TRADITIONAL GRAVITY MODEL OF INTERNATIONAL TRADE IN ART

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Abstract

In the paper the author takes up the issue of modelling international trade in works of art. The gravity approach to the international trade in art in 27 European Community countries has been presented. The analysis is based on Eurostat international trade database Comext (Harmonised System for export and import chapter 97 – works of art, collectors' pieces and antiques, including the following kinds of works of art: paintings, drawings and pastels; collages, graphic arts, sculptures and antiques). The gravity models are based on nonlinear (power function) regression made in *Statistica 9.0* software. Using the mentioned model the author explains the influence of GDP of considered countries and distances between them on total export and import of art in the period 2003-2012. It has been proven in the paper that gravity models of international trade, which have been successfully applied to description of international trade with different types of goods and services, may also be used with respect to such specific commodities as works of art. According to obtained results the power regression models explain about a half of variability of international trade in art by means of three independent variables, i.e: GDP of country *i*, GDP of country *j* and distance between countries *i* and *j*.

Key words: international trade, international art trade, gravity model, gravity in international trade, art trade, art market

JEL Code: F1, C5, Z1

Introduction

Gravity models used in analysis of socio-economic phenomena are derived from Newton's law of universal gravitation formulated on the grounds of physics in 1687[1]. Reasoning *per analogiam*, the existence of identical regularities that govern behaviour of masses in gravitational field and interaction between objects (retail hubs, cities, urban agglomerations, regions, countries) in geographical space is assumed. Two basic forces that have an impact on

[1] Gravity force active between two bodies is directly proportional to the product of masses of interacting bodies, and inversely proportional to the square of distance between their centres. Analogically, trade flows between two countries are directly proportional to economic "size" (mass) of these countries, and inversely proportional to the square of distance between them.

the interaction of the masses have been taken from the Newton's prototype. On one hand, in gravity models, attraction forces acting between masses are considered by referring to the sizes of these masses, and, on the other, the distance between considered masses (centres in geographical space) is assumed as a repulsive force. Gravity theory in the field of social sciences has been used for regional analysis (Ickle, Dodd), transport analysis (Ullman, Mac Lean), analysis of phone calls (Krings, Calabrese, Ratti, Blondel), analysis of people's migration (Ravenstein), analysis of trade between the hubs (Reilly, Huff, Lakshmanan-Hansen), and, finally, analysis of international trade, which will be the subject of this paper.

Gravity models in international trade were for the first time used in the 1960s by Tinbergen and Pőyhőnen (Tinbergen, 1962; Pőyhőnen, 1963)[2]. Later, gravity models found its use in works of Linnemann and Anderson (Linnemann, 1966; Anderson, 1979). In the 1990s the issue of applying gravity models to international trade was taken up repeatedly (Evenett, Keller, 1998; Endoh, 1999). Then, the issue of international trade in the context of gravity models appears in the works of: (Byers et al., 2000; Christie, 2002; Paas Tafenau, 2005; Sohn, 2005; Fazzio et al., 2009; Helpman et al., 2008; Bilici et al. 2011; Felipe, Kumar, 2012; Clever, 2012; Kucharcukova et al., 2012; Cuenca et al., 2013)[3]. In gravity models of international trade, interactions within respective pairs of countries are analysed.

In gravity models, two basic forces, which influence interaction of masses, have been taken from Newton's prototype. On one hand, the models take into account forces acting between masses by referring to sizes of these masses, while on the other, variously defined distance between considered masses (centres in geographical space) is assumed as repulsion force[4]. Positive impact on foreign trade is exerted by "mass" of the countries (measured for instance by means of GDP), and negative impact – by the distance between them. From theoretical perspective, independent variables concerning the level of GDP of countries - *i* and *j* should be positively associated with international trade (export, import, international trade turnover) ($\beta_1, \beta_2>0$), whereas the distance should have negative impact on dependent variable

[2] Gravity models belonging to the group of *Spatial Interactions Models* (*SIM)* on the ground of social sciences were used for, amongst other things, regional analysis (Ickle, Dodd), transport analysis (Ullman, Mac Lean, Erlander and Stewart), analysis of phone calls (Krings, Calabrese, Ratti, Blondel), analysis of human migration (Ravenstein, Massey, Letouze et al.), analysis of trade between the centres (Reilly, Huff, Lakshmanan-Hansen), and, finally, analysis of foreign trade, which should become the subject of further considerations.

[3] The newest works covering theoretical and application aspects of creating gravity models of international trade can be found, for instance, on the webpage of international organization - ETSG (*European Trade Study Group*) www.etsg.org.

[4] Among the types of distances the following may be listed: physical distance, communication distance, road distance, distance in time, transport cost, social distance, psychological distance.

($\beta_3 < 0$). Gravity approach requires verification with respect to works of art as objects of trade exchange between countries.

The paper presents results of analysis conducted for international trade in art between 27 countries of the European Union. The goal of the work is to find an answer to the question whether international trade in art can be described by means of gravity models, which have been successfully applied to international flow of other goods. Is international trade in art governed by the same regularities as trade in the case of other goods? The answer does not seem straightforward, primarily because of specific, unique character of works of art.

1 Models of Bilateral Trade in Art in the ECC

Based on the assumptions of the theory of international trade gravity, an attempt has been made at constructing models of foreign trade in art in the European Community countries. In constructed models, dependent variable is represented by export or import or by a total of export and import of works of art within a pair of countries: *i* and *j*. Independent variables in the model are the levels of GDP of countries: *i* and *j* and geographical distances in kilometres between partners of foreign trade. Data concerning values of export and import of art and the levels of GDP of European Community countries come from Eurostat database Comext, whereas data describing distances between the EU countries have been taken from global database of distances CEPII (fr. *Centre d'Etudes Prospectives et d'Informations Internationales)*[5]. Statistical data covering international trade in art between respective 27 EU member-countries have a shape of bilateral connections[6]. For the construction of gravity model presenting relationships between international trade in art and respective independent variables *Statistica 9* application has been used (especially the module: statistics – advanced models – advanced tools for linear and nonlinear modelling - linearizable nonlinear regression).

Gravity models of international trade in art in the EC countries will be presented in order for the following dependent variables: value of export, value of import, and international trade turnover (total of export and import) in art and GDP level of the EC

[5] Data for export and import of works of art (values and volume) include categories of works of art assumed in international nomenclature of foreign trade HS6 (Harmonized System 6), section XXI Works of Art, Collectors' Pieces and Antiques in chapter 97 under the same title, which includes categories of objects cited in the previous section.
Data concerning levels of GDP of the EU member countries come from Eurostat website:
http://epp.eurostat.ec.europa.eu/portal/page/portal/national_accounts/data/database
Data concerning distances may be found on the website of CEPII:
http://www.cepii.fr/francgraph/bdd/distances.htm.

[6] Overall, bilateral import-export connections of each pair of the EU member countries were subject to analysis.

countries in total. Power regression models of international trade in art in the EC has been constructed based on the method of least squares. Due to wide range of analyses run, only a part of received results will be presented in this paper. In turn: export, import and turnover of international trade in art have been assumed as dependent variable[7]. The results of estimation of parameters for respective models and assessment of obtained models of international trade in art in the EU in the period 2003-2012 are presented in the tables 1-5.

Tab. 1: Gravity models of international trade in art in the EU in 2003

Dependent variable	Independent variables	Beta	Standard error Beta	B	Standard error B	Student's t – test	P
Export	Absolute term			2.011820	1.800865	1.11714	0.264916
	GDP *i*	0.568491	0.046699	0.816591	0.067079	12.17360	0.000000
	GDP *j*	0.218923	0.046706	0.350615	0.074802	4.68724	0.000004
	Distance *i j*	-0.260028	0.046284	-0.924129	0.164491	-5.61812	0.000000
Import	Absolute term			1.02035	1.734988	0.58810	0.556904
	GDP *i*	0.427345	0.045002	0.66143	0.069653	9.49604	0.000000
	GDP *j*	0.389989	0.044990	0.62380	0.071964	8.66828	0.000000
	Distance *i j*	-0.292185	0.044783	-1.03521	0.158666	-6.52445	0.000000
Export + import	Absolute term			1.17920	1.602950	0.73564	0.462396
	GDP *i*	0.518121	0.039631	0.80471	0.061553	13.07349	0.000000
	GDP *j*	0.308031	0.039631	0.50431	0.064884	7.77252	0.000000
	Distance *i j*	-0.265167	0.039343	-1.00846	0.149625	-6.73994	0.000000

Variables measured in natural logarithms.
Source: author's own work

Tab. 2: Gravity models of international trade in art in the EU in 2006

Dependent variable	Independent variables	Beta	Standard error Beta	B	Standard error B	Student's t – test	P
Export	Absolute term			4.834726	1.261655	3.83205	0.000162
	GDP *i*	0.521186	0.043505	1.033813	0.086295	11.97995	0.000000
	GDP *j*	0.589582	0.042634	1.051097	0.076006	13.82907	0.000000
	Distance *i j*	-0.220856	0.043538	-0.892132	0.175867	-5.07278	0.000001
Import	Absolute term			5.360396	1.244822	4.30616	0.000024
	GDP *i*	0.648328	0.046838	1.065791	0.076996	13.84207	0.000000
	GDP *j*	0.414334	0.047406	0.784190	0.089724	8.74005	0.000000
	Distance *i j*	-0.211044	0.047634	-0.787729	0.177795	-4.43055	0.000014
Export + import	Absolute term			7.63162	1.123265	6.79414	0.000000
	GDP *i*	0.613196	0.037760	1.10692	0.068162	16.23942	0.000000
	GDP *j*	0.557785	0.037448	0.98929	0.066417	14.89502	0.000000
	Distance *i j*	-0.297083	0.037346	-1.22784	0.154351	-7.95486	0.000000

Variables measured in natural logarithms
Source: author's own work

[7] It is noteworthy that export from country X to country Y is not always identical to import to country Y from country X. This stems from different ways of listing export (according to Incoterms based on FOB *Free on Board*) and import (based on CIF *Cost Insurance and Freight*) as well as temporal differences in reporting export in exporter's country and import in importer's country.

Tab. 3: Gravity models of international trade in art in the EU in 2009

Dependent variable	Independent variables	Beta	Standard error Beta	B	Standard error with B	Student's t – test	P
Export	Absolute term			4.34130	1.562768	2.77796	0.006002
	GDP *i*	0.480291	0.052337	1.13313	0.123477	9.17685	0.000000
	GDP *j*	0.614595	0.050102	1.13018	0,092133	12.26689	0.000000
	Distance *i j*	-0.252591	0.051807	-1.05020	0.215398	-4.87564	0.000002
Import	Absolute term			5.54223	1.369711	4.04627	0.000075
	GDP *i*	0.662092	0.047219	1.20941	0.086253	14.02161	0.000000
	GDP *j*	0.404626	0.049799	0.87929	0.108217	8.12526	0.000000
	Distance *i j*	-0.267409	0.049896	-1.07497	0.200578	-5.35936	0.000000
Export + import	Absolute term			6.19127	1.303070	4.75130	0.000003
	GDP of country *i*	0.618956	0.042157	1.22578	0.083488	14.68218	0.000000
	GDP of country *j*	0.563216	0.041755	1.10507	0.081926	13.48865	0.000000
	Distance from *i* to *j*	-0.301188	0.041463	-1.32129	0.181895	-7.26405	0.000000

Variables measured in natural logarithms.
Source: author's own work

Tab. 4: Gravity models of international trade in art in the EU in 2012

Dependent variable	Independent variables	Beta	Standard error Beta	B	Standard error with B	Student's t – test	P
Export	Absolute term			3.628608	1.239815	2.92673	0.003644
	GDP *i*	0.576951	0,035269	1.430768	0.087462	16.35878	0.000000
	GDP *j*	0.542455	0.035361	1,056308	0.068857	15.34054	0.000000
	Distance *i j*	-0.234390	0.035344	-0.995431	0.150103	-6.63163	0.000000
Import	Absolute term			5.543452	1.099251	5.04294	0.000001
	GDP *i*	0.609924	0.037937	1.106931	0.068850	16.07736	0.000000
	GDP *j*	0.584266	0.037897	1.057536	0.068595	15.41716	0.000000
	Distance *i j*	-0.261669	0.036191	-0.986535	0.136446	-7.23021	0.000000
Export + import	Absolute term			5.62021	1.058592	5.30914	0.000000
	GDP of country *i*	0.620320	0.032153	1.28276	0.066489	19.29294	0.000000
	GDP of country *j*	0.580297	0.032092	1.08271	0.059876	18.08248	0.000000
	Distance from *i* to *j*	-0.256465	0.030972	-1.07390	0.129688	-8.28065	0.000000

Variables measured in natural logarithms.
Source: author's own work

Tab. 5: Assessment of models of international trade in art in the EU in 2003-2012

Year	Model	R^2	Adjusted R^2	F	p	Standard estimation error
2003	Export	0.41639740	0.40998418	F(3.273)=64.928	p<0.0000	1.9423
	Import	0.39474053	0.38872802	F(3.302)=65.653	p<0.0000	2.0432
	Export + import	0.40483607	0.40019843	F(3.385)=87.294	p<0.0000	2.0839
2006	Export	0.56798347	0.56258326	F(3.240) = 105.18	p<0.0000	1.9138
	Import	0.50628186	0.49995214	F(3.234)=79.985	p<0.0000	1.9325
	Export + import	0.58187402	0.57782764	F(3.310)=143.80	p<0.0000	1.8631
2009	Export	0.51875373	0.51138771	F(3.196)=70.425	p<0.0000	2.0338
	Import	0.57211695	0.56546592	F(3.193)=86.019	p<0.0000	1.8898
	Export + import	0.53994082	0.53506387	F(3.283)=110.71	p<0.0000	2.0833
2012	Export	0.57626548	0.57271463	F(3.358)=162.29	p<0.0000	2.0232
	Import	0.53351815	0.52961997	F(3.359)=136.86	p<0.0000	1.8693
	Export + import	0.57992114	0.57706993	F(3.442)=203.39	p<0.0000	1.9476

Source: author's own work

2 Interpretation of results

Estimated parameters of power regression model present direction (sign of parameter) and strength of relationship (value of parameter) between respective independent variables and dependent variable (export/import/total of export and import of works of art in the EC)[8]. Beta coefficients for the GDP level of countries *i* and *j* are positive, which means that value of foreign trade in art of countries with higher level of GDP is higher. Beta coefficients for distances always adopt minus sign proving inverse correlation between distance and foreign trade in art (smaller distance between countries – exchange partners favours increased international trade, and the other way round – with the growth of geographical distance between countries, bilateral exchange turnover decreases). Values of beta parameters with respect to GDP of the importer's country are on a higher level than for the GDP of the exporter's country (in gravity models for export beta parameter is higher for GDP variable of country *j*, in gravity models for import parameter adopts higher value for GDP of country *i*).

In the process of construction of regression model, statistical verification of obtained models has been run (F-distribution - Fisher-Snedecor test) as well as verification of significance of received regression function parameters for respective variables (Student's t-test), at assumed

[8] Beta – standardized regression coefficients, are calculated based on regression coefficients in such a way so as their average equals 0, and standard deviation equals 1. Beta coefficients indicate by which part of its own standard deviation the value of dependent variable will change, if the value of independent variable changes by one standard deviation, with the rest of variables remaining on constant level. B – regression coefficients; positive values indicate positive impact of independent variable on dependent variable and the other way round; interpretation – if the value of independent variable (expressed in its measurement unit) grows by one, then the value of dependent variable will grow by the value of regression coefficient (expressed in measurement units of dependent variable). In case of power regression function interpretation of parameters is held in %.

level of significance $\alpha = 0.05$[9]. Taking into account statistical significance of regression function parameters, the significance of received parameters for all independent variables considered in the model, i.e. GDP level of both countries, and distance between them, must be indicated. Obtained results of the determination coefficients R^2 ranging between 0.50 and 0.58 prove that predictors considered in the model in 50-58% explain foreign trade in works of art. It should be emphasized that during modelling process, removal of outliers (pairs of countries) was necessary, and it led to improvement of the level of model adjustment to empirical data.

Conducted analyses confirm opportunity to apply multiple power regression models to bilateral trade in works of art between countries. Received models always demonstrate statistical significance, and their parameters are significant, while having their signs in line with theoretical assumptions. Gravity models explain relatively large portion (about a half) of variability of international trade in art by means of mere three explanatory variables. In particular, based on gravity models of international trade in art in the EU, it might be stated that, first of all – there is statistically significant positive correlation between GDP level of countries – exchange partners and international trade in works of art, and secondly – there exists statistically significant negative correlation between distance from country *i* to country *j* and international trade in works of art between them. Countries, which are more economically developed, are characterized by higher volume and value of foreign trade in works of art. Bilateral art trade turnovers are reduced with the growth of geographical distance between the countries – exchange partners, whereas they increase with its reduction.

[9] F-statistic is used for verification of model significance. A zero hypothesis says that no independent variable has any significant impact on dependent variable. Rejection of the zero hypothesis in F-test confirms that regression formula explains, in a statistically significant manner, variability of dependent variable. Value of Student's t-test statistic allows for verification of significance of regression parameters. Subject to verification is the zero hypothesis of the lack of impact of a given independent variable on dependent variable.

Tab. 6: Beta power regression parameters for gravity models of international trade in art in the EU in the years 2003-2012

Dependent variable	Independent variables	2003	2006	2009	2012
Art export	GDP of country *i*	0.534897	0.521186	0.480291	0.576951
	GDP B of country *j*	0.217936	0.589582	0.614595	0.542455
	Distance from *i* to *j*	-0.228736	-0.220856	-0.252591	-0.234390
Art import	GDP of country *i*	0.422538	0.648328	0.662092	0.609924
	GDP of country *j*	0.394778	0.414334	0.404626	0.584266
	Distance from *i* to *j*	-0.290297	-0.211044	-0.267409	-0.261669
Art export + import	GDP of country *i*	0.518121	0.613196	0.618956	0.620320
	GDP of country *j*	0.308031	0.557785	0.563216	0.580297
	Distance from *i* to *j*	-0.265167	-0.297083	-0.301188	-0.256465

Source: author's own work

Tab. 7: Comparison of determination coefficient R^2, adjusted R^2 and standard estimation error for gravity models of international trade in art based on GDP in the EU in the years 2003-2012

Measures		2003	2006	2009	2012
R^2	Art export	0.41639740	0.56798347	0.51875373	0.57626548
	Art import	0.39474053	0.50628186	0.57211695	0.53351815
	Art export + import	0.40483607	0.58187402	0.53994082	0.57992114
Adjust. R^2	Art export	0.40998418	0.56258326	0.51138771	0.57271463
	Art import	0.38872802	0.49995214	0.56546592	0.52961997
	Art export + import	0.40019843	0.57782764	0.53506387	0.57706993
Standard estimation error	Art export	1.9423	1.9138	2.0338	2.0232
	Art import	2.0432	1.9325	1.8898	1.8693
	Art export + import	2.0839	1.8631	2.0833	1.9476

Source: author's own work

Conclusion

Concluding the considerations included in the paper, it can be stated that gravity theory of international trade, which has been successfully applied to description of international trade in different goods and services, might also be used for such specific commodities as works of art. Constructed and presented in the paper power regression models explain about a half of variability of international trade in art by means of only three explanatory variables. In particular, on the basis of gravity models of international trade in art in the European Community countries, it may be stated that there exists statistically significant positive correlation between GDP level of countries *i* and *j* – partners of foreign trade exchange and international trade in works of art. Moreover there exists a statistically significant negative

correlation between the distance from country *i* to country *j* and international trade in art between them (export, import and foreign trade turnover).

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