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Determinants of Austrian International Trade: Analysis Based on the Gravity Model

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Determinants of Austrian International Trade: Analysis Based on the Gravity Model

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Abstract:
The purpose of this paper is to examine Austrian foreign trade and estimate the country's export function. The analysis is based on the gravity model of trade in the log-log form, augmented by additional variables in order to control for the impact of institutions on decision-making. Our panel dataset consists of 3,396 observations of Austrian exports to 211 countries over the period from 1995 to 2011. At that time, the Austrian export was very closely dependant on the German market, which the model proved to be a natural outcome. In other respects it has been, however, diversified among many smaller trade partners whose importance has been gradually shifting eastwards. We employ Fixed Effects and Random Effects as estimation techniques. By taking advantage of the panel data structure, we estimate

the gravity equation as two alternative one-way estimators – as 17 segments of cross-sections and as 211 time series. This allows us to estimate factors related to two complementary questions of "where to export" and "how much to export over time". For each question we test and quantify the relevance of nine economic and ten institutional factors.

Keywords: Austria, export, gravity model, fixed effects, random effects

JEL: C13, C23, F10, F12, F14

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INTRODUCTION

Although Austria is small geographically and in population numbers, it nevertheless represents economic flexibility and market competition. The objective of this paper is to examine Austrian foreign trade and exports in particular. We attempt to discover the determining factors of volume of Austrian exports and discuss them from both the theoretical and an empirical point of view. Such an analysis is done on the basis of the gravity model (GM) of international trade, which has lately provided a popular framework, originally introduced in mid-1950s. Its initial idea is based on Newton's law of universal gravitation where the extent of bilateral trade flow is directly proportional to the size of economies (approximated by GDP) and indirectly proportional to their bilateral distance. In addition, we enrich this basic model by other possible determinants such as contiguity, common language, trade barriers, recession, institutional quality indices, currency overvaluation, etc.

Chapter 1 explains in detail GMs of trade. We describe their development, comment on advantages and potential drawbacks, and refer the reader to several derivations based on various economic theories. The empirical part follows. Our panel dataset contains Austrian exports to 211 countries all over the world over the period of 1995–2011. In Chapter 2, we scrutinise these data by examining the trade balance and imported and exported values relative to GDP, and investigate Austria's main export partners.

In Chapter 3 we prepare the groundwork for an econometric analysis of the dataset. We discuss how the model is specified and how the data are interpreted. We emphasise that the structure of different panel data matters. The coefficients differ in meaning in relation to whether we structure our dataset as 17 cross-sections or as 211 time series. For instance, under the cross-sectional data structure, an estimated coefficient at partner's GDP of 0.96 means that when the partner's GDP is higher by 1%, compared to another partner, the former one imports from Austria by 0.96% more, ceteris paribus. On the other hand, under the time-series data structure, an estimated coefficient at partner's GDP of 0.55 means that when the partner's GDP is higher by 1%, compared to its last year's GDP, this partner imports from Austria by 0.55% more than in the previous year, ceteris paribus.

Chapter 4 is devoted to estimation results. Under each data structure, we apply the Hausman test and decide on a suitable estimator (RE in cross-section and FE in time series part). Both estimates are more or less in line with each other and state that among the most important positive determinants are GDPs of partner and home countries and contiguity, whereas the most relevant negative factors seem to be distance, landlocked position of the country and relative partners´ currency depreciation (REER). Institutional and policy-related factors are relevant but they play a subsidiary role.

1 GRAVITY MODELS OF TRADE

The main purpose of the GM concept is to explain the extent of bilateral trade flows on the basis of the size of the countries and the bilateral distance between home and partner country. This initial idea is based on Newton's law of universal gravitation from 1687 stating that every point mass attracts every other point mass with a gravitational force F that is directly proportional to the product of their masses m_1 and m_2, and inversely proportional to the square of the distance r between them (Newton et al., 1999). Such relationship is expressed as[1]

$$F = G \cdot \frac{m_1 \cdot m_2}{r^2} \tag{1.1}$$

The mutual attractive force is represented by the trade flows in the GMs. The model suggests analogical relationship between this force, GDP that stands for the size (mass) of both partner countries and their distance. The basic theoretical model of trade between two countries (i and j) takes the following form (Bergeijk and Brakman, 2010):

$$X_{ij} = G \cdot \frac{GDP_i^{\alpha} \cdot GDP_j^{\beta}}{D_{ij}^{\theta}} \tag{1.2}$$

where X_{ij} is the bilateral trade between countries i and j, GDP is gross domestic product of countries i and j, respectively, D is the distance (latitude) between the trading countries,[2] and G is a constant. Coefficients α, β and θ represent elasticity as proven by the definition[3]

$$e_{GDP_i}^{X_{ij}} = \frac{\partial X_{ij}}{\partial GDP_i} \cdot \frac{GDP_i}{X_{ij}} = \alpha \cdot G \cdot GDP_j^{\beta} \cdot D_{ij}^{-\theta} \cdot GDP_i^{\alpha-1} \cdot \frac{GDP_i \cdot D_{ij}^{\theta}}{G \cdot GDP_i^{\alpha} \cdot GDP_j^{\beta} \cdot} = \alpha \tag{1.3}$$

For estimation purposes, the traditional GM of international trade could be rewritten in the log-log form:[4]

$$\log(X_{ij}) = \beta_0 + \beta_1 \cdot \log(GDP_i) + \beta_2 \cdot \log(GDP_j) + \beta_3 \cdot \log(D_{ij}) + \varepsilon_{ij} \tag{1.4}$$

[1] G is the gravitational constant equal to $6.67384 \times 10^{-11} m^3 kg^{-1} s^{-2}$ according to http://physics.nist.gov.

[2] Theories of GM presumed for long pragmatically that "distance" was a proxy for trade costs that increased with distance in a log-linear way (Shepherd, 2013, p. 16). However, since all trade (including local trade) is subject to some transaction costs, the "distance" should never be equal to zero. Our variable of distance uses the estimates of CEPII for weighted distances between producers and consumers where the location of main industrial centres of both countries is taken into the estimation of its values.

[3] In general, x-elasticity of y is defined as: $E_{y,x} = \left|\frac{\partial lnx}{\partial lny}\right| = \left|\frac{\partial y}{\partial x} \cdot \frac{x}{y}\right| \approx \left|\frac{\%\Delta y}{\%\Delta x}\right|$.

[4] Log stands for natural logarithm in the whole paper.

where ε is a disturbance term for which we assume:

$$\mathbb{E}(\mu_{ij}) = 1 \;\Rightarrow\; \mathbb{E}[\log(\mu_{ij})] = \mathbb{E}(\varepsilon_{ij}) = 0 \tag{1.5}$$

1.1 Historical Development

The beginnings of the GM are dated to mid-1950s when Isard and Peck (1954) and Isard (1954) elaborated the negative effects of distance, trade structure and political as well as cultural disparities on the bilateral trade. The GM was first stated as an equation by Tinbergen (1962). Since then the GMs have been performing very well in empirical applications. However, there has been a problem with a lack of theoretical foundations of this concept for a long time. Several economists casted doubt over the theoretical basis of GMs (see Leamer and Levinsohn (1995) or Rose (2000)).

As a reaction to the problem of bridging economic theory with empirical results, several papers that derive the GM specification by means of a well-known economic theory were published. The first proper theoretical foundation of the model was Anderson (1979) who justified the gravity equation by the theory of differentiated goods. In his paper Anderson provided first serious micro-foundations of the gravity equation based on Armington preferences. Nevertheless, his study used the assumption that each country specializes fully in production of one good, which is too strong and simplistic.

Anderson and Van Wincoop (2001) avoided this weakness and enhanced a new micro-founded theory. In their well-known paper the authors argue that bilateral trade is determined by relative trade costs and can be solved for multilateral trade resistance by using fixed effects for importers and exporters. The country-specific resistance terms control for unobserved characteristics of a country's propensity to import or export if unbiased coefficients are to be obtained.

Bergstrand (1985, 1989) continued to develop theoretical derivation of GMs based on the monopolistic competition model. Helpman and Krugman (1985, 1990) derived the gravity equation on the basis of increasing-returns-to-scale approach and Deardorff (1998) proved its coherence with common trade theory and factor-endowment approach based on the Heckscher-Ohlin model.

Helpman et al. (2008) is a most recent supporter of the gravity trade theory who derives the gravity equation from a heterogeneous-firms model of trade. The study also explains a new way to deal with zero trade observations, asymmetric trade flows, and extensive margin of trade. Cieslik (2009) employed incomplete specialisation models and Novy (2010) worked with a micro-founded general equilibrium framework. Most recently, Chaney (2013) explained how the role of distance variable of the traditional model can be interpreted as a proxy related to the Linder theory of trade dynamics, the chain of production input-output linkages and the structure of firm sizes. Baldwin and Taglioni (2006) offer an overview of GM theoretical derivations. As noticed by Frankel (1998, p. 2) the gravity equation has recently *”gone from an embarrassment of poverty of theoretical foundations to embarrassment of riches”*.

2 INTERNATIONAL TRADE OF AUSTRIA

Austria is a small open economy based on a well-developed market with a great potential. Austrian GDP PPP per capita has risen from $23,000 in 1995 to almost $42,000 in 2011, which is the 11th highest value in the world.[5] Besides the EU, Austria is member of the World Trade Organization[6] and the Organization for Economic Cooperation and Development.[7] Although Austria is small both geographically and in population numbers, and like the other small European states, has had no great impact on international politics, it still represents economic flexibility and market competition. The reason why Austria was chosen for this analysis is the similarity of Austrian economy to the Czech one. This paper can be thus used for comparison and possibly inspiration for the Czech Republic.

2.1 Main Export Partners

As a member of many economic, trade, and political organizations, Austria is trading with a wide range of countries all over the world. However, certain historic connections, similarly oriented demand, or minimal trade barriers have all together caused an intensive orientation of Austria to the German market. The northwest neighbour of Austria has historically been its main trading partner; the share of Germany in total Austrian import was almost 48% in 1995 and 44% in 2010. In terms of export, German proportion has decreased from 38% to 31% over the observed period from 1995 to 2010 (see Table 1). These very high ratios cause also a remarkable dependence of Austria on German economic situation and demand development, and make it vulnerable to sudden changes in German economy.

Skriner (2009) claims that Austria’s geographical distribution of exports reflects its high degree of economic integration with other industrial countries, especially the neighbouring EU members (see Table 1). Export to the top-5 partner countries comprises more than a half of the total Austrian exports. This ratio, however, is continually decreasing, which illustrates a tendency of Austria to diversify its export activities among additional partners. In many aspects Austrian and Czech structures of trade show similar features in both geographic and industrial orientation of exports.

[5] Source: IMF data & statistics.
[6] Since January 1, 1995; http://www.wto.org.
[7] Since September 29, 1961; http://www.oecd.org.

Therefore the findings of this research could be useful for understanding how the Czech export sector functions.

While the share of traditional Austria's trade partners is decreasing (Germany, Italy, Switzerland, France, the UK, Spain, or the Netherlands), the value of exports to the Eastern Europe and other emerging economies is growing (the Czech Republic, Poland, Slovakia, Slovenia, Russia, and China). This reorientation might have several reasons. First, the eastern enlargement of the EU facilitated foreign trade with its neighbours, i.e., the Czech Republic, Hungary, and especially Slovakia. Second, these partly post-communistic "eastern" countries are catching up with the "western" world. Their economies grow dynamically, and their aggregate demands for goods and services converge to the EU standard. Moreover, this country group has a certain comparative advantage in short distance and adjacency in comparison with Spain, the Netherlands, the UK and France.

Table 1: Main Austria's export partners 1995, 2000, 2005, 2010

1995		2000		2005		2010	
GERMANY	38%	GERMANY	33%	GERMANY	31%	GERMANY	31%
ITALY	9%	ITALY	9%	ITALY	9%	ITALY	8%
SWITZERLAND	6%	SWITZERLAND	6%	USA	6%	SWITZERLAND	5%
FRANCE	4%	USA	5%	SWITZERLAND	5%	USA	4%
HUNGARY	4%	HUNGARY	5%	FRANCE	4%	FRANCE	4%
	61%		**59%**		**55%**		**52%**
UTD KINGDOM	3%	FRANCE	4%	UTD KINGDOM	4%	CZECH REP.	4%
USA	3%	UTD KINGDOM	4%	HUNGARY	3%	HUNGARY	3%
NETHERLANDS	3%	CZECH REP.	3%	CZECH REP.	3%	UTD KINGDOM	3%
CZECH REP.	3%	SPAIN	3%	SPAIN	3%	POLAND	3%
SPAIN	2%	NETHERLANDS	2%	RUSSIA	2%	SLOVAKIA	3%
	75%		**75%**		**70%**		**68%**

source: Eurostat, author's calculations

As Wolfmayr (2004) clarifies, such a shift in the trade pattern is caused also by an increased demand for the new EU member states and the strong position of Austrian firms, as revealed by their high market shares especially in the neighbouring countries. Stankovsky and Wolfmayr (2003) argue as well that in order to take a better advantage of the opportunities offered to Austrian exporters, it would be desirable to aim at diversifying export by expanding into dynamic countries outside the traditional markets. On the basis of an econometric analysis the authors determined Hungary, the Czech Republic, Slovakia, and Russia to be the key potential countries due to their best opportunities for growth in export.

3 EMPIRICAL FRAMEWORK

In this part, we analyse and estimate the impact of a variety of determinants on Austrian international trade on the basis of the GM of trade pattern. We employ fixed effects (FE) and random effects (RE) estimation methods and prefer one of them according to the Hausman test. The technique is applied to a real dataset of Austrian international trade over the past 17 years. In this chapter, we present exact data and variables description together with the methodology and model specification. The subsequent chapter contains the tests and estimation results we've obtained.

This research has drawn a lot of insights from the seminal paper of Egger (2002) where it was proven that traditional techniques of GM estimation suffer of under-identification (i.e. of omitted variables problem) and, as a consequence, of biased estimation by traditional techniques. In contrast to most papers mentioned in Chapter 1, this paper employs the gravity modelling somewhat differently. A data panel usually contains bilateral trade data of all participating countries, i.e., there is no home country, and exports in country *i* automatically represent imports in country *j*. The estimated function is then a general foreign trade function valid for all countries involved. Unfortunately, this implies that such data sets are composed of various groups of countries whose behaviour is not homogenous. Mixing of subpopulations of data, whose reaction to stimuli of the exogenous variables is not compatible, results in non-stationarity in their behavioural processes and thus in the bias criticised by Egger (2002) and Fidrmuc (2009). This is a common error when working with panel data where the presence of time-series effects and cross-section effects is not tested for their relevance and incongruence. A similar problem arises when the matrix of bilateral trade flows ignores the incompatible exporter and importer effects by estimating them together. The bias is even augmented when the two-way error components model of estimation is applied (Egger, 2002, p. 307).

We focus solely on Austrian exports in this paper. The estimated function will be thus an export function valid for Austria in particular. We consider such an approach more concrete and realistic, and less misleading in the interpretation. Instead of finding a "general truth" and common factors pertinent to all exports of 211 countries,[8] we attempt to determine the pertinent impacts on the geographic flows of Austrian export alone. Austrian import function estimation, which should be approached differently, is left for further research. That allows us to concentrate in more detail on behavioural patterns pertinent to one country (the target of our analysis). The explanatory power of our model then increased substantially, revealing also a range of factors specific to Austria.

[8] Instead of working with an export matrix 211 * 211 countries observed for 17 years (i.e. with 756,857 potential observations of exports only), we estimated 3,396 observations pertinent exclusively to Austria. Considering that each export figure was related originally to 22 "explanatory" variables, the model required to collect altogether 78,108 numbers.

3.1 Data Issues

Our dataset consists of a real data panel from the period 1995-2011 for 211 observed countries. Some countries of the world had to be dropped from the sample due to poor data availability. Among these omitted countries are, for example, Vatican, Monte Negro, Norfolk Island, French Guyana, Pitcairn, etc. The dataset yields all together 3,396 complete observations instead of 3,587 observations offered by the Eurostat.

Our core variables in the model are the Austrian exported nominal values as a dependent variable together with the reporter's and partner's GDPs at purchasing power standards (PPS), and their bilateral distance from countries commercial centres as regressors. The model is further extended by other variables related to transaction costs (landlocked, contiguity, and barriers to trade), indices of institutional "distance" (government effectiveness, trade freedom, corruption, etc.), economic resistance variables (such as relative REER[9] index, common currency and recession dummy), and, last but not least, by a cultural "distance" proxied by common language and common political history dummies. The complete list of our variables is presented in Table **2** below.

Original data for the partners' GDP at PPS were valued in American dollars. In order to obtain relevant elasticity results compatible with exports quoted in the home currency of Austria (i.e. Euro), the values were recalculated by annual average USD-EUR exchange rate. Such GDPs are neutral to their overvaluation or undervaluation due to the local exchange rate changes – we are interested in impacts of the real domestic purchasing power and its economic growth in time on trade. At both GDP variables we expect a positive sign; the bigger the country's economy, the higher its foreign trade.

One of the shortcomings of GMs is that their applications disregard the factor of relative prices at home and abroad (expressed in common currency) that is related to the concept of "trade competitiveness" (Baldwin and Taglioni, 2006, p. 3). In fact, it is the real exchange rate change, which quantifies a large part of the evolution of competitiveness, which must have an impact on trade dynamics. Thus the competitiveness of Austrian exports varies vis-à-vis the changing REER of euro in Austria and the REER of the partner´s country. For example, importers are able to purchase more from Austria if their local currency appreciates and if euro depreciates (both in real effective exchange rates). Our indices of relative REER are defined as $RREER_t = REER_t^{partner} / REER_t^{Austria}$, where t are years and the indices of REER (whose base year of 2005 was set to unity) greater than 1 indicate

[9] REER is the acronyme for the real effective exchange rate, which quantifies how the partner´s effective exchange rate depreciated (or appreciated) relative to Euro, as the home currency of Austria. REER reported by the World Bank for most countries is the nominal effective exchange rate (a measure of the value of a domestic currency against a weighted average of several foreign currencies) divided by an index of relative domestic and foreign prices. Thus the REER for Austria is not related to Euro in all Eurozone countries as a weighted average but specifically to Austria alone.

depreciation. Some countries, however, were not in the World Bank's list. Their indices were therefore estimated on the basis of ERDI (exchange rate deviation index) provided by IMF, whose evolution was normalised to year 2005 (=100). Assuming that the Marshall-Lerner condition for Austrian trade is satisfied in the vast majority of its exports, the coefficient for relative REER is expected to be negative, as Austrian exports respond to amalgamated effects in both exchange rates.

Table 2: List of variables

	VALUES	UNIT	SOURCE
log(export) as dependent (explained) variable		EUR	Eurostat
1. log(GDP) partner at PPS		mil. EUR	IMF
2. log(GDP) Austria at PPS		mil. EUR	IMF
3. log(distance)		km	CPII
4. relative real effective exchange rate (R REER)	2005 = 100	per cent	World Bank, IMF
5. common language	0/1	dummy	CPII
6. common border	0/1	dummy	CPII
7. common political history (empire)	0/1	dummy	CPII
8. direct sea access (landlockness)	0/1	dummy	CPII
9. recession	0/1	dummy	own estimation
10. common currency (euro)	0/1	dummy	own estimation
11. trade barriers	0/1	dummy	own estimation
12. government effectiveness	0-100	per cent	World Bank
13. trade freedom (no discrimination of imports)	0-100	per cent	Heritage Foundation
14. fiscal prudence (low taxes)	0-100	per cent	Heritage Foundation
15. government prudent spending	0-100	per cent	Heritage Foundation
16. monetary freedom (low inflation, no price controls)	0-100	per cent	Heritage Foundation
17. investment freedom (low bureaucracy)	0-100	per cent	Heritage Foundation
18. financial freedom (private banking efficiency)	0-100	per cent	Heritage Foundation
19. education index	0-100	per cent	United Nations

Distance between two trading countries was calculated on the basis of a weighted formula developed by Head and Mayer (2002) that includes latitude, longitude and population data of main agglomerations in these countries. The distance variable is also taken in logarithms in order to obtain elasticity. We expect a negative relationship here since the distance variable represents a resistance to trade due to shipping, insurance and many other transaction costs correlated with distance.

The common language variable is a dummy variable. It takes the value 1 for German-speaking countries and 0 otherwise. A common border works similarly, i.e., 1 for Austrian neighbours and 0 for the others. Common history of political union ("empire") also takes the value 1 in the case when the partner country used to be a part of the former Austro-Hungarian Empire as well (for instance, the

Czech Republic, Slovakia, Hungary, Croatia, Liechtenstein, Slovenia and partially Poland and Romania fulfil this criterion). For all these dummies, the expected coefficient sign is positive.

Landlocked position of a country is another dummy that takes the value 1 for countries with no sea access, which amounts only to 35 countries in the sample. We expect landlocked countries to have a certain disadvantage since they cannot use fully the cheaper maritime infrastructure. The expected sign is thus negative. Austria's main trading partners are, however, European countries and Austria's neighbours, in particular. From this point of view, Italy and Germany, for example, have no advantage over the Czech Republic or Hungary, even though Italy has a direct access to sea.

By definition, a recession means two consecutive quarters of negative economic growth as measured by a country's gross domestic product.[10] In our dataset, the recession dummy variable takes the value 1 only for 2009 when Austria met the above criteria. There are countries that did not meet the official recession criterion in 2009 or countries with a decline in GDP in two successive quarters other than in 2009. Nevertheless, this variable simply stands for recession in Austria measured by Austrian GDP decline. The expected sign for recession is obviously negative.

Euro variable is again a dummy that takes the value 1 for a member country of European monetary union and 0 otherwise. The initial year for the EMU-founding members is set to 1999 due to the fact that their currencies have since been pegged to each other, euro was used as an account unit and the foreign exchange risk was thereby minimised. The expected sign is positive.[11] Trade barriers variable is a dummy that takes the value 0 for European Economic Area members, customs unions, and free trade areas, and 1 otherwise. We expect a negative sign as its coefficient.

The last 8 variables in our dataset represent various institutional factors. The role of institutions in explaining the behaviour of agents increased dramatically in the last 25 years as the neo-institutional economics revealed their importance for the study of decision-making related in particular to international transactions (see Seyoum, 2011; Alfaro, Kalemli-Ozcan & Volosovych, 2008; and Benáček et al., 2013). The information about the quality of institutions is measured in percentages – the closer to 100%, the better is the institution from the point of free market efficiency. One could probably expect correlation between some of these indices. A possible multicollinearity is tested further on. In practice, we found out that all the institutional variables have never been significant all

[10] See http://www.imf.org/external/pubs/ft/fandd/basics/recess.htm. This definition has been broadly used since 1974, when J. Shiskin used this determination for The New York Times.

[11] Nevertheless, there is a controversy in such claims. The original estimations of highly positive impact of euro on trade (Rose, 2000) were found to be false in many studies and the conclusions are indecisive (see Havránek, 2010).

at once, and for that reason only some of them were included in the final model. All their expected signs are expected to be positive.

3.2 Model Specification

We will employ the log-log version of the GM, which is based on panel data and their standardised more recent specifications (see e.g. Baldwin and Taglioni, 2006, or Rose, 2000). Following the extensions proposed by Seyoum (2011), in order to get elasticity coefficients the core variables in cardinal scale are specified in a natural logarithmic form, and the rest is left linear. The model is designed as follows (see Table 2 for interpretation):

$$\log(export_{jt}) = \beta_0 + \beta_1 \log(gdp\_part_{jt}) + \beta_2 \log(gdp\_at_t) + \beta_3 \log(dist_j) + \beta_4 rreer_{jt} + \\ + \beta_5 lang_j + \beta_6 cont_j + \beta_7 empire_j + \beta_8 landlock_j + \beta_9 reces_t + \beta_{10} euro_{jt} + \\ + \beta_{11} barrier_{jt} + \beta_{11} gov\_eff_{jt} + \beta_{13} trade_{jt} + \beta_{14} fiscal_{jt} + \beta_{15} gov\_spend_{jt} + \\ + \beta_{16} monet_{jt} + \beta_{17} invest_{jt} + \beta_{18} finance_{jt} + \beta_{19} educ_{jt} + \varepsilon_{jt} \qquad (3.1)$$

$j = 1,\ldots, 211$ stands for the partner country $\qquad t = 1995,\ldots, 2011$ represents time (years)

The data structure in estimating panels matters greatly. The issue is not only which variables (dummies) have to be left out while estimating the model by fixed effects (FE). More complicated issue arises when the economic meaning of coefficients changes depends on the way of estimation. Different data structure influences also the logic behind the fixed effects a_t *or* a_j, respectively, and their possible correlation with our units of interest (i.e. by the segments ordered by countries or the segments ordered by years).[12] For example, under the cross-sectional data structure we have 17 different segments of observation, each containing observations related to 211 countries in given year. The fixed effects a_t allow for a different intercept under each cross-section but one, i.e., for each year of t=1995 through 2010. One could reasonably expect that random effects (RE) estimator would be the more fitting one since this fixed effect is most probably expected to be randomly distributed across the observed period. In this case the exporters respond to trade-offs discriminating between countries in given time. However, under the time-series data structure, we have observed 211 different countries over the given period. That is a different problem in decision-making: how much to expand exports to given country in time. The fixed effect a_i thus allows for a different intercept for each time series, i.e., a country. Therefore, FE estimator makes more sense because one could expect that each country has its own propensity to trade. We test this hypothesis by the Hausman specification test.

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[12] For more information please see Benáček et al., 2013, p. 12, Fig. 1.

4 RESULTS

In the last chapter, we present all our econometric results and comment on the coefficients, their signs and significance. STATA was used as computer software. Before any econometric estimation technique is applied, one should test for its assumptions and correct any possible inadequacies to prevent problems in the estimation (such as type of bias in coefficients, inconsistency, inefficiency, or bias in the standard errors and thus over/underestimation of coefficient significance), as carried out in the first part of this chapter. Once the problems are corrected more credible results are gained.

4.1 Statistical Assumptions Violation Tests

First assumption to be tested is the rejection of **multicollinearity** in data. We can test this by simply generating the covariance matrix. The highest values were obtained for distance and trade barriers (0.77), financial freedom and investment freedom (0.75), and property rights and business freedom (0.74). Such values are not close enough to one and thus we do not assume multicollinearity to be a problem. Moreover, according to the VIF test for multicollinearity, our dataset does not suffer from this assumption violation either.

Additional tests were applied in order to test for **homoscedasticity in residuals**. The results of Cook-Weisberg, White's, Likelihood-ratio, Breusch-Pagan and Cameron-Trivedi's decomposition of IM-tests are presented in Table 3. Each of them rejects the null hypothesis of homoscedasticity at any confidence level. A possible solution is Huber-White's method (with robust standard errors) that corrects for the bias in standard errors. For example, Babecká-Kucharčuková et al. (2010) use this approach. We employ robust standard errors in our empirical model as well.

Table 3: Tests for heteroscedasticity

	χ^2statistic	p-value	
Cook-Weisberg test	1554.09	**0.0000**	
White's test	1195.01	**0.0000**	
Likelihood-ratio test	40.19	**0,0004**	
Breusch-Pagan test (manually)	373.54	**1.257e-69**	
Cameron & Trivedi's decomposition of IM-test	1195.01	0.0000	Heteroscedasticity
	63.2	0.0000	Skewness
	31.34	0.0000	Kurtosis
	1289.55	**0.0000**	**Total**

Source: authors' estimation

In order to obtain BLUE estimates, we need our idiosyncratic errors to be **serially uncorrelated**. We applied first-order autocorrelation test with no need for strict exogeneity. The p-value adds up to 0.175 and thus the null hypothesis even on 15% level of significance cannot be rejected. Wooldridge test for autocorrelation in panel data yields positive results as well, i.e., p-value 0.1453. Therefore, we do not consider our estimates to suffer from significant serial correlation in error terms.

The fact that our residuals are not **distributed normally** is indicated by skewness and kurtosis test for normality (joint p-value 0.000) and Shapiro-Wilk W test for normal data (p-value 0.000). These tests both strongly reject the null hypothesis of normally distributed error terms. Still, we do not consider such abnormality to be a major problem, as statistical inference is consistent for large N and small T, which our dataset fulfils. The approximation should work well here.

4.2 Results – Cross-Sectional Data Structure

Table 4: Cross-sectional data structure results – random effects estimator

Number of obs.	=	3396	R-squared:	within	=	0.8584
Number of groups	=	17		between	=	0.7897
Wald chi2(14)	=	833356		overall	=	0.8574
Prob > F	=	0.0000		lambda	=	0

log (export)	**coefficient**	**std. err.**	**p-value**	**[95% confidence interval]**	
log (GDP partner)	**.9566484**	.0176223	0.000	.9221094	.9911874
log (GDP Austria)	**.647622**	.3721523	0.082	-.0817831	1.377027
log (distance)	**-1.147782**	.0212737	0.000	-1.189478	-1.106087
REER	**-.0024624**	.0008121	0.002	-.004054	-.0008707
language	**.2049925**	.0159723	0.000	.1736874	.2362975
contiguity	**.6415977**	.0517715	0.000	.5401275	.7430679
empire	**.5708715**	.0395802	0.000	.4932957	.6484474
landlockness	**-.2580011**	.0389479	0.000	-.3343376	-.1816645
euro	**-.1039744**	.0483558	0.032	-.1987501	-.0091988
gov. effectiveness	**.0047387**	.0010756	0.000	.0026306	.0068468
fiscal policy	**.0084249**	.001014	0.000	.0064375	.0104123
gov. spending	**.0087702**	.0013969	0.000	.0060324	.011508
monetary policy	**-.0111246**	.0019078	0.000	-.0148637	-.0073854
education	**.0140502**	.0030146	0.000	.0081417	.0199587
intercept	**7.493431**	4.437874	0.091	-1.204642	16.1915

Source: authors' estimations

From the Hausman test application, we have obtained the p-value 0.6363. Consequently, RE estimator is preferable due to its consistency and a greater asymptotical efficiency. This result is in line with the expected nature of fixed effect term, as explained before. Our final estimates with robust standard errors are displayed in Table 4. The results seem to be quite convincing with within R^2 85.8%, joint p-value 0.0000 and mostly significant variables. Due to the robust standard errors we are convinced of correctness of the following statistical inference. Further, one should note the extreme value of λ-parameter. The RE estimates are identical to pooled OLS for $\lambda \cong 0$.

Both partner's and domestic GDP have a positive impact on bilateral trade, as expected. To be specific, the partner's and home-country GDP elasticities are 0.96 (export demand pull) and 0.65 (export supply push – though at 10% confidence level only), respectively. Both GDPs are thus important determinants of bilateral trade as illustrated by the forces behind the phenomenon, i.e., the growth of international trade in developed countries being traditionally higher than the growth in their GDP. Actually, the coefficient of 0.96 implies that its income elasticity for import absorption abroad is close to unity and that the distribution of exports among countries is proportional to their relative size, ceteris paribus. In addition, there is also a domestic supply-push effect that increases the volume of Austrian exports subject to the evolution of its own GDP. Its elasticity of 0.65 and lower significance signal a less intensive impact. These results suggest that in answering the question of where to export from Austria in a given time. Considering that this is not a dynamic decision-making in time but a static decision-making in space: the fixed total volume of exports is located abroad proportionally to the size of partners' GDP at purchasing power parity, which represents the foreign demand-pull.

However, as the other significant coefficients in our equation signal, the combined effects of countries' sizes must be adjusted to the effects of other determining factors of trade. For example, distance has a significant negative impact on Austrian exports. According to the model, there is a relatively high negative elasticity of 1.15. Language, contiguity and a common political history all play an exceptionally important role in Austrian exports. If these dummy variables take the value 1, exports from Austria grow by 22%, 90%, and 77%, respectively.[13] We can infer that Central Europe ("Mitteleuropa") retained its socio-economic ties notwithstanding the changes to the opposite direction in the period 1918-1989.

Higher relative REER of a partner country (i.e. a real appreciation of Austrian euro relative to the currency of the partner) influences Austrian exports in a negative way. Since it is significant at 1%, we conclude that a rise of this indicator by 10% results in a decrease in exports by 2.5% only. The low elasticity of this coefficient is not so much unexpected.[14] We should be aware that the one year sequence of observations is not sufficiently long enough for estimating the medium-run elasticity of exchange rate changes. The most important effects of the partner's currency depreciation of its imports occur with a delay of some 1-3 years, as described by the so-called J-curve impacts of depreciation.

[13] This is after the anti-log correction for the log-level model because these coefficients are elasticities related to the log(exports) and not directly to exports. This is only in the case when the coefficient β pertains to an explanatory variable x that is not in logarithmic form because it is measured either as a dummy <0, 1> or directly in percentages. The formula is as follows:
$\%\Delta y = 100 \cdot \left[\exp\left(\hat{\beta} \cdot \Delta x\right) - 1\right]$, see Wooldridge (2003).

[14] This can be compared with the estimates of Thorbecke and Kato (2012) who concluded that a 10% real appreciation would reduce German exports in medium run by 6%, even though they confirmed that exports of non-consumption goods are also converging to the levels of inelasticity we observed.

The association of Austria with Eurozone had (according to our model) a negative effect on the bilateral trade of Austria. I.e., the adoption of euro signals a decrease in exports to Eurozone countries by almost 10% (with other conditions unchanged), which is a finding compatible with results of some more recent studies (e.g. Dorn and Egger, 2013, or Havránek, 2010). This is probably connected to the tendency to exports' diversion in the direction of the eastern countries, as discussed in Chapter 2, and problems with euro during world and European financial crisis of 2007-2011.

Although some institutional and policy indices were insignificant (e.g. the trade freedom) and, for that reason, omitted, there remained still many of them that had an important effect on Austrian exports. For example, an increase in government effectiveness at a partner country by 10 percentage points was associated with a rise in exports to that country by 4.7%. Even higher elasticities of exports were found for such factors as prudent fiscal policy and government spending. A crucial place among the institutional (policy) factors is related to a high quality of education in destination countries. Austria, indeed, is an exporter of high quality products, which are penetrate easier to such advanced countries.

4.3 Results – Time-Series Data Structure

In contrast to the cross-sectional analysis, the time-series one-way estimations point to another decision-making problem of exporters and their importing partners, i.e., to the question of dynamic developments in trade expansion. Although this is a task complementary to the previous short-term geographic decision-making, these results point to the factors that decide about the growth of trade in a long time span.

The final estimates under time-series data structure are presented in Table 5. The method used here, in contrast to the previous estimation, is the FE estimator, which was underpinned by the Hausman test and its p-value 0.000. Consequently, the FE estimator should be consistent but the RE one is not. Employing FE estimation is again in line with our previous explanation, since each partner country might have its own propensity to trade. When estimating a one-way panel and applying it on time-series data structure there arises a conflict with explanatory variables that are invariable in time, such as distance, language, contiguity, past political union, and landlocked position. Their values acquire the role of dummies that are then perfectly collinear with auxiliary time dummies used by the FE estimator. Therefore they had to be omitted from the model. There is also another reason for that since it would be rather difficult to interpret the results of a model full of sluggish data. For example, how the growth of exports from Austria to its 211 partners would depend on distance, once that distance is constant in time.[15] Thus in this estimation we will work with a reduced specification of the GM where the distance variable is dropped. This is a standard approach when the stress is on the long-run export development strategies, as it was explained by Fidrmuc (2009, section 4). We should once again remind that our two different specifications addressed two different decision-making problems (a static country trade-off "to whom" versus the country dynamics of "how much"). Fixed effects and random effects proved each to be exclusive instruments for explaining just one of these problems.

Table 5: Time-series data structure results – fixed effects estimator

Number of obs.	=	3396	R-squared:	within	=	0.2418
Number of groups	=	211		between	=	0.7569
F(11, 3174)	=	94.86		overall	=	0.7058
Prob > F	=	0.00000		corr (u_i, xb)	=	0.6583

log (export)	**coefficient**	**std. err.**	**p-value**	**[95% confidence interval]**	
log (GDP partner)	**.5464392**	.0772425	0.000	.3941691	.6987093
log (GDP Austria)	**1.456824**	.2527946	0.000	.9584836	1.955164
recession	.0379119	.0521805	0.468	-.0649529	.0024462
euro	**-.1524546**	.0719972	0.035	-.2943846	.1407766
trade barriers	**-.1701384**	.0875475	0.053	-.3427229	-.0105247
REER	.0001344	.0005822	0.818	-.0010134	.0012821
trade freedom	**.0078478**	.0028133	0.006	.0023019	.0133938
gov. effectiveness	-.000218	.00298	0.942	-.0060925	.0056565
finance	-.0005103	.0020351	0.802	-.0045221	.0035016
education	-.0099629	.0073866	0.179	-.0245243	.0045986
intercept	**-6.474878**	2.647331	0.015	-11.69363	-1.256128

Source: authors' estimations

Our results presented in Table 5 are not that rich in significance as those under cross-sectional data structure by the RE estimator (see Table 4). This can be only partially explained by the adoption of the FE estimator that automatically excludes all variables constant in time. It is one of our main findings that institutions and policies are very important for explaining the previous problem of "where to export in given time". The model based on cross-section panel data pointed that Austrian exporters indeed discriminated between partners on grounds of real exchange rage, euro and five other

[15] Of course, we could presume that distance or common language could be factors, which decide implicitly (e.g. vis-à-vis the opportunity costs in other countries, about the growth of trade in that particular country in time. That would require applying a more sophisticated model than simple fixed effects for such a test. For example, the random effects model could do such a service since it is not sensitive to time-invariant data by assuming that explanatory variables are uncorrelated with random effects. However, in this case the RE model was rejected as a suitable instrument, which confirms indirectly that time invariant variables were not statistically appropriate factors for explaining trade dynamics.

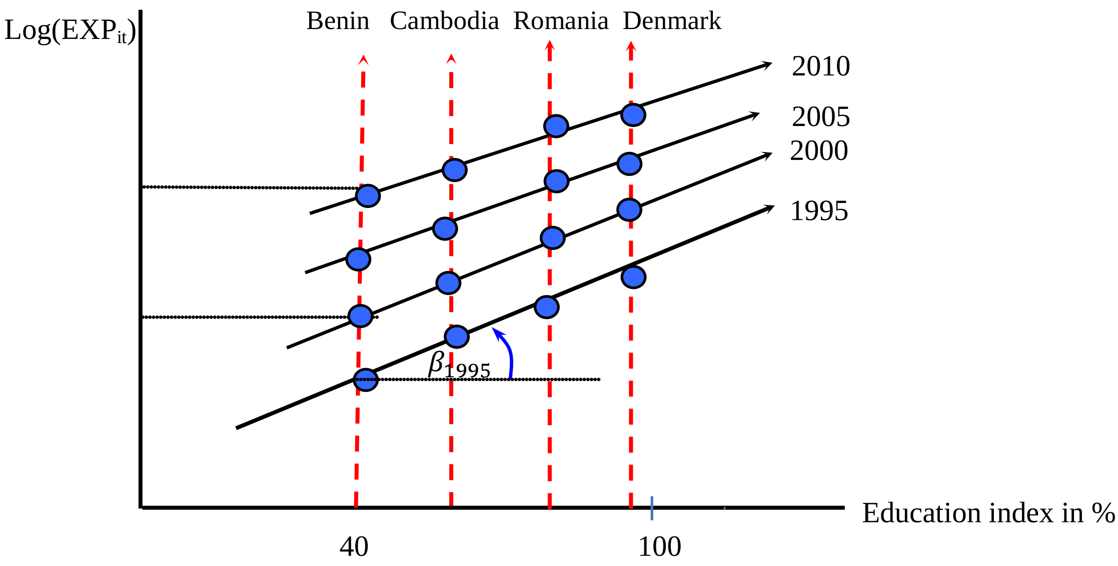
institutions. Now the latter shrank to one single statistically important institution. In another words, the long-run dynamics of trade are much less dependent on institutional and policy factors than short-term decisions.

Nonetheless, the model seems to perform well. Overall R^2 yields 70.6% with the model joint p-value of 0.0000. Both GDP variables remained very significant as well with the positive impact of 0.55% and 1.46% growth in export per 1% growth in GDP, respectively. Evidence that domestic GDP growth is more sensitive to the dynamics of trade growth than the GDP growth in the partner country is a finding of strategic importance revealing that the role of GDPs in the static and dynamic decision-making may differ. The success (or failure) of Austrian export growth has been intertwined primarily with domestic economic factors (i.e. the domestic GDP). Austria, as one of the most successful European countries in economic development, was not only pulled by exports but it was also systematically pushing exports.

Neither government efficiency, nor any other institutional indices such as finance or education are significant in this estimation, except for trade whose obtained p-value yielded 0.006. An increase in trade freedom index by 10 percentage points should then mean an increase in Austrian exports on average by 8.1%. Thus, unlike the previous cross-sectional data structure, it makes a difference whether a partner country improves its trade freedom over time or not. The sign of the education variable is statistically insignificant. It is not a paradox but an explanation that long-run dynamics of Austrian exports did not discriminate among countries according to education, government effectiveness or private banking. Relative real effective exchange rate did not seem to play any important role in time series structure either.

Sharing of the euro currency with the partner's country affects the bilateral trade again negatively. Though it seems counter-intuitive, our results refute the hypothesis that euro was a significant driver of trade. To the contrary, it helped divert Austrian exports outside of Eurozone. This is in line with meta-analysis of the Rose effect in the Eurozone, performed by Havránek (2010), who found the euro's trade promoting effect insignificant.

Figure 1: Estimation of the panel data by cross-section versus by time-series specifications (illustration of an asymmetry when the explanatory variable is highly time-invariant and thus is statistically insignificant)



Quite interestingly, the results of this model, the coefficients, their signs, and significances were quite similar when the RE estimator was employed. GDPs thus turned out to be the key variables (together with the distance that is also significant in the RE model) under time-series data structure. However, other invariant institutional indices (such as language, landlocked or empire variables) lost at their significance even in the RE model. How is this possible? As already explained, our two data structures address different decision-making problems. The significance of institutional variables in the former model, which is refuted in the latter model, should basically mean that in particular years Austria did distribute exports among its trade partners according to their institutional quality, but in the long-run these very institutions were not considered a sufficient reason for further expansion of trade. For example, if we take Denmark and Benin (as two institutionally different trade partners) where the former (due to its higher education relative to Benin) was in each year preferred in solving the problem “where to export”), these very institutional differences (and their changes) did not play any role in deciding that trade with Benin will grow at a faster rate than the trade with Denmark (ceteris paribus). Figure 1 illustrates such a situation by using stylized facts.

The panel data in Figure 1 consists of four countries – hosts of German exports observed in four years. Meanwhile the one-way panel dummies in the FE estimation set across years lead to a positive statistically significant coefficient β related to the variable of education (solving the problem of “where to invest” by the fit depicted by black arrows), a similar one-way panel specification based on countries leads to results that are statistically insignificant. That is shown by the statistically insignificant fits depicted by intermittent red arrows.

CONCLUSION

The aim of this paper was to analyse determinants of Austrian export of goods and services and to estimate the Austria's export function. The analysis was based on the gravity model of trade in a partial log-log form, augmented by additional variables in order to control for the impact of less frecuently used economic, geografic, institutional and policy factors on decision-making. Austrian exports are very closely dependant on the German and central European markets and the model proved this to be natural. However, remaining Austrian exports are diversified among many smaller trade partners whose importance has been gradually shifting eastwards. Such a shift in the trade pattern is attributed to several factors. First, the eastern enlargement of the EU simplified the trade with the New Member States. Second, nearly all post-communist economies have been catching-up in the quality and volumes of exports with the western world. They grew dynamically until 2008 and their import absorption recovered faster from the shocks of financial crisis than the advanced economies.

When estimating the export function, we take advantage of the panel data structure and estimate the gravity equation as two alternative one-way estimators, i.e., as 17 segments of cross-sections and 211 segments of time series. That allows us to estimate factors related to two complementary questions: "where to export in given time" (indicating the choice of a country in space); and "how much to expand exports" (indicating the dynamics of trade in time). The estimations were done by random effects and fixed effects, respectively.

What concerns our first question, the distribution of Austrian exports among countries depends primarily on the volume of partners' demand (domestic GDP) where the elasticity is close to unity. In addition, there is an auxiliary and less intensive domestic supply-push effect that increases the volume of Austrian exports subject to the evolution of its GDP. Furthermore, the inverse relationship between distance and trade flows is slightly more elastic than unity (-1.15), which impedes exports to very remote countries up to approximately 20-fold. Other important determinants seem to be a common language, contiguity and past history of political union with the effect of growth in exports by 22%, 90%, and 77%, respectively. A real effective exchange rate has had, as expected, a negative impact of rather low elasticity, since higher values of REER (i.e. the real depreciation abroad) represent loss in purchasing power in terms of imports. The cross-section specification of estimates points also to a highly significant importance of many institutional and policy-oriented factors, which promote or impede exports.

What concerns the answers to the question about factors of export expansion, the importance of both GDP variables was reversed: it became the evolution of Austrian domestic aggregate supply which dominated that strategy, while foreign aggregate demand assisted as subsidiary. The evidence that domestic GDP growth is more sensitive to the dynamics of trade than the GDP growth in the partner country is a finding of strategic importance, revealing that the roles of GDPs in the static (short-term) and dynamic (long-term) decision-making differ. In addition, diversification of Austrian exports outside the Eurozone causes the variable of Euro to act as a catalyst promoting such a step, which is a paradox since it was presumed that ensuing higher currency risks and transaction costs should act in an opposite direction.

The loss in significance at most of the institutional variables in the second model should basically mean that while in particular years Austrian exporters kept distributing exports among their trade partners according to the quality of institutions abroad, the decision-making about the trade dynamics was free from such concerns and became nearly exclusively dependent on the evolution of economic factors at home and abroad. Our innovative approach to the estimation of gravity models helped us unveil new views on the factors of trade growth applied on Austrian exports.

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