regarding exporter's and importer's currency, give a interesting result. The dummy regarding the exporter has a negative sign, meaning that being a member of the eurozone will have a negative impact on exports, in the sense that having the euro as currency makes exports relatively more expensive. In the same logic, the coefficient of the dummy for the importer has a positive sign. The interesting result, though, is that both coefficients are statistically insignificant when estimating the FE model with cluster-robust standard errors (and without this option only the importer dummy is significant at the 10% level). This result can be explained by the fact that this dummy is time-invariant for the three out of four largest traders of olive oil, namely Spain, Italy and Portugal which adopted the euro in January 1999 and Greece, the fourth of these countries (and third biggest exporter) who adopted the euro in January of 2001. Given the fact that these four countries account for almost 96% of exports and if we where examining only them, these dummies would have been dropped in the FE method, it explains why it is statistically insignificant for this particular set of data examined. We conclude that if all countries had the euro, this would make olive-oil less expensive in relative terms and thus traded quantities would increase.

Conclusions

Aim of this study was to measure and explain the positive and negative effects of various factors on exports of olive-oil with the aid of the gravity model. The gravity model has proven, empirically, to be a model that gives quite accurate explanation of such trade patterns. While when first derived it lacked a theoretical foundation, this was provided later on and it is considered now one of the most reliable methods to use for analysis of trade, either on aggregated data or of a specific commodity. It has also been widely used to examine trade flows of agricultural goods, which seem to be quite volatile due to their sensitive nature and their dependence on many unpredictable and uncontrollable factors, like weather conditions.

We performed regressions using the Pooled OLS method, the FE and RE methods and as expected, according to the literature on the gravity model, the FE method was the most appropriate, as was indicated by the F-test and the Hausman test. We also tried to check for error correlation by adding clustering on various levels with one-way clustering on exporter and two-way clustering on exporter and importer seeming to fit our data best.

We find that, as expected, price has a negative effect on exported quantity of olive-oil whereas a grow in the per capita GDP of either the exporter of the importer will rise exports of olive-oil within the European Union. The negative effect of distance between countries is reflected by the negative sign of the remoteness variable. We also find that if the exporter or the importer is a member of the eurozone is statistically insignificant, which is probably due to nature of the country set under examination and does not reflect the real positive effects of adoption of a common currency by a group of countries.

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