

# MULTI-DIMENSIONAL PANEL DATA GRAVITY MODEL: AN ANALYSIS OF APEC COUNTRIES



Kafkas University  
Economics and Administrative  
Sciences Faculty  
KAUJEASF  
Vol. 10, Issue 20, 2019  
ISSN: 1309 – 4289  
E – ISSN: 2149-9136

Article Submission Date: 18.02.2019 Accepted Date: 12.11.2019

Elanur TÜRKÜZ  
Research Assistant  
Istanbul Kultur University  
Faculty of Economics and  
Administrative Sciences  
e.turkuz@iku.edu.tr  
**Orcid id:** 0000-0002-5176-  
7792

Hatice Nazan ÇAĞLAR  
Assistant. Prof.  
Istanbul Kultur University  
Faculty of Economics and  
Administrative Sciences  
ncaglar@iku.edu.tr  
**Orcid id:** 0000-0003-2152-  
8747

**ABSTRACT** The traditional gravity model of international trade has been through many changes in order to develop and answer new research questions. Taking this development into account this paper investigates a more enhanced panel data approach by extending the classic approach by allowing for both individual and time effects to be apparent in order to capture country specific and time effects with a multidimensional panel data model for APEC countries. By using a three dimensional panel gravity model with a least squares dummy variable approach we were able to identify countries with stronger propensities to import and export.

**Keywords:** *International Trade, Gravity Model, Multi-Dimensional Panel Data Model*

**Jel codes:** *F10, F15, C23*

**Scope:** *Business Administration*

**Type:** *Research*

**DOI:** 10.36543/kauibfd.2019.043

**Cite this Paper:** Türküz, E. & Çağlar, H. N. (2019). Multi-Dimensional Panel Data Gravity Model: An Analysis of APEC Countries. *KAUJEASF*, 10(20), 1007-1027.

# ÇOK-BOYUTLU PANEL VERİ ÇEKİM MODELİ: APEC ÜLKELERİ İLE BİR UYGULAMA



Kafkas Üniversitesi  
İktisadi ve İdari Bilimler  
Fakültesi  
KAÜİİBFD  
Cilt, 10, Sayı 20, 2019  
ISSN: 1309 – 4289  
E – ISSN: 2149-9136

Makale Gönderim Tarihi: 18.02.2019 Yayına Kabul Tarihi: 12.11.2019

**Elanur TÜRKÜZ**  
Araştırma Görevlisi  
İstanbul Kültür Üniversitesi  
İktisadi ve İdari Bilimler  
Fakültesi  
e.turkuz@iku.edu.tr  
Orcid id: 0000-0002-5176-  
7792

**Hatice Nazan  
ÇAĞLAR**  
Dr. Öğr. Üyesi  
İstanbul Kültür Üniversitesi  
İktisadi ve İdari Bilimler  
Fakültesi  
[ncaglar@iku.edu.tr](mailto:ncaglar@iku.edu.tr)  
Orcid id: 0000-0003-2152-  
8747

**ÖZ** Uluslararası Ticarete geleneksel Çekim Modeli, yeni araştırma soruları geliştirmek ve cevaplamak amacı ile bir çok değişiklik geçirmiştir. Meydana gelen gelişmeler dikkate alınarak bu makalede seçilmiş APEC ülkeleri için Çok-Boyutlu Panel Veri Modeli ile ülkelere özgü birim ve zaman etkilerini yakalayabilmek amacıyla Klasik Panel Veri yaklaşımı genişletilerek üç boyutlu bir panel veri modeli kullanılmıştır. Kukla Değişkenli En Küçük Kareler yaklaşımı ile üç boyutlu bir panel çekim modeli yardımı ile güçlü ithalat ve ihracat eğilimi olan ülkeler belirlenmiştir.

**Anahtar Kelimeler:** Uluslararası Ticaret, Çekim Modeli, Çok-Boyutlu Panel Veri Modeli

**Jel codes:** F10, F15, C23

**Alanı:** İşletme

**Türü:** Araştırma

**Atıfta bulunmak için:** Türküz, E. & Çağlar, H. N. (2019). Çok-Boyutlu Panel Veri Çekim Modeli: APEC Ülkeleri ile Bir Uygulama. *KAÜİİBFD*, 10(20), 1007-1027.

## 1. INTRODUCTION

The Asia-Pacific Economic Cooperation (APEC) countries represent a potentially large-scale trade area. Considering many APEC countries experiencing extraordinary economic growth in the recent years economists, researchers and policy analysts have given considerable attention to the economic growth of the cooperation countries. When APEC was first established, its main goal was to promote and improve the cooperation across the Asia-Pacific region. Specifically, its objective was to promote a more open and freer environment for trade and investment among its member economies while promoting economic growth. Lately, it included financial development and regional integration among its objectives. The co-operations collective efforts have contributed unrivaled significant growth and rapid economic development after being established in 1989 and has promoted free open trade and investment.

To improve behind-the-border barriers of trade, APEC has been working to foster transparency, competition and better functioning markets in the Asia-Pacific through regulatory reform, improving public sector and corporate governance, and strengthening the legal infrastructure (APEC, 2017). To support sustainable economic growth in the Asia – Pacific region, APEC has built a dynamic and harmonious community by decreasing the number of obstacles in trade, reducing tariffs across APEC nations, encouraging the flow of goods, services, capital and technology by market transparency.

Not just within APEC but we can see that international trade has changed our world undeniably over the last centuries. There have been many theories which look into international trade from different perspectives. The foremost proponent theories of international trade date back to the Richardian model which attempts to explain trade flows on the basis of technological differences across the nations by centering the theory around comparative advantage and the Heckscher (1919) and Ohlin (1933) models which stresses the differences in factor endowments as the cause of international trade. Although these theories have enlightened us on international economics, they may perform poorly when it comes to explaining trade volumes and their patterns which may be correlated somehow with common language, international borders and other unobserved factors. Due to easily relating bilateral trade flows to GDP, distance and other factors that may affect trade flows, gravity models could probably be the most successful and popular empirical trade device of the last 50 years (Anderson, 1979, p. 106). The popularity of the model rests on two mainstays: *First*, international trade flows are a key element in economic relationship, so there is a high demand for knowing what normal trade flows are what they should be. *Second*, being in a more

digitalized world the availability of data storage has led researchers to gather their data necessary to estimate the model easier (Baldwin & Taglioni, 2006, p. 1).

The foundation of the gravity model in social sciences which is also the first application to migration flows goes back to Ernest Ravenstein's 1885 paper where he investigated whether migrations flows were directly relational to the capacity of trade along with industrial centers and inversely proportional to the geographical distance. Tinbergen (1962) was the first to develop the gravity model of international trade by adapting a mathematical formulation in his book "*Shaping the World Economy: Suggestions for an International Economic Policy*" by simply defining bilateral economic activity regarding to subject country's economic masses and distances. The two initial applications of Newton's Gravity Law to economics were found a-theoretical. Despite this, Linnemann (1966) included population as a measure of country size by extending the standard gravity model to the first *Augmented Gravity Model*. Taking in to account the criticism of Pöyhönen (1963) who believed the gravity model had no theoretical justification Aitken (1973) adjusted the model by a multi-equation export-import system. Anderson (1979) introduced differentiated consumer preference goods across regions by the assumptions of Constant Elasticity of Substitution (CES) expenditures which finally put the gravity model on a theoretical ground. Following Anderson's work Thursby (1987) developed a multi-equation system by including export and import prices whereas Bergstrand (1989) showed that a gravity model could be an adumbration of Paul Krugman's (1980) trade model based on monopolistic competition. Deardoff (1995) compared the gravity model among other trade theories such as the Heckschler – Ohlin model. Frankel et.al. (1996) have emphasized the importance of how cultural ties and common languages could be important to determine trade flows. Mansfield (1993), Mansfeild and Bronson (1994) have examined the effects of wars, colonial relationships and other political factors on bilateral trade and found trade generally higher in countries which have a political or colonial history.

Taking a close look at the literature one can see that the gravity model has been through many changes in order to develop and answer new research questions, thus this might have triggered another motive which increased the popularity of the model: its versatile application area which can be seen in many research papers such as Vanderkamp (1977), Poot et al., (2016) for migration studies, Khadaroo and Seetanah (2008), Keum (2010) and Morley et al., (2014) for international tourism studies, Lowe and Sen (1996) and Schuurman et al., (2017) for health care and patient studies and Sá et al., (2004) who studied the gravity model to investigate educational questions. In most of the applications, the gravity model has traditionally been estimated using cross-sectional data.

Pöyhönen (1963) was the first to develop a two-way gravity model to examine bilateral trade flows by adding another cross-sectional component. However, many papers have argued that this has been shown to generate biased results since models are not considering the heterogeneity among the countries in an appropriate way (Cheng & Wall, 2005, p. 50). To address this problem, researchers have turned towards panel data, which has the advantage of permitting heterogeneity. Matyas (1997) argued that a gravity model with panel data should not only lie in two dimensions ( $i, j$ ) but should also account for exporter ( $i$ ) and importer ( $j$ ) dynamics through time ( $t$ ).

This paper uses the augmented gravity model by a three-dimensional panel data approach to investigate bilateral trade flows between 14 APEC countries over the 1996-2016 period with annual data. In order to control the heterogeneous relationships of trade, we estimate the augmented panel gravity model with a two-way multi-dimensional panel data regression model. The remainder of this paper is organized as follows. Section 2 briefly outlines the standard gravity model whereas Section 3 introduces three dimensions to the augmented panel gravity model. Section 4 presents the data and variables which are used to estimate the model. Section 5 contains econometrics results followed by an overall conclusion.

## 2. THE STANDARD GRAVITY MODEL

Newton's Universal Gravitation Theory which was introduced in the 1680's basically set forth to the idea that gravity was a predictable force with a function of both mass and distance. The theory states that the force ( $F_{ij}$ ) between two objects  $i$  and  $j$  is directly proportional to their masses ( $M_i, M_j$ ) and inversely proportional to the square of the distance ( $D_{ij}^2$ ) between them.

$$F_{ij} = G \frac{M_i M_j}{D_{ij}^2} \quad (1)$$

In Tinbergen (1962)'s adaptation of the Newton Gravity equation the general formulation took the following multiplicative form;

$$EXP_{ij} = \beta_0 GDP_i^{\beta_1} GDP_j^{\beta_2} DIST_{ij}^{\beta_3} \quad (2)$$

where  $EXP_{ij}$  represents pair country  $i$  and  $j$  exports,  $GDP_i$  indicates the export amount a country is able to supply through its economic magnitude and  $GDP_j$  symbolizes the country  $j$ 's market size. The exponents  $\beta_1, \beta_2$  and  $\beta_3$  indicate that there is not necessarily direct proportionality (constant change per unit) in the explanatory variables and the dependent variable (Tinbergen, 1962, p. 94). Thus,

the interpretation of the exponential model's coefficients must be done carefully, since they are no longer the marginal difference but are now the elasticities<sup>1</sup>. After the logarithmic transformation of (2) the gravity model takes the additive form of a double logarithmic form:

$$\ln EXP_{ij} = \beta_0^* + \beta_1 \ln GDP_{it} + \beta_2 \ln GDP_{jt} + \beta_3 \ln DIST_{ij} \quad (3)$$

where  $\beta_0^* = \ln \beta_0^2$ .

### 3. THE MULTI-DIMENSIONAL AUGMENTED PANEL GRAVITY MODEL

Panel data refers to the pooling of observations on a repeated cross-section of households, firms, states or countries over several time periods (Baltagi, 2008, p. 1) thus this technique provides multiple observations on each repeated unit in the sample (Hsiao, 2003, p. 1). Panel data has many advantages, and these could be listed as: (i) controlling for heterogeneity by including both dimensions of units and time through individuals, firms, states or countries over a fixed time period. (ii) giving more information and variability due to the combination referred in (i) and reduces the possibility of correlation among variables by the provided information. (iii) well suited for studying dynamic changes of policies by studying more complicated behaviors with panel data than purely cross-sectional or time series data. (iv) better able to measure hidden effects in the cross-sectional and time dimension. See Hsiao (2003) and Baltagi (2008) for a broader definition.

Unlike the two-dimensional panel regression models multi-dimensional panel regression models are becoming more available and easier usage to study a variety of research questions like international trade flows between countries or regions through time (Balazsi, Matyas, & Wansbeek 2018, p. 213). The cross-sectional component of a multi-dimensional panel data model could be expressed in two forms where (i) the cross-sectional units could be nested in each other such as countries and states or countries and firms etc. (ii) they could be non-nested were the units are not a subgroup of the other (Tatoglu, 2016, p. 61). This paper focuses on the non-nested approach of the unit dimensions where the dependent variable is observed along three indices,  $y_{ijt}$ ,  $i = 1, \dots, N_1$   $j = 1, \dots, N_2$  and  $t = 1, \dots, T$ . Here  $i$  and  $j$  are non-nested cross-sectional units and  $t$  is the time dimension.

---

<sup>1</sup> One per cent increase in the GDP of country  $j$  will result in a  $\beta_2$  per cent difference in the exports of supplying country  $i$ .

<sup>2</sup>  $\beta_0^*$  is a biased estimator.

The first attempt in improving the standard panel data model for the gravity model specification was proposed by Matyas (1997). The specification of the two-way panel data model is

$$y_{ijt} = \beta' x_{ijt} + \alpha_i + \gamma_j + \lambda_t + \varepsilon_{ijt} \quad i = 1, \dots, N \quad j = 1, \dots, N \quad t = 1, \dots, T \quad (4)$$

were  $\alpha_i$  and  $\gamma_j$  are individual specific effects and  $\lambda_t$  is the time specific effects.  $x_{ijt}$  is the explanatory variable matrix which is added to the right-hand side of the equation,  $\beta$  ( $K \times 1$ ) is structural parameter vector and  $\varepsilon_{ijt}$  are the i.i.d.  $(0, \sigma_\varepsilon^2)$  idiosyncratic disturbance terms. One other assumption is that the explanatory variables are not random meaning they are not correlated with the disturbance terms. The notation could also be in vector form thus, the model would be expressed as;

$$y = X\beta + D_N\alpha + D_J\gamma + D_T\lambda + u \quad (5)$$

where  $y$  is the  $(N \times N \times T) \times 1$  vector of observations of the dependent variable which has a size of  $(N^2T \times 1)$ . The matrix of the dependent variable would be shown as below;

$$y = [y_{121}, y_{122}, y_{123} \dots, y_{12T}, \dots, y_{N11}, \dots, y_{N1T}, \dots, y_{N(N-1)1}, \dots, y_{N(N-1)T}] \quad (6)$$

$X$  is the matrix of observations of the explanatory variables and is organized in a similar way like  $y$  in (6). The matrix of explanatory variables has a size of  $(N^2T \times K)$ .  $D_N$ ,  $D_J$  and  $D_T$  are dummy variable matrices ( $D_N = I_N \otimes l_{NT}$ ,  $D_J = I_N \otimes l_N \otimes I_N$ ,  $D_T = I_{N^2} \otimes I_T$  where  $l$  is the vector of ones with its size in the index and  $I$  is the identity matrix)  $\alpha$ ,  $\gamma$  and  $\lambda$  are  $(N \times 1)$ ,  $((N+1) \times 1)$  and  $(T \times 1)$  vectors respectively.  $\beta$  is a  $(K \times 1)$  parameter vector with  $K$  number explanatory variables and  $u$  is the vector of disturbance terms.

While one is investigating bilateral trade flows with the gravity model, it is important to take in to account the unobserved (omitted or excluded) heterogeneity or in other words the country dependent characteristics which do not vary over time and unobserved (omitted or excluded) time dependent characteristics which do not change over countries. Omitting these country specific bilateral effects and time dependent business cycle effects may yield to biased estimates resulting from a specification error. These effects may find some useful interpretation: while the exporter (importer) effect measures the general

economic openness of a country with respect to its partner countries included in the sample, the bilateral trade effects account for any time invariant geographical, historical, political, cultural or other influences which lead to deviations from a country pair's normal propensity to trade (Egger & Pfaffermayr, 2003, p. 573) whereas the time effects can help accounting for the business cycle. In order to capture heterogeneity, here we estimate the two-way three-dimensional panel data regression model with dummy variables. Therefore, one should carefully handle the multi-collinearity resulting from the dummy variable trap.

#### **4. LITERATURE**

The gravity model has long been the workhorse for empirical studies for the pattern of trade. As in the Newtonian equation after which it is named, attraction (trade) depends upon mass (the product of economic size) and geographic or economic distance (Bayoumi & Eichengreen, 1995, p.2). The literature regarding Gravity models used in the analysis of international trade has shown itself to be very diverse in its applications after its first introductions coming from Tinbergen (1962) and Pöyhönen (1963) and it has remained as one of the most commonly used devices in the empirical trade literature for nearly 60 years. Here in this section we have tried to give an overview of some of the prominent work which have investigated trade flows from different perspectives.

Tinbergen (1962) was the first to apply the Newton's Universal Law of Gravitation to predict bilateral trade flows between any two countries as a function of their size and their distance. In order to describe the patterns of bilateral trade; economic size was measured as Gross Domestic Product and geographical distance was measured as the distance between two countries' capital cities. Tinbergen's findings were that while two countries economic sizes were positively correlated the distance between their masses were negatively correlated. This indicated that the gravity model was not actually an intuitive but also a promising devise.

After Jan Tinbergen released this theory the Gravity model started to attract a lot of attention. We could say that it started with Pöyhönen's 1963 paper where he examined the international trade flows of 10 European countries. The paper investigates whether GDP, geographic distance, exports, imports and other variables such as trade agreements, cultural and regional ties have any effect on international trade flows between the selected countries for the year 1958. The cross-sectional gravity model's founding's where that; trade agreements, geographical distance, cultural and regional ties have a positive impact on trade.

Even though there have been many contributions to the gravity model of

international trade flows, Krugman (1980) was the first to theoretically point out the significance of trade barriers in the gravity equation by using it as a proxy for distance. His analysis shows by highlighting monopolistic competition; without making any pretense of generality there is some justification for the idea that countries export what they have in their home markets. Results are also compatible with earlier work where trade flows were found to be proportional to country size and inversely related to trade barriers.

Even though many International Trade related Gravity models have been studied through cross sectional data in the past, Matyas (1997) has argued about the model specification and that it lacks in controlling both exporter and importer dynamics through time. Matyas (1997) has noted that bilateral trade flows should be represented by a three-way specification which is also known as the multi-dimensional panel data model. In order to investigate his proposal that the previous gravity models were misspecified from an econometric point of view, he has demonstrated his proposed panel gravity model on a data set gathered from the APEC countries. The data set contains GDP, Population, Foreign Currency Reserves and Real Exchange Rate explanatory variables. The dependent variable was chosen as Exports. He has estimated two different models; one without the specific effects and one including the specific effects. Specific effects were added in order to see if the gravity model is able to explain local country effects and time effects. Results show that the second model which contain the specific effects of the local countries are statistically significant proving that the gravity model was misspecified from the very beginning.

Egger (2001) had two things mind. One was that he believed the econometric specification of the standard gravity model was wrong so some type of modification which was already proposed by Matyas (1997) had to be formalized and two he was curious which level the bilateral trade flows where at between the 15 EU and 10 CEEC countries. So, he analyzed the two groups with a Panel Gravity Model by taking into account both units through the 1986-1997 period. In order to analyze the time effects along with the unit effects which are assumed to be time invariant both Random Effects and Fixed Effects models were estimated with 11 explanatory variables. These could be listed as; Bilateral Sum of GDP, Similarity in Country Size, Difference in Relative Factor Endowments, Exporter Variability of Contracts, Importer Variability of Contracts, Exporters Rule of Law, Importers Rule of Law, Real Exchange Rate, Distance, Common Border and Common Language. Results indicate that the most efficient model among all was the Hausman & Taylor AR (1) estimator. Since this estimator was never been used before, it could be counted as Egger's contribution to the Panel Gravity Model analysis literature.

Considering Pöyhönen's work it was very natural to think of the common language effect on international trade and so did Feenstra, Markusen & Rose (2001). They were curious if alternative theories were able to predict subtle differences depending on whether goods are homogeneous or differentiated and whether or not there are barriers to enter markets. In order to do so, they have examined USA and Canada trade flows in the period of 1970-1990 with Common Border, Free Trade Agreement and Common Language dummy variables along with GDP and Distance. Authors have estimated three different models which separately try to explain the exports of differentiated goods, exports of reference prices goods and exports of homogeneous goods as dependent variables respectively. The OLS regression results indicate that the home market effects change according to the type of the goods that are to be traded and differentiated products have a significant effect on the home market whereas the trade of heterogeneous goods act in a reverse motion. Their conclusions were that; the gravity equation is open to improvement and is a tool to distinguish different theoretical models.

Anderson & van Wincoop (2003) investigated whether the gravity equation had a theoretical foundation for 22 customs union countries with two cross-sectional models. These cross-sectional models are the two-country and multi-country models. They have used trade flows and exchange rate mechanisms as explanatory variables. Their results have shown that while national borders are an important factor in the reduction of bilateral trade omitting the national border variable would actually cause substantial estimation bias. This could also be seen as a justification of the need to develop and have a common ground on the specification of the gravity model.

"How can we construct a panel data gravity model when the bilateral trade of two countries is zero?" was and still is a natural question to be asked when two countries have not traded during the period under investigation or do not trade at all. Since it is also very natural to experience such a thing due to many reasons Westerlund & Wilhelmsson (2008) believed that it is important to provide some kind of material to prevent researchers from discarding zero bilateral trade data from the dataset. In their paper they have argued that correcting or discarding the zeros in the dataset might lead to substantial bias in the model parameters. In order to fix this problem; they proposed to estimate the multi-dimensional fixed effects gravity model with the Panel Pooled Maximum Likelihood estimator. The demonstration of the proposed estimator was done in order to reveal Austria, Finland and Sweden's trade adhesion to the EU. The model was conducted on a sample taken from the period 1992-2002. According to the results; it is worthwhile to note that in such situations using the Panel Pooled Maximum

Likelihood estimator will avoid potential bias due to zero trade.

Bayumi & Eichengreen (1995) have considered analyzing the impact of Europe's preferential arrangements on trade. Using pooled data of industrial and developing countries in a gravity model analysis means gathering a data set from different levels of mass and different types of goods. This heterogeneous form of data was the authors main curiosity. Authors had foreseen the problem of different levels of income elasticity of trade varying between the country groups. In order to take heterogeneity into account they estimated the gravity equation with a first difference model so that unobserved heterogeneity across countries that is constant over time would not contaminate their results. The analysis was conducted on EEC and EFTA countries for 1956-1973, 1966-1980 and 1975-1992 three different time periods with a fixed effect OLS regression. Results show that comparing their model specification to previous models studied in the literature, their proposed technique is able to identify significant effects regarding the EEC and EFTA countries.

Following the panel approach Cheng and Wall (2005) have argued that; since refusing heterogeneity among units cause biased results it would be appropriate to permit heterogeneity through a mutli-dimensional fixed effects panel data gravity model. Authors work with a balanced panel data set containing 3,188 observations. They have found that the country-pair fixed effects model is statistically preferred among models which do not consider heterogeneity.

Kurihura (2003) has estimated the gravity model to measure the impact of exchange-rate variability on trade flows of 21 APEC countries. Their panel data set contains five-year intervals which are 1980-1985, 1985-1990, 1990-1995 and 1995-1998. Kurihura (2003) has introduced a one-year-lagged dependent variable of trade to investigate how much of an importance the history of trade has. There are two models that were estimated; the two-way panel OLS regression model and 2SLS regression model. Both contain past exports, exchange rate, GDP, GDP per capita, distance, common distance, common border, free trade agreement, political union membership and colony-colonizer explanatory variables. Findings shows that the OLS and 2SLS results show remarkable consistency. They have also found that the dollar currency union would be much more profitable than adopting a yen currency union for each country in APEC.

Tang (2005) utilized the gravity model to examine the trade effects of NAFTA, ANZCER and ASEAN. The paper addresses the issue whether trade would increase among the member countries at the expense of non-member countries. Since the choice of the data set is a heterogeneous sample authors have used the modified gravity model for their analysis. They contribute to the existing literature by adding the trade creation and diversion effects of three free trade

areas which are represented by regional dummy variables. They also apply the Linder hypothesis to explain the trade patterns in the developed and developing countries respectively. A total of 21 countries were investigated for the period of 1989-2000 as well as three sub-periods (1989-1992, 1993-1996, 1997-2000) with OLS and 2SLS regressions. Explanatory variables are; GDP, GDP per capita, distance, volatility of exchange rate, income similarity, NAFTA membership for both or one partner, ANZCER membership for both or one partner and ASEAN membership for both or one partner. Results show that the 2SLS method provides a better estimation for the modified gravity model since it can take solve a common problem in estimating the exchange rate volatility effect on international trade which is called “simultaneous causality” by adopting an IV approach.

A two-way panel data gravity model was also studied by Golovko (2009) where the author investigated which factors were significant for the selected Eurasian countries mutual trade between the years 1994-2005. Results show that the fixed effects model was a better choice in explaining the relationship. Authors have found that even though the traditional variables which are geographical distance, sharing the same border, having a common language and being affiliated in the same economic union have a positive effect on trade, they do not have a remarkable impact on explaining the trade flows and as a result one should not always rely on their intuitions before an analysis.

In order to investigate the external trade efficiency between Romania and its 74 partner countries and to identify significant factors of bilateral trade upon Romania’s most effective and ineffective partnerships, Viorica (2012) has estimated the standard gravity model with its traditional variables; Bilateral Trade Flows, Gross Domestic Product, Distance and dummy variables by Ordinary Least Squares (OLS) regression. The model’s findings with cross sectional data indicate consistency with the traditional gravity model results.

Chaney (2013) tried to bring light into the mystery of the role played by distance in the gravity equation. The model was estimated on firm level and sectoral data. Findings show that the role of distance is actually immune to changes in the technology of trading goods, the types of the goods, political barriers to trade and the set of countries involved in trade. It was also interestingly found that; as long as the individuals that engage in trade are in direct contact with their clients and suppliers the traditional expectations of the gravity model collapse because the new era of trade has slightly changed.

## **5. DATA AND VARIABLES**

A typical multi-dimensional panel gravity model database will contain a large

amount data due to its cross-sectional dimensions varying across time. In our three-dimensional case with  $N$  countries and  $T$  years there will be  $N \times (N-1)$  pair countries in a year and  $N \times (N-1) \times T$  observations in the same sample size. Thus with 16 APEC<sup>3</sup> countries being studied over the 1996-2016 period we have 5040 observations. Even though the data for gravity models are much easier to access, building a gravity data base means the data from different resources will be merged into a single database. Therefore, the researcher will need to invest time and care to manipulate a large data set due to the difference of some resources measuring and classifying variables.

Even though gravity models do a good job at explaining bilateral trade flows with the economic mass of countries (GDP), country distances (DIST) and country population (POP) we believe it could be important to augment the model with variables such as common language (COMLAN) and common border (COMBRD) variables. In order to explain the bilateral trade between countries the three-dimensional augmented panel gravity model could be expressed as;

$$\ln EXP_{ijt} = \beta_0 + \beta_1 \ln GDP_{it} + \beta_2 \ln GDP_{jt} + \beta_3 \ln POP_{it} + \beta_4 \ln POP_{jt} + \beta_5 COMLAN_{ij} + \beta_6 COMBRD_{ij} + \beta_7 \ln DIST_{ij} + \alpha_i + \gamma_j + \lambda_t + \varepsilon_{ijt} \quad (7)$$

where the dependent variable  $\ln EXP_{it}$  is the logarithm of the volume of exports in current dollars from country  $i$  to country  $j$  obtained from the World Integrated Trade Solution database of World Bank.  $\ln GDP_{it}$  and  $\ln GDP_{jt}$  are the logarithms of nominal GDP in each country obtained from the World Development Indicators database of World Bank.  $\ln POP_i$  and  $\ln POP_j$  are the logarithms of total population of the exporter and importer countries respectively.  $DIST_{ij}$  is the distance variable calculated following the great circle formula, which uses latitudes and longitudes of the country's official capitals. This measure incorporates internal distances based on areas (Mayer & Zignago, 2011, p. 10) obtained from the CEPII data base provided by Head and Mayer (2002).  $COMLAN_{ij}$  and  $COMBRD_{ij}$  are dummy variables which take the value 1 if countries share the same language and share a border respectively. These dummy variables were obtained again from the CEPII database. The sample covers annual data of 16 APEC countries over the 1996-2016 period. Model was estimated with Stata14.

<sup>3</sup> Australia, Canada, Chile, China, Hong Kong, Japan, Korea, Indonesia, Malaysia, Mexico, New Zealand, Russia, Peru, Philippines, Singapore and United States of America. Other APEC countries were not included due to the lack of data.

## 6. EMPIRICAL RESULTS

This paper investigates the three-dimensional panel gravity model with a two-way least square dummy regression model (LSDV) by adding dummy variables in order to see the effects of each dimension on the bilateral trade flows represented by exports. The two-way dummy variable least squares regression model (LSDV) is an easy tool to capture these effects by simply adding dummy variables to the regression model.

Here the domestic variables representing the supply of exports are indexed by  $(it)$  and  $(jt)$  indexed variables are the target variables representing the demand of exports. Variables which are indexed with  $(ijt)$  vary with domestic and target country factors. Looking at the summary results of the three-dimensional panel gravity model in Table.1 we could see that both domestic ( $\ln GDP_{it}$ ) and target country ( $\ln GDP_{jt}$ ) GDP's are significant and positive with the domestic country's GDP dominating the target country GDP. The target country GDP is a measure of how big the target country's economy is to take in the exports whereas the domestic country GDP represents the exporter country's economic mass in terms of available goods, where one could expect larger economies to tend to export more.

The determination of the population variable and its sign for both domestic and target countries have been a challenge in the literature. Here we see that both domestic ( $\ln POP_{it}$ ) and target country ( $\ln POP_{jt}$ ) population parameters are significant with a negative sign indicating two highly accepted phenomena which are; (i) domestic countries exports are relatively capital intensive while target countries trade are mainly in luxuries and (ii) larger countries tend to be relatively less open to trade since they are able to find what they want in their own borders. As a result, larger domestic economies and larger potential target markets could decrease export flows. Since distance is a proxy for transportation costs and the time elapsed during shipment, the strong significance of the distance variable ( $\ln DIST_{ij}$ ) with a negative sign is not surprising. This indicates that the more countries are apart the less trade they do. Even though these five variables might seem adequate to explain exports flows, we believe they are not enough to explain the huge variation in trade.

Distance is not the only trade impeding effect. Countries sharing a common language and a border could also be influential factors. Our estimates confirm this proposition: country pairs which speak the same language ( $COMLAN_{ij}$ ) trade 0.66% higher than countries that do not share a common language together with country pairs sharing a common border trade 1.07% higher than countries that do not.

Speaking for the unobservable country heterogeneity for the domestic countries we can see that Canada, Chile, Hong Kong and Singapore's domestic country specific effects are insignificant. Countries that appear to have a higher propensity to export from the APEC region are China, Indonesia and USA whereas New Zealand and Peru have the lowest propensity to import (relative to the omitted country Australia). The countries which exhibit the highest propensity to import from the APEC region are China and USA whereas Chile has the lowest propensity of imports from the region. The business cycle results are very interesting. Here we can see that the business cycle does not have a significant effect on the export flows until 2004. Taking in to account the 1997 Asian Financial Crisis we could say that the APEC region has recovered after 2004 with an increase of the business cycle every year since.

**Table.1** Estimation Results of the Multi-Dimensional Panel Gravity Model

<i>Model : No restrictions</i>			
Dependent Variable is the logarithm of the Bilateral Export Volume " <i>lnEXP<sub>ijt</sub></i> "			
Variables	Coefficient( $\beta$ )	Standard Error	t-statistic <sup>(iii)</sup>
<i>Constant</i>	24.5744	7.5621	3.25
<i>lnGDP<sub>it</sub></i>	1.1414	0.0888	12.84
<i>lnGDP<sub>jt</sub></i>	1.0129	0.0889	11.38
<i>lnPOP<sub>it</sub></i>	-0.5977	0.2932	-2.04*
<i>lnPOP<sub>jt</sub></i>	-0.9522	0.2951	-3.23*
<i>lnDIST<sub>ij</sub></i>	-0.8484	0.0190	-44.63
<i>COMLAN<sub>ij</sub></i>	0.5147	0.0356	14.45
<i>COMBRD<sub>ij</sub></i>	0.7332	0.0606	12.09
<i>CANADA</i>	0.1067	0.1457	0.73*
<i>CHILE</i>	0.0590	0.1556	0.38*
<i>CHINA</i>	7.2960	1.1999	6.08
<i>HONGKONG</i>	0.1734	0.3423	0.51*
<i>INDONESIA</i>	4.3364	0.7112	6.10
<i>JAPAN</i>	2.9554	0.5333	5.54
<i>KOREA</i>	2.6069	0.2569	10.14
<i>MEXICO</i>	1.8081	0.4921	3.67
<i>MALEYSIA</i>	1.8765	0.1726	10.87
<i>NEW ZEALAND</i>	-1.9192	0.4842	-3.96
<i>PERU</i>	0.5540	0.2290	2.42
<i>PHILIPPINES</i>	2.6808	0.4720	5.68
<i>RUSSIA</i>	1.7087	0.5675	3.01

<i>SINGAPORE</i>	-0.7168	0.4532	-1.58*
<i>USA</i>	4.0242	0.7817	5.15
<i>CANADA</i>	0.6619	0.1465	4.52
<i>CHILE</i>	-0.3786	0.1564	-2.42
<i>CHINA</i>	8.3793	1.2060	6.95
<i>HONGKONG</i>	-0.4517	0.3449	-1.31*
<i>INDONESIA</i>	4.6816	0.7139	6.56
<i>JAPAN</i>	3.6970	0.5369	6.89
<i>KOREA</i>	2.6743	0.2579	10.37
<i>MEXICO</i>	3.3458	0.4941	6.77
<i>MALEYSIA</i>	1.4782	0.1725	8.57
<i>NEW ZEALAND</i>	-2.9271	0.4876	-6.00
<i>PERU</i>	0.6066	0.2288	2.65
<i>PHILIPPINES</i>	3.6080	0.4725	7.63
<i>RUSSIA</i>	2.3371	0.5700	4.10
<i>SINGAPORE</i>	-1.5021	0.4562	-3.29
<i>USA</i>	5.3267	0.7868	6.77
1997	0.0038	0.0728	0.05*
1998	-0.1093	0.0733	-1.49*
1999	-0.1955	0.0746	-2.62
2000	-0.0465	0.0769	-0.61*
2001	-0.0766	0.0789	-0.97*
2002	-0.0703	0.0816	-0.86*
2003	0.0077	0.0844	0.09*
2004	0.1200	0.0886	1.35*
2005	0.2011	0.0931	2.16
2006	0.2685	0.0989	2.71
2007	0.3560	0.1047	3.40
2008	0.5079	0.1091	4.65
2009	0.3550	0.1109	3.20
2010	0.5312	0.1175	4.52
2011	0.6287	0.1230	5.11
2012	0.6185	0.1284	4.82
2013	0.6117	0.1334	4.58
2014	0.6060	0.1382	4.39
2015	0.4210	0.1426	2.95
2016	0.3632	0.1473	2.46
Observations	5015		

---

Adj. $R^2$	0.8863
------------	--------

---

*Note: (i) \* indicates insignificance at 5%. (ii) since the model includes an intercept term Australia as domestic and target country and also 1996 have been omitted. (iii) t statistics are heteroscedasticity robust.*

## 7. CONCLUSION

The goal of this study was to examine the bilateral export flows within the APEC region between the period of 1996-2016 with annual data. This paper investigates a more enhanced panel data approach by using an augmented panel gravity model by allowing for both individual and time effects to be apparent in order to capture country specific and time effects with a multidimensional panel data model for APEC countries. By using a three dimensional panel gravity model with a least squares dummy variable approach we were able to identify countries with stronger propensities to import and export. We believe it is crucial to reveal and also discover the unobservable country and time specific characteristics when trading blocs such as APEC are setting up policy decisions to trigger exports flows. Policy makers whom are interested in expanding their exports in the region could do well looking at China, Indonesia and the USA as potential markets. Where as New Zealand, Peru and Chile could be thought of superficially closed economies which would not be an ideal decision to consider for target country potential markets.

## 8. REFERENCES

- Aitken, N. D. (1973). The effect of the EEC and EFTA on European trade: a temporal cross-section analysis. *The American Economic Review*, 63(5), 881-892.
- Anderson, J. (1979). A theoretical foundation for the gravity equation. *The American Economic Review*, 69(1), 106-116.
- Anderson, J E. & Wincoop, E. (2003). Gravity with gravitas: a solution to the border puzzle. *American Economic Review*, 93 (1), 170-192. doi: 10.1257/000282803321455214
- APEC (Asia Pacific Economic Cooperation). (2015). Asia pacific economic cooperation, achievements and benefits. 20 Ocak 2019 tarihinde <https://www.apec.org/About-Us/About-APEC/Achievements-and-Benefits> adresinden erişildi.
- Balazsi, L., Matyas, L., & Wansbeek, T. (2018). The estimation of multidimensional fixed effects panel data models. *Econometric Reviews*,

37(3), 212-227.

- Baldwin, R., & Taglioni, D. (2006). Gravity for dummies and dummies for gravity equations. *National Bureau of Economic Research, Working Papers, 12516*, National Bureau of Economic Research, Inc. <https://www.nber.org/papers/w12516>
- Baltagi, H.B. (2008). *Econometric analysis of panel data*. England: John Wiley & Sons, Ltd.
- Bayoumi, T. & Eichengreen, B. (1995). Is regionalism simply a diversion? Evidence from evolution of the EC and EFTA countries. *National Bureau of Economic Research Working Paper, 5283*, National Bureau of Economic Research, Inc. <https://www.nber.org/papers/w5283>
- Bergstrand, J.H. (1989). The generalized gravity equation, monopolistic competition, and the factor-proportions theory in international trade. *The Review of Economics and Statistics, 71(1)*, 143-153.
- Chaney, T. (2013). The gravity equation in international trade: an explanation. *NBER Working Papers, 19285*, National Bureau of Economic Research, Inc. <https://www.nber.org/papers/w19285>
- Cheng, I. H., & Wall, J.H. (2005). Controlling for heterogeneity in gravity models of trade and integration. *Economic Research Federal Reserve Bank of St. Louis, 87(1)*, 49-63.
- Deardorff, A.V. (1995). Determinants of bilateral trade: does gravity work in neoclassical world?. *National Bureau of Economic Research, Working Paper, 5377*, National Bureau of Economic Research, Inc. <https://www.nber.org/papers/w5377>
- Egger, P. (2002). An econometric view on the estimation on gravity models and the calculation of trade potentials. *The World Economy, 25(2)*, 297-312. doi: 10.1111/1467-9701.00432
- Egger, P., & Pfaffermayr, M. (2003). The proper econometric specification of the gravity equation: a three-way model with bilateral interaction effects. *Empirical Economics, 28*, 571-580.
- Frankel, J.A., & Romer, D. (1996). Trade and growth: an empirical investigation. National Bureau of Economic Research, Working Paper, 5476, National Bureau of Economic Research, Inc. <https://www.nber.org/papers/w5476>
- Feenstra, R.C., Markusen, J. R., & Rose, A. K. (2001). Using the gravity equation

- to differentiate among alternative theories of trade. *Canadian Journal of Economics*, 34 (2), 430-447. doi: 10.1111/0008-4085.00082.
- Golovko, A. (2009). Çekim modeli: Avrasya ülkelerinin dış ticareti. *EconAnadolu 2009: Anadolu Uluslararası İktisat Kongresi*, 17-19 Haziran 2019, Eskişehir.
- Head, K., & Mayer, T. (2002). Illusory border effects: distance mismeasurement inflates estimates of home bias in trade. *Centre d'etudes prospectives et d'informations internationales, Working Papers*, 2002-01, [http://www.cepii.fr/PDF\\_PUB/wp/2011/wp2011-25.pdf](http://www.cepii.fr/PDF_PUB/wp/2011/wp2011-25.pdf)
- Heckscher, E. (1919). The effect of foreign trade on the distribution of income. *Ekonomisk Tidskrift*, 21, 497-512.
- Hsiao, C. (2003). *Analysis of panel data*. New York: Chambridge University Press.
- Kadaroo, J., & Seetana, B. (2008). The role of transport infrastructure in international tourism development: a gravity model approach. *Tourism Management*, 29, 831-840.
- Keum, K. (2010). Tourism flows and trade theory: a panel data analysis with the gravity model. *The Annals of Regional Science*, 44(3), 541-557.
- Krugman, P. (1980). Scale economies, product differentiation and the pattern of trade. *The American Economic Review*, 70(5), 950-959.
- Kurihara, Y. (2003). APEC: international trade and output, *Pacific Economic Review*, 8(3), 207-217.
- Linnemann, H. (1966). *An econometric study of international trade flows*, Amsterdam: North-Holland Publishing Co.
- Lowe, J.M., & Sen, A. (1996). Gravity model applications in health planning. analysis of an urban hospital market. *Journal of Regional Science*, 36(3), 437-461.
- Mansfield E.D., & Bronson, R. (1994). Alliances, preferential trading arrangements and international trade. *American Political Science Review*, 91(1), 94-107.
- Mansfield E.D., & Gowa J. (1993). Power politics and international trade. *The American Political Science Review*, 87(2), 408-420.
- Matyas, L. (1997). Proper econometrics specification of the gravity model. *The*

*World Economy*, 20(3), 363-368.

- Mayer, T., & Zignago, S. (2011). Notes on CEPII's distance measures: the geodist database. Centre d'etudes prospectives et d'informations internationales, CEPII Working papers, 25, [http://www.cepii.fr/PDF\\_PUB/wp/2011/wp2011-25.pdf](http://www.cepii.fr/PDF_PUB/wp/2011/wp2011-25.pdf)
- Morley, C., Rossello, J., & Gallego, M.S. (2014). Gravity models for tourism demand: theory and use. *Annals of Tourism Research*, 48, 1-40.
- Ohlin, B. (1933). *Interregional and international trade*. Cambridge: Harvard University Press.
- Poot, J., Alimi, O., Cameron, M.P., & Mare, D. (2016). The gravity model of migration: the successful comeback of an ageing superstar in regional science. *Journal of Regional Research*, 36, 63-86.
- Pöyhönen, P. (1963). A tentative model for the volume of trade between countries. *The Review of Economics and Statistics*, 67(3), 474-481.
- Ravenstein, E.G. (1885). The laws of migration. *Journal of Statistical Society of London*, 48(2), 167-235.
- Richardo, D. (1817). *The principals of political economy and taxation*, Canada: Batoche Books.
- Sa, C., Florax, R.J.G.M., & Rietveld, P. (2004). Determinants of the regional demand for higher education in the netherlands: a gravity model approach. *Regional Studies*, 38(4), 375-392.
- Shuurman, N., Berube, M., & Crooks, V.A. (2017). Measuring potential spatial to primary health care physicians using a modified growth model. *The Canadian Geographer*, 54(1), 29-45.
- Tang, D. (2005). *Effects of the regional trade agreements on trade: evidence from the NAFTA, ANZCER and ASEAN countries, 1989-2000*. *The Journal of International Trade & Economic Development*, 14(2), 241-265.
- Tatoğlu, Y.F. (2016). Üç boyutlu sabit ve tesadüfi etkili panel veri modellerinin tahmini için çeşitli yaklaşımlar. *Eurasian Econometrics, Statistics and Emprical Economics Journal*, 5, 60-70.
- Tinbergen, J. (1962). Shaping the world economy: suggestions for an international economic policy. *The Economic Journal*, 79(301), 92-95.
- Thursby, J. G., & Thursby, M. (1987). Bilateral trade flows, the linder hypothesis

and exchange risk. *The Review of Economics and Statistics*, 69(3), 488-495.

Vanderkamp, J. (1977). The gravity model and migration behaviour: an economic interpretation. *Journal of Economic Studies*, 4(2), 89-102.

Viorica, E. D. (2012). The econometric estimation of a gravity model for the external trade of Romania. *Journal of Eastern Europe Research in Business & Economics*, 2012 (2012), 1-9.

Westerlund, J. & Wilhelmsson F. (2008). Estimating the gravity model without gravity using panel data. *Applied Economics*, 43(6), 641- 658.