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# An Econometric Analysis on Factors Affecting Intra-Industry Trade in Turkish Automotive Industry[1]

## Türkiye Otomotiv Sektöründe Endüstri İçi Ticareti Etkileyen Faktörler Üzerine Ekonometrik Bir Analiz

Ömer DORU[2], Örsan ÖZER[3]

**Abstract**

**Purpose**: It is to empirically examine the factors affecting intra-industry trade in the automotive sector between Turkey and 24 OECD member trade partners.

**Design/Methodology:** The determinants of intra-industry trade were tested with panel data analysis in the automotive sector. As a result of the test carried out to determine the model, regression analysis was performed with the Driscoll-Kraay standard error estimation method.

**Findings:** The variables market size, development level, and trade openness have a positive impact on intra-industrial trade, while the variables market size difference, income inequality, and geographical distance have a reverse impact on intra-industry trade.

**Limitations**: Export and import data for 2003–2019 are used in international trade figures in the 3-digit Standard International Trade Classification, SITC Revision-3.

**Originality/Value**: Empirical application on the factors affecting intra-industry trade in the Turkish automotive sector is considered to be important and different in terms of subject.

**Keywords**: Automotive Industry, Driscoll-Kraay Standard Error, Intra-Industry Trade, Grubel Lloyd Index, Panel Data Analysis

**Öz**

**Amaç:** Türkiye ve OECD üyesi 24 ticaret ortağı arasında otomotiv sektöründe endüstri içi ticareti etkileyen faktörleri ampirik olarak incelemektir.

**Tasarım/Yöntem:** Otomotiv sektöründe endüstri içi ticaretin belirleyicileri panel veri analizi ile test edilmiştir. Model belirlemek üzere yapılan testler neticesinde Driscoll-Kraay Standart Hata Tahmincisi yöntemi ile regresyon analizi gerçekleştirilmiştir.

**Bulgular:** Piyasa büyüklüğü, kalkınma düzeyi ve dışa açıklık değişkenleri endüstri içi ticareti pozitif yönde; piyasa büyüklüğü farkı, kalkınma düzeyi farkı ve coğrafi uzaklık değişkenleri ise endüstri içi ticareti zıt yönde etkilemektedir.

**Sınırlılıklar:** Dış ticaret rakamlarında, Standart Uluslararası Ticaret Sınıflaması SITC Revizyon-3, 3 basamaklı sınıflandırmada 2003-2019 yılları ihracat ve ithalat verileri kullanılmıştır.

**Özgünlük/Değer:** Türkiye otomotiv sektöründe endüstri içi ticareti etkileyen faktörler üzerine ampirik uygulamanın konu itibariyle önemli ve farklı olduğu düşünülmektedir.

**Anahtar Kelimeler:** Otomotiv Sektörü, Driscoll-Kraay Standart Hatalar, Endüstri İçi Ticaret, Grubel Lloyd Endeksi, Panel Veri Analizi

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[2] Dr. Öğr. Üyesi, Mardin Artuklu Üniversitesi, İktisadi ve İdari Bilimler Fakültesi, İktisat Bölümü, omerdoru@artuklu.edu.tr, ORCID: 0000-0001-8119-4908

[3] Doktora Öğrencisi, Mardin Artuklu Üniversitesi, Lisansüstü Eğitim Enstitüsü, İktisat Anabilim Dalı, orsanozerm@gmail.com, ORCID: 0000-0002-3206-1313

## 1. INTRODUCTION

Economic literature suggests that a significant part of world trade can be classified as "intra-industry trade," in which a country's goods are imported and exported simultaneously in the same product category. Empirical studies show that the size of intra-industry trade in international trade has grown dramatically. Although there is much literature on intra-industry trade in industrialized countries, empirical studies in developing countries have recently increased. Therefore, it is considered significant to define the situation of intra-industry trade in Turkey's international trade, and sectorial empirical studies may provide more specific results in foreign trade.

The automotive is one of the important sectors of the Turkish manufacturing industry. The sector has been in the first place in Turkey's exports according to statistics for 15 years. Because of its nature, the automotive industry is connected to numerous industries and has a notable influence on the economies of countries. Basic industries such as steel, light metals, petrochemicals, rubber, and plastics supply the automotive sector. Indeed, the industry is inseparably linked to a substantial part of the economy. With export-oriented production in the automotive sector, Turkey has become 14th largest manufacturer in the world. Additionally, at the end of 2019, Turkey ranked fourth among European countries in terms of vehicle production. Despite the COVID-19 pandemic, Turkey's automotive exports were estimated at $25.5 billion in 2020. EU countries' share of Turkey automotive exports was 75% in 2020 (Uludag Exporters' Association, 2021: 1).

In this study, the 3-digit classification based upon the Standard International Trade Classification (SITC) is used to reduce the categorical aggregation of automotive import and export data. The Grubel-Lloyd index technique, widely used in literature, is used to calculate index values for the intra-industry trade. Data from 2003 to 2019 will be used for the empirical application. An analysis of panel data on determinants affecting automotive sector intra-industry trade was carried out in 24 OECD Member States, which has an important dimension in international trade with Turkey.

The study consists of five parts. After the introductory, the theoretical framework and the literature are contained in the following part. The scope and the data set are reported in chapter three, and econometric analysis and then empirical findings are explicated. Finally, last chapter contains the result.

## 2. LITERATURE

There are various definitions of intra-industry trade (IIT) that arose from the establishment of the European Economic Community (EEC) and trade liberalization. Caves (1981) defined intra-industry trade as the increase in bilateral trade of comparable goods that occurs as a short-term response to trade liberalization. According to Lancaster (1980), IIT is a fact of trade between industrial economies rather than a prediction of the classical theory of trade. Grubel and Lloyd (1971) defined intra-industry trade as the export value exactly equal to imports from the same industry. The purpose of calculating one country's intra-industry trade with another country or with various groups of countries is to measure the intensity and nature of the two-way trade. The trend of globalization leads to a new model in the international economy that involves the synchronous export and import of a product within a particular sector called "intra-industry trade" or "two-way trade" (Leitão & Shahbaz, 2012: 505). Since the establishment of the EEC, trade between the members has been liberalized mainly by the exchange of differentiated goods within industry, indicating that economic integration affects IIT (Balassa, 1967: 21).

In the IIT literature, economies of scale are considered an important prerequisite for specialization within an industry. Even if there are no disparities in resources or technology, economies of scale encourage countries to specialize and engage in international trade (Krugman et al., 2015: 193). In the absence of economies of scale, goods can only be produced locally, so there may not happen intra-industry trade (Balassa & Bauwens, 1987: 938).

Product differentiation is another considerable factor in the progress of IIT. According to Lancaster (1980) and Helpman (1981), product differentiation is considered a prerequisite for intra-industry specialization. Intra-industry trade is not expected to appear in standardized goods (Balassa, 1986:224). In empirical studies, Balassa (1986), Aggarwal and Chakraborty (2017) concluded that intra-industry trade is same-way related with product differentiation.

After this part of the study, empirical findings on the determinants of IIT will be presented. Empirical applications generally use country-specific macroeconomic variables like GDP, GDP per capita, inequality of development level, distance, and trade openness, but other works have various variables.

Loertscher and Wolter (1980) studied the determinants of IIT between OECD countries as part of their empirical study. According to the findings, inequality in development level, differences in market size, economies of scale, and distance variables have a reverse impact on the IIT, while the variable of average market size has a same direction effect on the IIT. Balassa (1986) used 1979 data to examine IIT values for 167 industry categories in the US and 37 other countries. With the method of weighted least squares by logarithmic value and the method of nonlinear least squares, product differentiation, offshore opening, and trade orientation variables have a same direction effect on the IIT. The variables of economies of scale, degree of concentration, foreign direct investment, transport costs, income inequality, market size differentials, and distance are reverse effect on IIT. In the study of Greenaway et al. (1994), according to 1988 data, two-thirds of the IIT between England and 62 country are carried out as a vertical IIT. As expected, the market size and customs membership have same way effect on vertical IIT. Unlike expectations, there is a reverse correlation between IIT and per capita income. The horizontal values of the IIT in the study showed results similar to the vertical and total values of the IIT, but with less statistical significance. According to Zhang and Chuan (2006), market size is considerable determinant of the IIT in Chinese manufacturing, which positively correlates with both horizontal IIT and vertical IIT. The openness variable has also been same-way related with IIT in all regressions. As expected, the inequality in market size has a reverse effect on the horizontal IIT. The inequality of per capita income is negatively linked to the IIT, but not statistically significant, and all regressions show a positive relationship with the IIT except for the vertical IIT, which is calculated at a price threshold of 25% for the variable for foreign direct investment. In the empirical study of Leitão and Shahbaz (2012) contains between the United Kingdom and 17 selected countries. The variables; difference between GDP, per capita income dissimilarity, trade imbalance, and geographic distance have a reverse effect on the IIT, while the variables average GDP and foreign direct investment have a same-way effect on the IIT. Łapińska (2016) investigated determinants of IIT between Poland and its 26 European Union trading partners. Empirical findings show that the proportion of processed products from the trading partner, the size of total trade, and the size of GDP have a same-way effect on IIT. The variables "trade imbalance," "the difference between GDP," and "the geographical distance between trading partners" have a reverse effect on IIT. According to the findings of the Aggarwal and Chakraborty study (2017) between India and 25 selected countries, the vertical IIT between India and its trading partners is dominant. The difference between per capita income variables and the labor-capital ratio shows a positive correlation with the IIT. The logistic performance index and the "boundary" are positively correlated with the IIT, while the variable "distance" correlates negatively with the IIT. Given that the coefficient of the simulated language variable was negative, this suggests that India's participation in intra-industry trade with non-English speaking countries is higher. According to Nguyen et al. (2020), the empirical findings between Vietnam and 11 members of the Trans-Pacific Partnership (TPP) show that the economic size of the TPP countries is positively associated with the IIT. The inequality in per capita income, trade openness, and geographical distance is inversely related to the IIT.

Looking at the studies on the determinants of IIT between Turkey and its trading partners, some of these focused on the economy as a whole, while others focused exclusively on manufacturing. Emirhan (2005) examined the determinants of the vertical IIT between Turkey and nine trading partners based on data from 1989–2002, and the results point to Turkey's share of IIT is low among industrialized countries, while it is increasing among developing countries. IITs account for 83.6% of total intra-industry trade. There is a same-way related between difference between GDP and per capita income dissimilarity with vertical IIT, while there is a reverse connection between geographic distance and vertical IIT. According to Şentürk's (2014) findings on the determinants of intra-industry trade between Turkey and its 20 trading partners for 1995–2012, as expected, the variables of difference in development level, the difference in trade openness, and geographical distance have a reverse effect on IIT. The variable for the market size difference was negatively correlated as expected but was not statistically significant. Sezer (2019) studied the determinants of IIT between Turkey and 29 countries which have the majority of foreign trade in manufacturing. Empirical results show that IIT and the development of the variable level and economic integration are positively related. Contrary to expectations, the development levels inequality were positive. As expected, the geographical distance variable has a reverse effect on IIT.

From a sectoral perspective, empirical studies on the IIT determinants in the automotive and automotive parts sector are increasing. Leitão and Faustino (2009) studied the determinants of IIT between Portugal and the EU-27, the BRIC countries (Brazil, Russia, India, and China), and the United States. Contrary to expectations, the inequality in per capita income has a same-way effect on the IIT, while the "power consumption difference," which represents the difference in factor endowment, has a reverse connection on the IIT as expected. The economic dimension variable has a same-way effect on the IIT, while the geographical distance variable has a reverse connection on the IIT. Turkcan and Ates (2010) investigated the determinants of IIT in the automotive industry between the US and 37 trading partners based on data from 1989 to 2006. The share of the inter-industry automotive trade in the United States decreased from 84% in 1989 to 79% in 2006, and the share of IIT increased considerably in this process. Empirical results show that the market size variable is positively associated with the IIT. Contrary to expectations, the difference in market size, the difference in per capita income, and the foreign direct investment variables all showed a positive correlation with the IIT. The geographical distance variable was found to have a reverse effect, while the exchange rate variable had a positive effect on IIT. Marius-Răzvan and Camelia (2015) studied the determinants of intra-industry trade in motor vehicle parts and accessories between Romania and 13 EU Member States. According to the results on lag length, the IIT is positively influenced by past developments. The per capita income, used in the study as a similarity to economic growth, has a same-way impact on the IIT. The difference in per capita electricity consumption and the difference in factor endowments have a reverse impact on the IIT. Although the country's size and R & D expenditure are not statistically significant, they are positively related to the IIT. Xie et al. (2020) studied the determinants of the IIT in the Guangzhou automotive industry. The variables "economic scale" and "R & D expenditures," which were used as data on the number of manufacturers in the automotive sector, are positively correlated with the IIT. The per capita income, average annual exchange rate, and trade imbalance are negatively correlated with IIT.

Since no empirical study has been found on the determinants of IIT in the automotive and automotive parts sector between Turkey and its trade partners, it is considered significant to determine the determinants of IIT in the automotive sector, important sector of Turkey’s foreign trade.

## 3. SCOPE and DATASET

The study analyzed the determinants of IIT in the automotive industry between Turkey and 24 selected OECD countries [4]. The panel data method was used to analyze the study. The dependent variable in the study was the "IIT Index", calculated by using the Grubel-Lloyd (GL) method, while the independent variables were "average GDP, dissimilarity in GDP, average per capita income, dissimilarity in per capita income, trade openness ratio and geographical distance. Due to data availability limitations in some countries, annual data was used from 2003 to 2019. The study's data are all presented in US dollars at current prices. The data were obtained from the websites and databases of United Nations Conference on Trade and Development (UNCTAD), the World Bank, and Google Maps. The index values of the automotive industry's GL index values were calculated using the three-digit export and import data from Revision 3 of the Standard International Trade Classification (SITC) Revision-3. The automotive sector is divided into six categories based on the 3-digit SITC categorization. Table 1 shows the classification of products.

[4] Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, Korea, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom, United States.

**Table 1: SITC Rev. 3 Automotive Industry Product Codes**

| Code | Products |
|---|---|
| 781 | Motor passenger vehicles (passenger cars, etc.) |
| 782 | Motor vehicles for the transport of goods |
| 783 | Motor road vehicles not elsewhere specified |
| 784 | Parts and chassis, chassis and bodywork of motor vehicles |
| 785 | Motorcycles, bicycles, seats for the disabled, etc. component parts |
| 786 | Trailers and semi-trailers |

**Source:** United Nations Conference on Trade and Development

The GL index is one of the most prevalent used in empirical applications for measuring IIT. Although various explanatory variables are analyzed as determinants of IIT, level of development, dissimilarity in the level of development, market size, dissimilarity in market size, trade openness, and geographical distance are among the most commonly analyzed variables. In this context, the variables used in the study are explained under the following headings:

### 3.1. Dependent Variable: Grubel-Lloyd index

Grubel and Lloyd (1971) empirically studied the importance of IIT within the framework of the SITC used by most countries. At the 3-digit level of SITC aggregation, they developed an index for the calculation of IIT of the main developed countries among OECD members, which is still used today. For an industry at any level of the cluster, IIT is the value of exports that corresponds exactly to the value of imports in the same industry (Grubel & Lloyd, 1971: 496). The GL index contains a correction that expresses foreign trade minus total trade (Greenaway & Milner, 1987: 44). The index is calculated based upon the weighted averages of each industry when there are no product groups in the industry by method 1.

$$GL = \frac{\sum_i^n [(X_i + M_i) - |X_i - M_i|]}{\sum_i^n (X_i + M_i)} \times 100 \tag{1}$$

where, *GL* represents Grubel-Lloyd index; $X_i$ represents the total exports and $M_i$ represents the total imports of the product. The index value varies from 0 to 100. If the export within the industry is equal to the import, the index is 100, if the product is exported in the country and there is no import, or vice versa, the index results as 0 (Grubel & Lloyd, 1971: 496). If the index value approaches 100, it indicates high IIT, and close to 0 indicates low IIT.

### 3.2. Independent Variables

The most commonly analyzed variables as determinants of IIT are explained under the titles and hypotheses are used in the study:

**Level of Development:** Many academic studies, such as Loertscher and Wolter (1980), Balassa (1986), Balassa and Bauwens (1987), explain the positive relationship between average income levels. Higher per capita income signifies a higher level of economic development, increasing demand for differentiated products and increasing the share of IIT (Bergstrand, 1990: 1217).

Hypothesis 1- If a country's development level is high, IIT intense.

In the literature, it is assumed that development level of country has a same-way effect on IIT. In the study, the development level is calculated based upon the arithmetic average of the country's per capita income.

$$PGDP_{ij} = \frac{PGDP_i + PGDP_j}{2} \tag{2}$$

where, $PGDP_{ij}$ represents the average per capita income; and $PGDP_i$ and $PGDP_j$ represent the countries' per capita income.

**Dissimilarity in Development Level:** The different levels of development in literature are explained by Linder's theory of similarity of preferences. According to theory, the similarity in the demand or preferences of countries is related to the countries' per capita income. If two countries have identical demand structures, all exportable and importable goods from one country will also be exportable and importable from the other country. The similarity of the average income level of forces affecting the structure of a country's demand structure (Linder, 1961: 94).

Hypothesis 2- IIT reduces if the development level dissimilarity of countries is high.

The inequality in per capita income is likely to have a reverse connection on trade between industries. The per capita income dissimilarity is calculated by using the method 3, based on earlier studies such as Balassa (1986), Umemoto (2005), Łapinska (2016), and others. This index varies from 0 to 1, in any case of the trading partner's per capita income.

$$PGDPF_{ij} = 1 + \frac{[w\, Inw + (1 - w) In(1 - w)]}{In2} \quad (3)$$

$$w = \frac{PGDP_i}{PGDP_i + PGDP_j} \quad (4)$$

where $PGDP_i$ and $PGDP_j$ represent the country's per capita income , $w$ represents the trading partner's per capita income rate and $In$ represents calculation of the natural logarithm.

**Market Size:** The larger the average market size of a country in terms of total income, the larger the share of IIT in overall trade. Countries with high GDP have an impact on economies of scale and differentiated goods. Many differentiated goods can be produced in large markets with economies of scale (Greenaway et al., 1994: 79; Loertscher & Wolter, 1980: 283).

Hypothesis 3- If the market size is large, IIT intense.

The high average GDP is expected to positively affect IIT. In the study, market size was calculated with the average of GDP.

$$GDP_{ij} = \frac{GDP_i + GDP_j}{2} \quad (5)$$

where, $GDP_{ij}$ represents the average of GDP; $GDP_i$, $GDP_j$ represents the GDP of the countries.

**Dissimilarity in Market Size:** Suppose that the two countries have the same capital-to-labor ratio, the volume of trade increases as each country reallocates resources to maintain the initial capital-to-labor ratio as inequality in the country decreases. If two countries are the same size, their trade volume is the largest (Helpman, 1981: 327).

Hypothesis 4- IIT reduces if the market size dissimilarity is large.

According to Balassa (1986), Umemoto (2005), Łapinska (2016), and other studies, the dissimilarity in GDP is calculated with applying the following formula:

$$GDPF_{ij} = 1 + \frac{[w\, Inw + (1 - w) In(1 - w)]}{In2} \quad (6)$$

$$w = \frac{GDP_i}{GDP_i + GDP_j} \quad (7)$$

where $GDP_i$ *and* $GDP_j$ represents the GDP of the countries, $w$ represents the GDP ratio among the trading partners and $In$ represents calculation of the natural logarithm.

**Trade Openness:** The frequency of trade between two countries is represented by the opening of international trade. The higher frequency of trade, the more trade can be made in differentiated goods. As the volume of trade increases, the level of differentiated goods also increases as trade volumes increase (Nguyen et al., 2020: 127). According to Helpman (1981), trade openness does not lead to active inter-industry trade, but rather to intra-industry trade.

Hypothesis 5: If the trade openness is high, IIT intense.

In the literature, trade openness has a same-way effect on IIT. In the study, trade openness is measured with applying the following formula:

$$OPEN_{ij} = \frac{X_{ij} + M_{ij}}{GDP_i} \tag{8}$$

where, $X_{ij}$ is export from $i$ country to $j$ country; $M_{ij}$ is the $i$ country's imports from $j$ country.

**Geographical Distance:** Due to transport costs, trade reduces when distance between countries is high. Studies such as Balassa (1986), Umemoto (2005), Aggarwal and Chakraborty (2017) have shown a negative correlation between intra-industry and distance. It is useful to compare the different indices of distance with another variable, which is known to vary with market size in the analysis (Weiss, 1972: 248). According to the studies of Balassa and Bauwens (1987), Türkcan and Ateş (2010), Aggarwal and Chakraborty (2017), the geographical distance is calculated by using equation 3.9.

Hypothesis 6- IIT reduces if the geographical distance between countries is high.

$$DIST_{ij} = \frac{GDP_{it}\ x\ distance}{\sum_{i=1}^{j} GDP_t} \tag{9}$$

where, $distance$ represents the distance of the country's capitals in km; $GDP_{it}$ represents GDP for $i$ in the year $t$, and $GDP_t$ denotes the $i$ $and$ $j$ country's total GDP in the $t$ year.

The variables used in the study are summarized in table 2. The GL-dependent variable, the intra-industry trade index, and the independent variables, logarithmic values of the development level, the market size, and the geographical distance, were calculated in the model. The equations for the variables dissimilarity in developmental and market size variables contain logarithms. Therefore, the study model was derived using equation 10.

**Table 2: Determinants of Intra-Industry Trade**

| Independent variable | Variable's Definition | Applied Equation | Expected Effect | Source* |
|---|---|---|---|---|
| PGDP | level of development | $PGDP_{ij} = \frac{PGDP_i + PGDP_j}{2}$ | + | Worldbank |
| PGDPF | development level dissimilarity | $PGDPF_{ij} = 1 + \frac{[w\ Inw + (1-w)In(1-w)]}{In2}$ | - | Worldbank |
| GDP | market size | $GDP_{ij} = \frac{GDP_i + GDP_j}{2}$ | + | Worldbank |
| GDPF | market size dissimilarity | $GDPF_{ij} = 1 + \frac{[w\ Inw + (1-w)In(1-w)]}{In2}$ | - | Worldbank |
| OPEN | trade openness | $OPEN_{ij} = \frac{X_{ij} + M_{ij}}{GDP_i}$ | + | Worldbank, Unctad |
| DIST | geographical distance | $DIST_{ij} = \frac{GDP_{it}\ x\ distance}{\sum_{i=1}^{j} GDP_t}$ | - | Worldbank, Google Maps |

* The data of the variables are calculated with the equation applied by using the sources.

$$LEIT_{iT} = \beta_0 + \beta_1 LPGDP_{it} + \beta_2 PGDPF_{it} + \beta_3 LGDP_{it} + \beta_4 GDPF_{it} + \beta_5 OPEN_{it} + \beta_6 LDIST_{it} + \varepsilon_{it} \quad (10)$$

### 3.3. Econometric Method

This study examined the relationship between IIT in the automotive industry with frequently used variables between Turkey and 24 trading partners of OECD members based on data for the period 2003–2019. Panel data can be used to better measure effects that are not readily detected in cross-sectional or time-series data. Panel data analysis allows to test behavioral models that are more complex than cross-sectional or temporal series data. In addition, panel data may have a more complex hierarchical structure or grouping (Hsiao, 2007: 1–9; Baltagi, 2008: 4–11). In this context, in the analysis of panel data, healthier results can be obtained by analyzing cross-sectional dependency to test the relationships between variables through appropriate panel data analysis (Çuhadar & Doru, 2020: 175).

In the analysis, because of the estimation of heteroscedasticity, autocorrelation, and cross-sectional dependence in the model was made using the Driscoll-Kraay method, which includes a variance correction. The Driscoll-Kraay standard errors forecaster is used because it is consistent regardless of cross-sections; in other words, when the cross-sections is greater than the time dimension (N > T), the model is robust predictor.

Several tests are carried out to select the model. The hypothesis that the variance in random unit effects is tested using the Breusch-Pagan LM test (1980). If the test result is equal to zero, the method of least squares (classic model) is appropriate (Greene, 2000: 298). The Breusch-Pagan LM Statistical test:

$$LM = \frac{nT}{2(T-1)}\left[\frac{\sum_{i=1}^{N}[\sum_{t=1}^{T}\varepsilon_{it}]^2}{\sum_{i=1}^{N}\sum_{t=1}^{T}\varepsilon_{it}^2} - 1\right]^2 \quad (11)$$

In the null hypothesis ($H_0$), the LM statistic is distributed as $\chi^2$ with one degree of freedom (Greene, 2000: 299).

Pesaran et al. (2008) recommends $LM_{adj}$ (Bias-Adjusted Cross Sectionally Dependence Lagrange Multiplier) test, a modified of LM test by using the definite mean and variance of the LM statistic. For large panels, before $T \rightarrow \infty$ *and then* $N \rightarrow \infty$, with finite sample adjustments and where deviations are shown as corrected (Pesaran et al., 2008: 108; Menyah et al., 2014: 390; Koçbulut & Altıntaş, 2016: 151).

$$LM_{adj} = \sqrt{\left(\frac{2}{N(N-1)}\right)}\sum_{i=1}^{N-1}\sum_{j=i+1}^{N} T\,\hat{\rho}_{ij}\frac{(T-k)\hat{\rho}_{ij}^2 - \mu_{Tij}}{\sqrt{v_{Tij}^2}} \quad (12)$$

where k denotes the regressor number, $\mu_{Tij}$ and $v_{Tij}^2$ symbolize the mean and variance of $(T-k)\hat{\rho}_{ij}^2$, respectively.

Frees (1995, 2004) recommended statistics prop up the aggregate of the squared rank correlation coefficients (De Hoyos & Sarafidis, 2006: 488):

$$R_{ave}^2 = \frac{2}{N(N-1)}\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}\hat{r}_{ij}^2 \quad (13)$$

Frees (1995, 2004) follows the joint distribution of this statistic for two independently drawn $\chi 2$ variables.

$$\mathrm{FRE} = \mathrm{N}\{\mathrm{R}_{\mathrm{ave}}^2 - (T-1)^{-1}\} \xrightarrow{d} \mathrm{Q} = \mathrm{a}(\mathrm{T})\{\chi_{1,\mathrm{T}-1}^2 - (T-1)\} + \mathrm{b}(\mathrm{T})\{\chi_{2,\mathrm{T}(\mathrm{T}-3)/2}^2 - \mathrm{T}(T-3)/2\} \quad (14)$$

where $\chi_{1,T-1}^2$ *and* $\chi_{2,\mathrm{T}(T-3)/2}^2$ represent respectively $(T-1)\mathrm{T}(T-3)/2$ degrees of freedom and $\chi^2$ of independent random variables. If $\mathrm{R}_{\mathrm{ave}}^2 > (\mathrm{T}-1)^{-1} + \frac{\mathrm{Q_q}}{\mathrm{N}}$, the $H_0$ is refused. Here, $\mathrm{Q_q}$ denotes the appropriate quantile of the distribution Q.

The Q distribution is the (weighted) sum of two random variables distributed $\chi^2$ and bound up with the size of T. Therefore, calculating appropriate quantities can be problematic. Where T is not small, Frees recommends using a normal approximation to $Q$ distribution by the variance of $Q$ (De Hoyos & Sarafidis, 2006: 489):

$$\frac{\mathrm{FRE}}{\sqrt{\mathrm{Var(Q)}}} \approx \mathrm{N}(0,1) \quad (15)$$

The F statistic aims to determine whether any combination of a set of coefficients is different from zero (Wooldridge, 2015: 5). The F test is used to essay the effectiveness of the pooled least squares (classical) model. In the F test, all unit effects are equal to zero is tested ( $H_0: \mu_1 = \mu_2 \dots = \mu_{N-1} = 0$). According to the F test result, the classical model is appropriate when the data does not differ according to the units (Yerdelen Tatoğlu, 2013: 164-166).

The LR (Likelihood Ratio) test is used to fix the validity of the classic model against the random effects. The LR test statistic estimates the random effects and the classic model with the maximum likelihood method and uses logarithmic likelihood values for the two models. The test statistics are figure out with applying the equation 16.

$$LR = -2\log\frac{l(restricted)}{l(unrestricted)} \quad (16)$$

where, $l(restricted)$, represents the likelihood function of the classical model; $l(unrestricted)$ the likelihood function of the random effects model. The distribution of the LR test statistic fits the $\chi^2$ distribution with q degrees of freedom. If the calculated LR test statistic is more than the table value, the basic hypothesis is refused and in this case it is decided that the classical model is not suitable (Baltagi, 2008: 63-64).

The Hausman test is used to determine between predictors. Of course, random effects estimates should be compared with fixed effects estimates to see if significant differences occur (Hausman, 1978: 1269). In order to test the existence of the fixed effect, it is established null hypothesis, $\mathrm{E}\left(\alpha_\mathrm{I} + \frac{\mathrm{e_{it}}}{\mathrm{X_{it}}}\right) = 0$, in the equation; $\mathrm{Y_{it}} = \alpha_\mathrm{i} + \mathrm{X_{it}}\beta + \mathrm{e_{it}}$ (Hoechle, 2007: 305).

In panel data models, the error term may vary between units and periods depending on the units of cross-sectional variance. A modified wald are used to test the $H_0$, against to the alternative of the group-based heteroscedasticity model (Greene, 2000: 323). To test the autocorrelation in the fixed effects, Baltagi and Wu's Local Best Invariant (LBI) test, and the Durbin-Watson tests of Bhargava, Franzini, and Narendranathan are applied. Baltagi and Wu (1999) also provide a test of the local best invariance for zero first-order serial correlation versus positive or negative serial correlations for panel data with unequal spacing (Baltagi 2008: 89-90).

$$\varepsilon_{it} = \rho\varepsilon_{i,t-1} + v_{it} \quad (17)$$

where, $\varepsilon_{\mathrm{it}}$ denotes the error term; $\mathrm{v_{it}}$ denotes independent and uniformly distributed unit and time compensation; $\rho$ represents the population autocorrelation coefficient.

Bhargava, Franzini, and Narendranathan (1983) propose the following generalization of Durbin-Watson statistics. When the results of Baltagi-Wu and D. Watson LBI tests are below the critical value of 2, this indicates autocorrelation for fixed-effect models (Verbeek, 2008:357).

$$dw_\rho = \frac{\sum_{i=1}^{N}\sum_{t=2}^{T}\left(\hat{\varepsilon}_{it}-\hat{\varepsilon}_{i,t-1}\right)^2}{\sum_{i=1}^{N}\sum_{t=1}^{T}\hat{\varepsilon}_{it}^2} \quad (18)$$

Parks-Kmenta, Beck-Katz and Driscoll-Kraay estimators that include a correction appropriate for variance provide resilient estimators when heteroscedasticity, autocorrelation, and correlation between units are present (Yerdelen Tatoğlu, 2013: 276-277). When the T time dimension of the panel is lesser than the N cross-section dimension, the Parks-Kmenta method is inelastic. Beck-Katz (1995) proposed an estimate of the least squares for the coefficients based on the corrected standard errors of the panel to reduce the problems of the Parks-Kmenta method. Regression of pooled least squares based on corrected standard errors for simultaneous correlation between cross-sections and corrected for large T asymptotic works well on small panels. For the Driscoll-Kraay model based on cross-sectional means, standard error estimates are consistent regardless of cross-section of the units. Driscoll and Kraay demonstrate that consistency is achieved even when N approaches infinity (Hoechle, 2007: 281-290).

$$\hat{\Omega}_j = \sum_{t=j+1}^{T} h_t(\hat{\beta})h_{t-j}(\hat{\beta})' \quad with \quad h_t(\hat{\beta}) = \sum_{i=1}^{N(t)} h_{it}(\hat{\beta}) \quad (19)$$

In this formula, the sum of the unit time conditions $h_t(\hat{\beta})$, extends from 1 to $(t)$ , allowing $N$ to be replaced by $t$. This minor adjustment to Driscoll-Kraay's (1998) original estimator is sufficient to use the estimator on unstable panels. For the pooled OLS estimation, the individual steepness conditions in the formula $h_{it}(\hat{\beta})$ are the dimensional moment conditions of the linear regression model; $(K + 1) \times 1$ that is,

$$h_{it}(\hat{\beta}) = x_{it}\hat{\varepsilon}_{it} = x_{it}\left(y_{it} - x'_{it}\hat{\beta}\right) \quad (20)$$

In equation 3.20, Driscoll-Kraay's covariance matrix estimator is equal to Newey and West (1987)'s heteroscedasticity and autocorrelation resistive covariance matrix estimator. Estimated standard errors based on cross-sectional means are consistent regardless of the panel's cross-section size $N$. Driscoll and Kraay (1998) show that this consistency result is also valid in the limiting situation $N \rightarrow \infty$. In addition, the estimation of the covariance matrix with the Driscoll and Kraay model; gives standard errors resistant to cross-sectional and temporal dependency forms (Hoechle, 2007:287-288, Yerdelen Tatoğlu, 2013:242-277).

## 4. Results

A series of tests were implemented for the selection of the model to be applied in the study. First, to test the existence of autocorrelation Breusch-Pagan LM, Pesaran $LM_{adj}$ and Frees Q test results are presented in table 3.

**Table 3: Breusch-Pagan LM, Pesaran $LM_{adj}$ and Frees Q Test Results**

| Test Name | Test Statistics | Probability Value |
|---|---|---|
| Breusch-Pagan LM | 1169.34 | 0.0000 |
| Pesaran $LM_{adj}$ | 7,729 | 0.0000 |
| Frees Q* | 1,559 | |

*Frees Q critical values; 0.10 : 0.1521, 0.05 : 0.1996, 0.01 : 0.2928.

Comparing between Breusch-Pagan LM test statistic (1169.34) and Pesaran $LM_{ajd}$ test statistics (7.729) in 1 degree of freedom at 0.01 significance level $\chi^2$ table value (6.635), the hypothesis that the variance of unit effects is equal to zero is rejected. The main hypothesis, which assumes that there is no correlation between units according to the Frees Q test results, is rejected because 1.559 test statistics is greater than 0.01 critical value. According to the test results, there is a correlation between units in the model.

F test, to test the validity of the least squares model in the model; LR test to opt between the classical model and the random effects model; Hausman test was performed to opt between fixed and random effects.

**Table 4: F, LR and Hausman Test Results**

| Test Name | Test Statistics | Probability Value |
|---|---|---|
| F | 30.39 | 0.0000 |
| LR Likelihood Test | 298.13 | 0.0000 |
| Hausman | 24.06 | 0.0005 |

Comparing F test statistics (30.39); at 0.01 significant level and (23.378) degrees of freedom with F distribution table value (1.86), the null hypothesis that the variance of unit and time effects is equal to zero is rejected. This indicates that the pooled least squares (classical) model should not be used for the study. Comparing LR likelihood test statistic (293.43); at 1 degree of freedom at 0.01 significance level with $\chi^2$ table value (6.63), the main hypothesis that the unit effects standard errors equal zero is rejected. Test results indicated the presence of unit effect in the model. Comparing Hausman test statistics for the selection of the fixed and random effects estimator (24.06) with $\chi^2$ table value (16.81) at 6 degrees of freedom and 0.01 significance level, the main hypothesis is rejected. The explanatory variables and the unit effect are correlated and the fixed effects model is valid.

The Modified Wald test can be used to test heteroscedasticity in fixed effect panel data models, and the Durbin-Watson test by Bhargava, Franzini, and Narentnarathan and Baltagi-Wu's best local invariance test can be used to test autocorrelation (Güriş, 2018: 76-94; Yerdelen Tatoğlu, 2013: 232). The test results to check the heteroskedasticity and autocorrelation of the model are given in table 5.

**Table 5: Heteroscedasticity and Autocorrelation Tests**

| Test Name | Test Statistics | Probability Value |
|---|---|---|
| Modified Wald | 12815.04 | 0.0000 |
| Ax Wu Lbi | 1.2414394 | |
| Bhargava et al. Durbin-Watson | 1.0649393 | |

Comparing Modified Wald test statistic (12815.04) applied to test the problem of varying variance in the model with $\chi^2$ table value (42.98) at 24 degrees of freedom and 0.01 significance level, the null hypothesis that the variances are homoscedastic is rejected. There is a variance problem in the model that changes according to the units. According to Baltagi-Wu's local best invariant test and Bhargava, Franzini and Narendnarathan's Durbin-Watson test applied to put the autocorrelation problem, since both of the test statistics are less than 2, autocorrelation problem has been detected in the model.

The test results demonstrated that there is heteroscedasticity and autocorrelation in the model. Compared to Parks-Kmenta Beck-Katz estimators, Driscoll-Kraay estimator also produces resistant standard errors independent from the cross-section size $(N)$ in the case of $(N \rightarrow \infty)$. So, Driscoll-Kraay estimator was used in order to obtain resistant standard errors, because number of cross-sections is much larger than time dimension in the study.

According to the Driscoll-Kraay estimator, GDPF, PGDPF, LDIST and OPEN variables were statistically significant at 99% confidence level and LPGDP variable at 90% confidence level. LGDP variable is not statistically significant.

**Table 6: Driscoll-Kraay Standard Errors Estimation Results**

| Independent variables | Coefficient | Standard error | t statistic | Possibility |
|---|---|---|---|---|
| GDPF | -1.685221 | 0.2908321 | -5.79 | 0.000* |
| PGDPF | -2.641940 | 0.4126174 | -6.40 | 0.000* |
| LGDP | 0.070234 | 0.0818965 | 0.86 | 0.404 |
| LPGDP | 0.391910 | 0.2240464 | 1.75 | 0.099** |
| LDIST | -0.756541 | 0.0842343 | -8.98 | 0.000* |
| OPEN | 0.286095 | 0.0756712 | 3.78 | 0.002* |
| CONS | 3.230417 | 2.8174790 | 1.15 | 0.268 |
| Number of Observations | 408 | | | |
| Test of the model | F(6.16) : 528.78* | | | |
| Table values | F(6.16) : 4.20 | | | |

* and ** indicate 1% and 10% significance levels, respectively.

According to the findings, IIT in the automotive sector, as expected, is affected positively with the increase in Turkey and OECD trading partners average level of development. a 1% increase in the independent GDP variable, which represents the level of development, leads to an increase of 0.39% in the value of the IIT. The same-way relationship between IIT and per capita income is coherent with the studies of Linder (1961), Loertscher and Wolter (1980), Avrylyshyn and Civan (1983), Balassa and Bauwens (I987). As might be expected, the difference in the development level has a reverse effect on IIT. An increase of 1% in the PGDPF variable indicates the difference in development level leads to a 2.64% decrease in the value of the IIT. The negative ratio between intra-industry trade and the preference similarity theory represented by difference in per capita income levels, gives similar results Linder (1961), Loertscher and Wolter (1980), and Greenaway et al. (1994)'s studies. According to the coefficients calculated, the variable "development difference" has a significant impact on IIT. As expected, the "market size" variable had a same-way effect but was not statistically significant. Therefore, results could not be obtained for the variable "average market size." As expected, the difference in market size level has a reverse impact on IIT. An increase of 1% in the GDPF variable, which represents the difference in market size, leads to a 1.68% decrease in the value of the IIT. The negative relationship between IIT and the difference in market size was similar to that of Helpman (1981), Balassa (1986), and Loertscher and Wolter (1980). According to the coefficients calculated, the "market size difference" variable significantly affects intra-industry trade. As might be expected, the "trade openness" variable has a positive effect on intra-industry trade. An increase of 1% in the degree of openness of countries results in a 0.28% increase in the value of the IIT. The same-way relationship between IIT and openness was found to be similar to studies by Balassa (1986) and Zhang and Chuan (2006). The range variable between countries resulted as expected, and a 1% increase in the geographical distance led to a 0.75% decrease in the IIT value. The inverse effect between IIT and geographical distance was found to be similar to studies by Balassa (1986), Umemoto (2005), and Aggarwal and Chakraborty (2017). The independent variables tested as determinants of IIT in the automotive sector are summarized in table 7 under the labels of "expected effect," "conclusion, and statistical significance.

**Table 7: Impact Direction of IIT Determinants in the Turkish Automotive Sector**

| Independent variable | | Tested Hypothesis | Expected Effect | Conclusion: Direction of Influence | Statistical Significance |
|---|---|---|---|---|---|
| Hypothesis 1 | PGDP | If a country's development level is high, IIT intense | + | + | Significant |
| Hypothesis 2 | PGDPF | IIT reduces if the development level dissimilarity of countries is high | - | - | Significant |
| Hypothesis 3 | GDP | If the market size is large, IIT intense | + | + | Insignificant |
| Hypothesis 4 | GDPF | IIT reduces if the market size dissimilarity is large | - | - | Significant |
| Hypothesis 5 | OPEN | If the trade openness is high, IIT intense | + | + | Significant |
| Hypothesis 6 | DIST | IIT reduces if the geographical distance between countries is high | - | - | Significant |

## 5. CONCLUSION

The objective of this study is to analyze IIT in the automotive industry between Turkey and 24 OECD trading partners based on explanatory variables. The study concludes that as the variables of development and dissimilarity in market size in the automotive sector are important factors affecting IIT, the share of IIT can be increased by incentives to expand the sector. Increased economies of scale and product differentiation in industry, the market size of countries, and the manufacturing of products with high demand should be promoted.

In addition, various cost-reducing measures should be taken to increase IIT. The implementation of cost-reducing rebates and exemptions on supplies from the industry of basic industries such as iron, steel, light metals, and plastics can support the automotive industry. National logistics companies should be encouraged to reduce freight costs. It is expected that IIT can be increased through the production of raw materials, intermediate products, R & D investment, and technological development, thereby reducing import dependence. It is also proposed to strengthen sector-oriented studies with explanatory variables for IIT in developing countries.

***Ethics Statement:*** *In this study, no method requiring the permission of the "Ethics Committee" was used.*

***Etik Beyan:*** *Bu çalışmada "Etik Kurul" izini alınmasını gerektiren bir yöntem kullanılmamıştır.*

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