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Gravity Model of Turkish Agricultural Exports to the European Union

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Abstract

This study analyzes the determinants of Turkish agricultural exports to the European Union (EU) by estimating the gravity model for the panel of 23 trading partners in the EU covering the period 1996-2004. We find that Turkish agricultural exports to the EU are positively correlated with the size of the economy, the importer population, the Turkish population living in the EU countries, the non-Mediterranean climatic environment, and the membership to the EU-Turkey Customs Union Agreement while they are negatively correlated with agricultural arable land of the EU countries and geographical distance between Turkey and the EU countries.

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Keywords: Gravity model, panel data, Turkish agricultural exports, the EU.
JEL Classification: C23, F14.

1. Introduction

Turkey has been in the process of full membership to EU. The EU has the biggest share of Turkish agricultural exports to the world, accounting for more than 40 percent during the last decade (see Appendix 1). Germany, Italy, United Kingdom, Netherlands, France, Belgium, and Spain have more than 85 percent of Turkish agricultural exports to the EU (see Appendix 2). The following includes common features of these countries: i) they are more developed countries of the EU relative to other countries; ii) they are countries in which the Turkish population in the EU mostly live; iii) they have the membership to the EU-Turkey Customs Union Agreement; finally iv) climatic features of some countries such as Germany, United Kingdom, Netherlands, and Belgium are different from Turkey's.

This study attempts to analyze the importance of such factors in Turkish agricultural exports to the EU. To this end, the gravity model which is a widely used tool in the analysis of trade flows is estimated utilizing econometric analysis of panel data.

The gravity model was used to analyze factor effecting agricultural trade flows such as economic integration (Sanz and Gil, 2001), exchange rate uncertainty (Cho *et al.,* 2002), exchange rate volatility (Yuan and Awokuse, 2003), border effects (Furtan and van Melle, 2004; de Frahan and Vancauteren, 2006), trade creation and diversion effects of regional preferential trade agreements, language commonality, and arable land (Koo *et al*., 2006; Hilbun *et al*., 2006; Jayasinghe and Sarker, 2007). Besides these studies Sevela (2002) used a gravity-type model to examine the determinants of agricultural exports of Czech Republic. He finds a positive impact of gross national income (GNI) and negative impacts of distance and GNI per capita. Sevela argues that a negative coefficient of GNI per capita corresponds with the relative lower competitiveness of Czech Republic agricultural exports into more developed economies.

Turkish agricultural commodity's exports to the EU were analyzed with the gravity model by Danzinger *et al.* (2005) and by Atici and Guloglu (2006). Danzinger *et al.* (2005) analyzed the impact of the customs union between Turkey and the EU on Turkey's sixteen most important export sectors. Estimation and simulation results for agricultural markets (edible vegetables, edible fruit and nuts, and preparations of vegetables, fruit, and nuts) show positive impacts of real exchange rate, extending customs union including agricultural sector, and Turkish agricultural policy adaptation to Common Agricultural Policy. Atici and Guloglu (2006) analyzed the factors determining Turkey's fresh and processed fruit and vegetable exports to the EU. They find that the size of the economy which is measured as the sum of GDPs of Turkey and its trading partner, the importer population, the Turkish population living in the EU member countries, and being a non-Mediterranean country are the significant factors.

These studies applied econometric analysis of either cross-section (Sanz and Gill, 2001; Sevela, 2002; Koo *et al.*, 2006; and Hilbun *et al*., 2006) or panel data (Cho *et al*., 2002; Yuan and Awokuse, 2003; Danzinger *et al.,* 2005; Atici and Guloglu, 2006; de Frahan and Vancauteren, 2006; Jayasinghe and Sarker, 2007). In this study, panel data analysis is utilized for our purpose because it has some advantages over cross-section data analysis (see Baltagi, 2001).

The remains of the study are organized as follows. Section 2 briefly explains the gravity model. Section 3 outlines the econometric model and discusses the data. Section 4 explains the procedure of econometric analyis. Section 5 discusses the empirical findings. Section 6 represents concluding remarks.

2. The Gravity Model

The gravity model explains trade flows between countries as a function of income, population, geographical distance, and a set of other variables (Martinez-Zarzoso, 2003). The trade flows equation is thus formulated as follows:

$$X_{ij} = \beta_0 Y_i^{\beta_1} Y_j^{\beta_2} N_i^{\beta_3} N_j^{\beta_4} D_{ij}^{\beta_5} A_{ij}^{\beta_6} u_{ij} \qquad (1)$$

where X_{ij} represents the trade flows between countries, Y_i (Y_j) indicates the income of the exporter (importer), N_i (N_j) denotes exporter (importer) population, D_{ij} is the distance between the two countries' capitals (or economic centres), and A_{ij} represents any other factors effecting the trade flows, u_{ij} is the error term. This formulation of the gravity model is often used to estimate aggregated trade flows. In the alternative formulation of the equation (1), per capita incomes of the exporter (YP_i) and importer (YP_j) are used instead of population to estimate bilateral trade flows for specific products. In this approach, the equation (1) is reformulated as follows:

$$X_{ij} = \beta_0 Y_i^{\beta_1} Y_j^{\beta_2} YP_i^{\beta_3} YP_j^{\beta_4} D_{ij}^{\beta_5} A_{ij}^{\beta_6} u_{ij} \qquad (2)$$

A parameter estimate of the importer income is expected to be postive because an increase in the importer income should increase the demand for imports. The coefficient on the exporter income is expected to be positive since a high level of the exporter income increases the quantity of goods exported. An estimate of the importer population may be positive or negative depending upon whether a heavily populated country imports less (absorption effect) or imports more (scale effect). The impact of the exporter population on the trade flows is also expected to have an ambiguous sign, for similar reasons. The coefficient on distance is expected to be negative since the distance amounts for transportation and insurance costs.

3. Econometric Model and Data

An empirical form of the gravity model to determine the factors explaining Turkey's agricultural exports to the EU is developed as follows:

$$\ln E_{ijt} = \ln\alpha + \beta_1 \ln Y_{ijt} + \beta_2 \ln P_{jt} + \beta_3 \ln D_{ij} + \beta_4 \ln \mathrm{AL}_{jt} + \beta_5 TP_{jt} + \beta_6 C\mathrm{U}_{jt} + \beta_7 N\mathrm{MED}_{jt} + u_{ijt} \qquad (3)$$

$$u_{ijt} = \mu_{ij} + \lambda_t + \nu_{ijt} \qquad (3.1)$$

where μ_{ij} denotes the unobservable individual effects, λ_t denotes the unobservable time effects, ν_{ijt} denotes the remainder stochastic error term, i represents Turkey, j stands for the EU countries ($j=1,2,\ldots,23$)[1], and t is the time period ($t=1996\text{-}2004$). The variables used in the gravity equation are as follows:

- $\boldsymbol{E_{ijt}}$ is Turkey's agricultural exports to the EU country j measured in thousands of current US$.
- $\boldsymbol{Y_{ijt}}$ is the sum of the GDP of Turkey and the EU country j in thousands of current US$ as a proxy for the size of the economies.
- $\boldsymbol{P_{jt}}$ is the population of the EU country j and determines the market size. Although the coefficient on importer population may be negative or positive on its trading partner's exports, Atici and Guloglu (2006) assume that the estimated coefficient of importer population on its agricultural imports will be positive because agricultural trade flows could stem from certain climatic and geographic conditions.
- $\boldsymbol{D_{ij}}$ is the geographical distance between the capital cities of Turkey and the EU country j in kilometers.

[1] The model includes Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Lithuania, Latvia, Malta, Netherlands, Poland, Portugal, Spain, Sweden, Slovenia, Slovakia, and United Kingdom. Luxemburg and Cyprus are excluded from the model due to missing data.

- $\boldsymbol{AL_{jt}}$ represents total arable land of the EU country j in hectares. Since an importer country having more arable land could produce more agricultural products, the coefficient of this variable is expected to be negative. It is important to note that both the sum of GDP and the total arable land catch the size of the economy. However, Koo *et al.* (2006) used both income and arable land variables as explanatory variables in their model, and found the significant positive impact of arable land on agricultural trade flows.

- $\boldsymbol{TP_{jt}}$ is the dummy variable for the Turkish population living in the EU country j. The estimated coefficient of this variable is expected to be positive because of similar tastes and preferences of the Turkish people. This dummy variable is equal to one if the Turkish people living in country j are more than 100,000 (i.e., Germany, Austria, France, and Netherlands), otherwise it is zero. Atici and Guloglu (2006) found the positive impact of Turkish population living in the EU countries on Turkey's fresh and processed fruit and vegetable exports to the EU.

- $\boldsymbol{CU_{jt}}$ is a customs union dummy variable which is equal to one if the EU country j is a member of the EU - Turkey Customs Union Agreement, otherwise zero. The EU- Turkey Customs Union Agreement which came into force in 1 January 1996. The agreement includes industrial goods and processed agricultural products, while agricultural products are outside the customs union. However, the EU has granted trade preferences to Turkish agricultural products with the 1963 Ankara Association Agreement, and abolished most *ad valorem* tariffs on agricultural imports from Turkey in 1987 (Oskam *et al.*, 2004). We add this dummy variable into our model to see whether the membership to customs union has a positive impact on Turkish agricultural exports to the EU.

- $\boldsymbol{NMED_{jt}}$ is a dummy variable which is equal to one if the EU country j is being a non-Mediterranean country, otherwise zero. This variable is added to the model to see the effects of different climatic environment on Turkish agricultural exports to the EU. Since having different climatic features leads more imports of agricultural products, the sign of this variable is expected to be positive.

The data sources derive from Undersecretariat of the Prime Ministry for Foreign Trade (2006) for the export data; World Bank (2006) for GDP, population, and total arable land; www.mapcrow.info for geographical distance; personal correspondence with a chief from Ministry of Labor and Social Security for Turkish people living in the EU country; and Economic Development Foundation (2005) for the members of the EU-Turkey Customs Union.

4. Estimation Methodology

In the estimation of our model, we utilize a panel data estimation method. We can use the ordinary least squares (OLS), the fixed-effects model (FEM), or the random-effects model (REM) for linear panel data models. However, the FEM can not directly estimate the coefficients of time-invariant variables such as distance and dummy variables. The REM model theoretically seems to be the proper choice for our model because OLS ignores the unobservable individual and time effects which are significant in most cases (Atici and Guloglu, 2006).

To test the significance of random individual and time effects, Lagrange Multiplier (LM) tests developed by Breusch and Pagan (1980) could be utilized based on the residuals from OLS estimation. LM_{group} statistic tests the significance of individual effects under the null of $H_0^a : \sigma_\mu^2 = 0$; LM_{time} statistic tests the significance of time effects under the null hypothesis of of $H_0^a : \sigma_\lambda^2 = 0$; and LM statistic tests the significance of individual and time effects jointly under the null hypotheses of $H_0^a : \sigma_\mu^2 = \sigma_\lambda^2 = 0$. One problem with the LM tests is that if variance components are non-negative, two-sided alternative hypotheses of these tests should be one-sided (Baltagi, 2001). Honda (1985) derived modified LM statistics under the one-sided alternative hypotheses for $H_1 : \sigma_\mu^2 > 0$, $H_1 : \sigma_\lambda^2 > 0$, and $H_1 : \sigma_\mu^2 > 0$ or $H_1 : \sigma_\lambda^2 > 0$. If we reject one of the null hypotheses of $\text{Honda}_{\text{group}}$ or $\text{Honda}_{\text{time}}$, the model is one-way REM; on the other hand, if we reject both of them then the model takes the form of two-way REM.

$$LM_{group} = \frac{\mathrm{NT}}{2(\mathrm{T}-1)}\left[1 - \frac{\mathrm{u}'(\mathrm{I_N} \otimes \mathrm{J_T})\mathrm{u}}{\mathrm{u}'\mathrm{u}}\right]^2 \sim \chi_1^2 \qquad Honda_{group} = \sqrt{LM_{group}} \sim \mathrm{N}(0,1)$$

$$LM_{time} = \frac{\mathrm{NT}}{2(\mathrm{N}-1)}\left[1 - \frac{\mathrm{u}'(\mathrm{J_N} \otimes \mathrm{I_T})\mathrm{u}}{\mathrm{u}'\mathrm{u}}\right]^2 \sim \chi_1^2 \qquad Honda_{time} = \sqrt{LM_{time}} \sim \mathrm{N}(0,1)$$

$$LM = LM_{group} + LM_{time} \sim \chi_2^2 \qquad Honda = \tfrac{1}{2}\left\lfloor \sqrt{LM_{group}} + \sqrt{LM_{time}} \right\rfloor \sim \mathrm{N}(0,1)$$

One of the assumptions of the REM is that unobservable effects and the explanatory variables are uncorrelated. If this assumption is violated, the REM can not be estimated consistently by Feasible Generalised Least Squares (FGLS) (Baltagi, 2001). To test this assumption, Hausman (1978) developed a test on the basis of differences between FGLS and Within estimators. Since Within estimator can not estimate the parameters of time-invariant variables, Hausman and Taylor (1981) showed that the statistic can be obtained from differences between FGLS and Between estimators. Erlat (2006) emphasizes that outcome of the Hausman test does not lead to a choice between the FEM and REM. The test is applied to the REM to decide whether random effects are correlated with the explanatory variables. Once this correlation is justified, then the FEM should be used; but this does not mean that the effects have now become fixed. It simply means that the FGLS estimator is no longer consistent but the Within estimator is. If random effects are uncorrelated with the explanatory variables, then FGLS should be used. If the question is of a choice, this is not between models but between estimators. From this point of view, the REM is the proper choice if Honda test rejects the null of $H_0^a : \sigma_\mu^2 = \sigma_\lambda^2 = 0$ (Egger, 2005).

Other assumption of the REM is that there is a particular nature of autocorrelation. It is constant across time within each cross-sectional unit, remains the same for every cross-sectional unit, and is zero across units (Erlat, 2006). To deal with this problem and obtain efficient estimators, the FGLS method can be utilized. Wallace and Hussain (1969), Swamy and Arora, (1972) and Wansbeek and Kapteyn (1982) proposed alternative FGLS approaches. Wallace and Hussain (1969) use OLS residuals; Swamy and Arora (1972) use residuals from Within and Between estimators; and Wansbeek and Kapteyn (1982) use Within estimator residuals. Since our model includes time-invariant variables which can not be estimated by Within estimator, Wallace and Hussain’s approach is an appropriate method.

The standard error component model given by equation (3.1) assumes that the regression disturbances are homoscedastic with the same variance across time and individuals. When heteroscedasticity is present assuming homoscedastic disturbances will result in consistent but inefficient coefficient of the variables and biased standard errors (Baltagi, 2001). The heteroscedastic models assume that the variances of the μ_{it} and/or the u_{it} change between cross-sectional units and this difference is not accounted for by variables. $\text{LM}_{het.}$ statistic could be used under the null hypothesis of homoscedasticity to test the heteroscedasticity in u_{it}. This LM test uses the residuals from the OLS estimation. If we expect heteroscedasticity to exist in the u_{it} in the REM case, then the statistic based on the OLS estimation may also be used in the REM. Once the heteroscedasticity is detected, one possible way to correct heteroscedastic bias in the variance-covariance matrix is to use the White’s estimator (Erlat, 2006; Greene, 2003).

$$LM_{het.} = \frac{T}{2}\sum_{i=1}^{N}\left[\frac{\hat{\sigma}_{\varepsilon i}^{2}}{\hat{\sigma}_{\varepsilon}^{2}} - 1\right]^{2} \sim \chi_{N-1}^{2}$$

Similar to the problem of heteroscedasticity, the presence of the serial correlation results in consistent but inefficient estimates of the regression coefficients and biased standard errors (Baltagi, 2001). Wooldridge (2002) proposes an AR(1) serial correlation test under the null hypothesis of no serial correlation for one-way panel data models. The test is applied by regressing the residuals from the OLS estimation of first-differenced variables on the lagged residuals. If the residuals from this estimation have an autocorrelation coefficient of -0.5, then the null hypothesis can not be rejected. Drukker (2003) developed a Wald test ($F_{AR(1)}$) for this testing approach that is used here.

5. Empirical Findings

The gravity model estimation and the tests results are reported in Table 1. The LM and Honda statistics show that both random individual and time effects are significant. The LM_{group} and $Honda_{group}$ show that individual random effects are significant. On the other hand, time effects are not significant according to the LM_{time} and $Honda_{time}$. The Hausman test confirms that there is no correlation between individual random effects and explanatory variables, indicating that the REM is consistent and efficient. Tests results verify our model selection and refer to the one-way REM including only individual effects.

Test result for heteroscedasticity shows that the null of homoscedasticity is rejected at the conventional levels of significance. We therefore estimate our model under the heteroscedasticity by using White's correction. Wald test statistic for AR(1) serial correlation shows that null of no serial correlation can not be rejected at 10 percent level of significance, implying that we do not need to consider AR(1) disturbances in the estimation of the model.

The analysis explains the more than 90 percent of variance of agricultural exports to the EU. The signs of the explanatory variables are as expected and all the parameters are statistically significant. The sum of GDPs, the importer population, and the dummy variables positively affect Turkish agricultural exports, while distance and agricultural arable land have negative impacts. The estimated coefficient of the lnY indicates the wealth effect of the size of the economies, implying that a 1 percent increase in the sum of GDPs will increase Turkish agricultural exports to the EU by 0.83 percent. Similarly, the coefficient of lnP shows the positive effect (i.e. scale effect) of the market size, indicating that a 1 percent increase in the importer population will lead to more agricultural imports from Turkey by 0.80%.

Table 1: Estimation and tests results

Variables	Coefficient	(Std.Error)	[prob.]	Test	Statistic	[prob.]
lnY	0.83	(0.1214)	[0.0000]	LM	317.45	[0.00]
lnP	0.80	(0.1379)	[0.0000]	LM_{group}	317.26	[0.00]
lnD	-0.82	(0.3322)	[0.0230]	LM_{time}	0.189	[0.66]
lnAL	-0.23	(0.0997)	[0.0161]	Honda	9.12	[0.00]
TP	0.31	(0.1121)	[0.0062]	$Honda_{group}$	17.81	[0.00]
CU	0.83	(0.2214)	[0.0002]	$Honda_{time}$	0.45	[0.33]
NMED	0.17	(0.0611)	[0.0050]	Hausman	3.52	[0.83]
Constant	-10.13	(2.5529)	[0.0001]	$LM_{het.}$	105.06	[0.00]
R-square	0.91			$F_{AR(1)}$	3.83	[0.06]
N	207					

N is the number of observations. Numbers in parenthesis are the standard errors.

As far as dummy variables are concerned, the coefficients of the TP, CU and NMED show that Turkey exports to the EU countries, which these variables are equal to 1, are more than others. The coefficient of the TP indicates that Turkish agricultural exports to the EU countries, which have more than 100,000 Turkish populations, are 36.38 percent higher than other countries. The coefficient of the CU shows that Turkish agricultural exports to the EU countries, which are the member of the customs union, are 130.82 percent higher than others. The coefficient of the NMED shows a positive impact of climatic differences on Turkish agricultural exports to the EU. Accordingly, Turkish agricultural exports to non-Mediterranean countries in the EU are 18.97 percent higher than others.

6. Conclusion

This study analyzed the determinants of Turkish agricultural exports to the EU using the gravity model. The results show that conventional variables (the size of the economy, the importer population, and distance) of the gravity model and other factors described in this study such as the Turkish population living in the EU countries, the non-Mediterranean climatic environment, the membership to the EU-Turkey Customs Union Agreement, the agricultural arable land of the EU countries have significant impacts on Turkish agricultural exports to EU.

On 1 April 2004, the EU – Turkey Customs Union was extended with the enlargement of the EU in 1 May 2004. This enlargement will result in trade liberalization of industrial goods and processed agricultural products between Turkey and the new members. Since our results show the significant positive impact of the membership to the EU-Turkey Customs Union on Turkish agricultural exports to EU, it is rational to expect that Turkish agricultural exports to and market shares in the EU new member countries will increase in the near future.

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Appendix 1: Turkish Agricultural Exports (1000 $).

	1996	2000	2001	2002	2003	2004
To the World	4.948	3.855	4.348	4.052	5.257	6.501
To the EU	2.177	1.750	1.923	1.947	2.434	3.125
Share of the EU (%)	44.00	45.40	44.23	48.07	46.31	48.08

Source: Undersecretariat of the Prime Ministry for Foreign Trade (2006).

Appendix 2: Distribution of Turkish Agricultural Exports to the EU (%)

Country	1996	2000	2001	2002	2003	2004
Austria	2.69	3.27	3.37	3.02	2.53	2.23
Belgium	6.50	5.29	5.69	5.70	5.31	5.88
Czech Republic	1.78	0.75	0.97	0.92	1.01	0.82
Denmark	1.58	1.43	1.26	1.50	1.27	1.26
Estonia	0.06	0.07	0.11	0.11	0.13	0.13
Finland	0.49	0.57	0.25	0.20	0.23	0.23
France	8.71	8.72	8.71	8.97	8.95	9.23
Germany	34.14	33.70	31.17	31.59	29.64	28.81
Greece	1.85	2.41	2.96	3.99	4.17	3.99
Hungary	0.80	0.58	0.73	0.69	0.76	0.67
Ireland	0.48	0.60	0.33	0.47	0.44	0.41
Italy	13.03	11.74	15.98	13.66	16.10	16.68
Latvia	0.23	0.31	0.25	0.26	0.26	0.38
Lithuania	0.04	0.15	0.14	0.27	0.33	0.31
Malta	0.07	0.07	0.05	0.07	0.06	0.05
Netherlands	9.24	9.97	8.50	9.21	9.21	9.73
Poland	1.24	1.36	1.59	1.58	1.59	1.86
Portugal	1.01	0.91	1.01	0.52	0.60	0.51
Slovakia	0.26	0.21	0.31	0.32	0.41	0.58
Slovenia	0.19	0.41	0.28	0.55	0.42	0.20
Spain	4.67	5.46	6.13	5.50	6.24	5.04
Sweden	1.39	1.24	1.23	1.16	1.24	1.29
United Kingdom	9.52	10.78	8.98	9.72	9.11	9.71

Source: Undersecretariat of the Prime Ministry for Foreign Trade (2006).