Evaluation of the effect of the location of the steering wheel on the volume of international trade of vehicles

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Abstract

Nowadays there are two directions of the road traffic: right-hand traffic and left-hand traffic. According to the side of the road on which vehicles are driven, they are also divided to those with the steering wheel on the left-hand side of the car and on right-hand side of the car. In this paper, we evaluate the impact of the location of the steering wheel on the volume of international trade of vehicles using gravity model. We collected data for the year 2015, including 42 exporting countries and 161 importing countries. The difference in ways of transportation of new vehicles were also considered in the analysis: by road and by the sea. We proved positive and significant impact of the steering wheel arrangement on the volume of international trade of vehicles using OLS, NLS and Poisson pseudo-maximum likelihood (PPML) estimators. According to the results, identical location of steering wheels in two trading countries (both on the right-hand side or both on the left-hand side) leads to increase of the volume of trade of vehicles by 22.5%, 43.6% and 64.4% in different models using OLS estimator. Estimations of other control variables including in the model (GDP per capita, population, production of cars by exporting country, distance, costs, duty and colonial links) are valid and correspond to the estimations in gravity models of other researches.

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1 Introduction

There is no common opinion in the world as to which side of the road to drive cars. Nowadays about 65% of the world population drives on right hand side of the road and 34% on the left hand side of the road. According with the side of the road on which cars are driven, there are motor vehicles with right- and left-hand drive. Left-hand drive vehicles have its steering wheel on the left side of the car and are designed to be used in countries with right-hand traffic, and in contrast, right-hand drive vehicle with the steering wheel on the right side of the vehicle are designed to be used in countries with left-hand traffic. Therefore, steering wheel of the vehicle is located nearer to the center of the road in accordance with the safety regulations. In this research work, we evaluate how location of the steering wheel influence on the volume of trade of vehicles exported from one country to another. Does the same location of the steering wheel in vehicles in two countries (both on the right-hand side, or both on the left-hand side) gives trade benefit? Or in other words, does the fact that location of steering wheel does not match in two trading countries is a strong barrier which significantly decreases the unit of cars exporting from one country to another? Answers to these questions will be given during the research.

This problem is very important and actual in our days both from a practical and scientific point of view, as accurate assessment of the impact of the steering wheel arrangement will enable the authorities to increase the efficiency of trade and industrial policy.

The aim of the research: determine the effect of steering wheel arrangement on the volume of international trade in cars.

2 Literature review

Empirical research on the impact of the location of the steering wheel in cars on the volume of international trade was not conducted, so the theoretical basis in this paper is the history and legislation of different countries on the rules of road traffic, as well as the gravity model and empirical studies on bilateral trade.

2.1 The history of the appearance of right-hand and left-hand traffic in countries

Rule about on which side of the road to have traffic was identified in many countries in ancient times to reduce the number of accidents and congestions on the roads. On Figure 1, you can see distribution of countries according to right- and left-hand traffic.

Red colored countries drive on the right, while blue colored countries drive on the left side of the road. Nowadays right-hand traffic is used in 163 countries and territories, with the remaining 76 countries and territories use left-hand traffic.

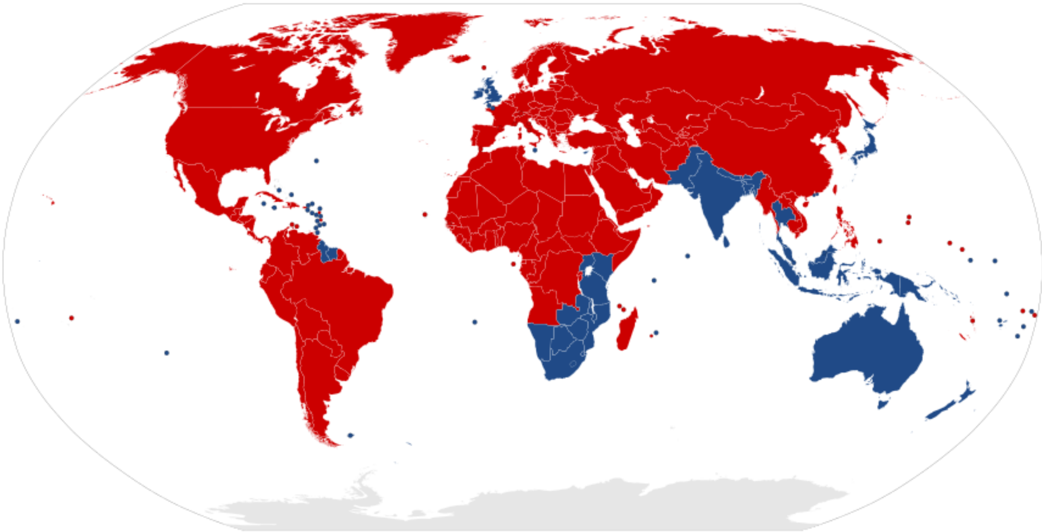
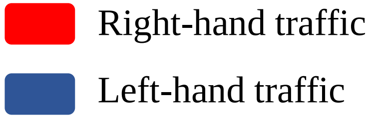


Figure 1: Distribution of countries to right- and left-hand traffic



The main two factors that determined which side of the road to ride better are social status and the fact that most people are right-handed people.

- traveler (pedestrian), carrying any luggage on his shoulder held it with his right (leading) hand , and therefore instinctively, trying to protect his property from a collision, kept himself to the right side of the road;

- Crews and wagons - on the right side; it was easier for a charioteer to pull the reins by a stronger right arm, so they kept themselves on the right side;
- Walking or horse warriors - on the left side, because they attacked the opponent with a strong right hand. Therefore, it was easier for armed people to pass each other on the left side. This caused a contradiction in traffic even during that time.

Traffic was left-handed where historically there were many warriors and military campaigns (for example, in the Roman Empire).

Influential in Europe for changing to right-hand traffic was 1920 Paris Convention. In England, the "Road Act" was adopted in 1776, according to which the left-hand traffic was the dominant one. Most former British colonies, with some exceptions, drive on the left side of the road.

In most cases, it is legal to entry into right-hand driving country in a left-hand car (and vice versa). But some countries have got restrictions about this rule. Left-hand cars are forbidden in Australia. In New Zealand, you need to get a special permit. In Slovakia and Lithuania, right-hand drive vehicles cannot be registered at all.

2.2 Gravity model in bilateral trade

To evaluate effect of the location of steering wheel in motor transport vehicles we use gravity model. According to the research of Alan Deardorff (1984) gravity models explain very well trade relationships between two economic objects (cities, countries and etc.). It asserts that economic interaction between two geographic objects (countries, regions, cities, etc.) is proportional to the economic size of these objects (most often using gross domestic products measurement) and inversely proportional to the distance between them.

The model was first used by Jan Tinbergen in 1962. The basic model for the trade between two countries (i and j) takes the form of

$$F_{ij} = G\frac{M_i^{\beta_1} M_j^{\beta_2}}{D_{ij}^{\beta_3}} \qquad (1)$$

Where F is the trade flow, M is the economic mass of each country, D is the distance and G is a constant. The model has been used by economists to analyze the determinants of bilateral trade flows such as common borders, common languages, common legal systems, common colonial legacies, and it has been used to test the effectiveness of trade agreements and organizations such as the North American Free Trade Agreement (NAFTA) and the World Trade Organization (WTO) (Head and Mayer 2014).

To estimate gravity equation with the econometric analysis, we rewrite formula (1) in the following form:

$$F_{ij} = G\frac{M_i^{\beta 1}M_j^{\beta 2}}{D_{ij}^{\beta 3}}n_{ij} \qquad (2)$$

Where F_{ij} is the trade volume from country i to country j, $M_i$and $M_j$are usually the gross domestic product (GDP) for countries i and j, D_{ij} determines the distance between countries, n_{ij} represents the error.

The traditional approach to estimating this equation consists in taking logs of both sides, leading to a log-log model of the form:

$$\ln\left(F_{ij}\right) = \beta_0 + \beta_1 * \ln(M_i) + \beta_2 * \ln\left(M_j\right) - \beta_3 * \ln(D_{ij)} + \ln(n_{ij}) \qquad (3)$$

As it is obvious from equation (3) distance is one of the barrier with the negative impact on the volume of trade between the objects.

However, J. M. C. Santos Silva and Silvana Tenreyro (2006) argue that log-linearization of the empirical model due to heteroscedasticity leads to inconsistent estimates. As an alternative, they propose that the model should be estimated in its multiplicative form, i.e., using a Poisson pseudo-maximum likelihood (PPML) estimator. Therefore, regression will take the following form:

$$F_{ij} = \exp[\beta_0 + \beta_1 * \ln(M_i) + \beta_2 * \ln\left(M_j\right) - \beta_3 * \ln(D_{ij)}]n_{ij} \qquad (4)$$

Gravity equation in economic researches was widely used to examine trade flow effects of various institutions. Some economists agree with statement of Kenichi Ohmae that borders have "effectively disappeared" (1990 p. 172), especially with trading blocs such as the North American Free Trade Agreement and the European Union. However, McCallum (1995) proved “border effect”, the situation where there is a higher volume of intranational trade (within a country) than international trade (between countries) due to border barrier. Author shows that previous studies have had an upwards bias in the estimation of the border effect. He provided influence of Canada-US border on regional trade patterns. He found that for the United States and Canada, inter-province trade is 20 times larger than international trade, and it is an evidence of border barrier for bilateral trade. James E. Anderson and Eric Van Wincoop (2003) solved McCallum border puzzle. In the research, they developed a method that efficiently estimate a theoretical gravity equation. Applying this method, they discovered that national borders decrease trade between industrialized countries by amounts of 20-50 %.

3 Emperical research

3.1 Data

The period considered is 2015. As exporting countries, the first 50 countries with the highest level of production of cars for 2015 were selected. In the final sample, we have 42 exporting countries and 161 importing countries (after dropping missing and too deviant)

Data on international trade of cars between countries were taken from the database on trade from the United Nations (UN) website, https://comtrade.un.org/data. The code of commodity for data is 8703 – motor cars and other motor vehicles, principally designed for the transport of person. The number of cars produced per year by exporting countries, were taken from the website of International Organization of Motor Vehicle Manufacturers (OICA) http://www.oica.net/. GDP per capita in US$ and population of importing countries were taken from World Bank. The main variable that determine the effect of arrangement of steering wheel in vehicles is hand_side, which is equal to 1 if arrangement is the same for two countries (both drives on vehicles with right hand-side, or both with left) and equal to 0 if arrangement of steering wheel is different in two trading countries. So the data about the side of road on which cars are driven in countries are taken from the site of United Nations. Data about colonial links between trading countries were taken from database on CEPII. Data about custom duties were taken from WTO Tariff databases, measured in % from the price of new motor vehicles.

We consider ways of calculation of distance in more details. To calculate the distance between exporting and importing countries we use distance between their capitals. The data were taken from the site searates.com, which is an aggregator in the transportation sector, and shows the distances for transporting new passenger cars through land and across the sea, as well as transportation costs. In this case, two variants of distance calculation were used: transportation on the road by truck or transportation through the sea or ocean using a sea container, depending on the availability of one or the other method. If both options were available, then the one that gave the shortest path was used.

When transported by sea, three distances were recorded:

1. from the capital of the exporting country to the nearest port of the country (dist_exp);
2. from the port of the exporting country to the port of the importing country - distance by sea (dist_sea);
3. from the port of the importing country to the capital of the importing country (dist_imp).

So we used two types of distances: dist_land and dist_sea.

If new motor vehicle was transported only by land then this value was recorded in the variable dist_land. If it was transported by sea, then variable dist_land equals to sum of dist_exp and dist_imp. Variable dist_sea measures the distance from the port of exporting country to the port of importing country by containership.

In addition, the same site searates.com took into account the cost of transportation. In the case of land transportation costs only for transportation on the road (roadhaulage), measured in US dollars. In the case of sea transportation, we have two cost indicators: export costs (cost_exp) and import costs (cost_imp). Expenses for export include the costs of transportation on the way, the cost of loading on a container and port dues. The cost of imports includes the costs of transportation on the road + the cost of unloading from the sea container.

3.2 Estimation and results

The main hypothesis of this research we expect is that the effect of arrangement of steering wheel in vehicles significantly and positively affect the volume of trade of vehicles exporting from one country and importing to another.

Table 1 Estimations of results

Model	1	2	3	4	5	6	7	8	9
Method	OLS	Poisson	NLS	OLS	Poisson	NLS	OLS	Poisson	OLS
Hand_side	0.203** (0.084)	0.04 *** (0.014)	0.210** (0.084)	0.362*** (0.083)	0.064*** (0.014)	0.357*** (0.084)	0.497*** (0.117)	0.09*** (0.020)	0.196** (0.084)
Log exporter's production of cars **lnprod_exp**	0.805*** (0.025)	0.140*** (0.005)	0.802 *** (0.025)	0.731*** (0.025)	0.128*** (0.004)	0.724*** (0.025)	0.772*** (0.035)	0.134*** (0.006)	0.803*** (0.025)
Log importer's GDP per capita **lnGDP_imp**	0.756 *** (0.029)	0.130*** (0.005)	0.752*** (0.028)	0.739*** (0.030)	0.127*** (0.005)	0.746*** (0.028)	0.714*** (0.043)	0.120*** (0.007)	0.758*** (0.029)
Log importer's population **lnpop**	0.585*** (0.025)	0.098*** (0.004)	0.587 *** (0.023)	0.617*** (0.025)	0.104*** (0.004)	0.603*** (0.024)	0.586*** (0.036)	0.101*** (0.006)	0.585*** (0.025)
Log of distance from exporting country to the importing **ln_dist**	-1.008 *** (0.038)	-0.161 *** (0.007)							-1.001*** (0.039)
γ			-1.045 *** (0.054)						
Distance from exporting to importing country by land **Dist_land**			1.121 *** (0.119)						
Log of total costs of transportation **lncost**				-0.763*** (0.032)	-0.122*** (0.006)		-0.577*** (0.058)	-0.098*** (0.011)	
ω						-0.728*** (0.044)			
Costs for import (by sea) **Cost_imp**						0.551*** (0.134)			
Costs for transportation by road **roadhaluage**						0.697*** (0.130)			
Custom duties **duty**							-0.017*** (0.004)	-0.003*** (0.001)	

Colonial links **colony**									0.453*** (0.162)
Constant	-8.853 *** (0.616)	-0.918*** (0.103)	-8.434 *** (0.715)	-12.103*** (0.573)	-1.435*** (0.097)	-12.355*** (0.062)	-13.157*** (0.822)	-1.564*** (0.141)	
N (sample size)	3404	3404	3404	3404	3404	3404	2269	2269	3404
R-squared	0.4120		0.4125	0.4014		0.4035	0.3684		0.4132
***,**,* denote significance at the 1%, 5% and 10% respectively									

The basic equation of the gravity model in our case will look like this (Model 1 in Table1):

$$\ln Q=\beta_0+\beta_1 * \text{Hand\_side}+\beta_2 * \text{lnprod\_exp} +\beta_3 * \text{lnGDP\_imp} +\beta_4 * \text{lnpop} +\beta_5 * \text{lndist} \quad (5)$$

Where

- Q reflects the volume of trade in cars between the exporting and importing countries, measured in the number of units of cars exported from one country to another per year;
- Hand_side is dummy variable that equals to 1 if steering wheel arrangement is similar in two trading countries (both on the right hand-side, or both on the left hand-side) and equals to 0 if steering wheel arrangement is different in two trading countries;
- lnprod_exp is a logarithm of the number of cars produced per year by the exporting country;
- lnGDP_imp represents logarithm of GDP per capita of the importing country;
- lnpop is a logarithm of population of importing country;
- lndist is a logarithm of distance between capitals of exporting and importing countries;

The results of this regression (5) are presented in Table 1 (Model 1).

We also examine the model built upon equation (5) only using PPML estimator. The results are presented in Table 1 (Model 2).

We also built nonlinear regression model to identify the difference in the ways of transportation: through the sea by containership and by the road by truck. Gravity equation using Non-linear least squares (NLS) model will take next form:

$$lnQ= \beta_0+\beta_1* \text{Hand\_side}+\beta_2* \text{lnprod\_exp} +\beta_3* \text{lnGDP\_imp} +\beta_4*\text{lnpop} +\gamma*\ln(\text{dist\_sea}+\beta_6*dist\text{\_land}) \quad (6)$$

The results of equation (6) are presented in Table 1 (model 3)

We also measured costs of transportation as important factor for determining dependent variable:

$$lnQ=\beta_0+\beta_1* \text{Hand\_side}+\beta_2* \text{lnprod\_exp} +\beta_3* \text{lnGDP\_imp} +\beta_4*\text{lnpop} +\beta_7* ln\text{costs} \quad (7)$$

Where lncosts are total costs of transportation of new cars from the capital of exporting country to the capital of importing country. The results of this regression are presented in Table 1 (Model 4).

The results of equation (7) using PPML estimator are presented in Table 1 (Model 5).

The data also allows us to compare costs of transportation measured by the sea and by the land. NLS model to evaluate the differences in costs takes the next form:

$$lnQ=\beta_0+\beta_1* \text{Hand\_side}+\beta_2* \text{lnprod\_exp} +\beta_3* \text{lnGDP\_imp} +\beta_4*\text{lnpop} +\omega*\ln(\text{cost\_exp}+ \beta_8*\text{cost\_imp}+ \beta_9*\text{roadhaluage}) \quad (8)$$

Where cost_exp and cost_imp are costs for export and import respectively while transportation by sea by containership; roadhaluage is costs of transportation by road by truck.

The results of the equation (8) are presented in Table 1 (Model 6)

We added customs duties for the model 4 to explain it better:

$$lnQ=\beta_0+\beta_1* \text{Hand\_side}+\beta_2* \text{lnprod\_exp} +\beta_3* \text{lnGDP\_imp} +\beta_4*\text{lnpop} +\beta_7* ln\text{costs}+ \beta_{10}* \text{duty} \quad (9)$$

Where variable duty shows customs duties for importing new motor vehicles in countries.

The results of this regression are presented in Table 1 (model 7).

We also estimated equation (9) using PPML estimator, the results are presented in Table 1 (model 8).

According to the history of appearing right- and left-hand traffic in different countries, many of them applied the same side of the road traffic as their colonizer. And of course, colonial links partly explain volume of trade of vehicles. Therefore, there is a question, in what degree there is a correlation between colonial links and hand_side. We approve that effect of the location of steering wheel found in empirical research certainly shows its own effect but not the effect of colonial links between countries. For this purpose we check exact Fisher test:

Hand_side	colony 0	colony 1	Total
0	1,119	39	1,158
1	2,117	129	2,246
Total	3,236	168	3,404

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         Fisher's exact =                 0.003
 1-sided Fisher's exact =                 0.001
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According to the Fisher's exact test, there is a correlation between Hand_side and colony, but it is not very high, so the results of evaluation of steering wheel location on trade volume of vehicles are appropriate. We include colonial links in our basic model 1:

$$\ln Q=\beta_0+\beta_1 * \text{Hand\_side}+\beta_2 * \text{lnprod\_exp} +\beta_3 * \text{lnGDP\_imp} +\beta_4 * \text{lnpop} +\beta_5 * \text{lndist} +\beta_{10} * \text{colony} \quad (10)$$

Where colony is dummy variable, which equals 1 if two trading countries have ever had a colonial link, and equal 0 otherwise.

The results of the regression built upon equation (10) are presented in Table 1 (Model 9).

3.3 Discussion

According to the results of Table 1 our main hypothesis is confirmed that identical steering wheel position in the car (both on the right-hand side or both on the left-hand side) increases the volume of cars exported from one country and imported to another.

Identical steering wheel position in the car increases the volume of trade of cars between countries to 22.5%, 43.6% and 64.4% in Models 1, 4 and 7 respectively using OLS method. Besides that, our results about other explanatory factors correspond to conclusions of other researches in gravity models: GDP per capita, population of importing country, production of cars per year of exporting country, presence of colonial links increases the volume of international trade of cars, while distance, costs and duties decreases it. Therefore, results are logical and conduct our theoretical hypothesis. Coefficient estimates of models using Poisson method are lower than those using OLS method, and such results were confirmed not only by Santos Silva and Silvana Tenreyro (2006) research but also by Inmaculada Martínez-Zarzoso (2013).

In Table 1 (Model 9) you can see the results of regression including colonial links as an additional explanatory variable. As you can see the coefficient behind our main variable hand_side become a bit less with adding colonial links in model. It is still positive and significantly different from zero. All other variables almost kept the same results as in model 1. As expected, variable colony has a positive impact on the volume of trade of vehicles between trading countries.

4 Conclusion

After conducting empirical research, the main hypothesis of positive and significant effect of steering wheel location on the volume of international trade of vehicles was confirmed. To estimate such effect we implied gravity model. According to the results identical location of steering wheels in two trading countries (both on the right-hand side or both on the left-hand side) leads to increase of volume of trade of vehicles by 22.5%, 43.6% and 64.4% in Models 1, 4 and 7 respectively using OLS method. Furthermore, we estimated the same models using Poisson pseudo-maximum likelihood (PPML) estimator, and values of coefficients are much lower comparing with OLS, but it is corroborated by researches of authors, who proposed such method.

Colonial links also positively affect the volume of trade of vehicles, but they do not eliminate the effect of the steering wheel location (according to Fisher's exact test). Thus, the effect of the steering wheel location on the volume of international trade of vehicles was estimated during the research. Probably such research may be useful for effective trading policy, as in gravity model you can compute trade value between two countries according to their economic sizes (GDP per capita of importing country, car production), distance, duty, colonial links and location of the steering wheel in both countries.

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