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ON THE ROLE OF EXPORTS FOR ECONOMIC GROWTH AT A GLOBAL LEVEL THROUGH A LMM APPROACH

Abstract. *At a theoretical level, exports benefit a country'seconomy through contributing to aggregate demand and through positive externalities such as knowledge spillovers and economies of scale. In this research, we take a global approach and investigate the impact of a country's exports importance at a macroeconomic level for its economic growth through the* Linear mixed-effects *method*(*LMM). We include 186 countries in our analysis and find that generally there is statistically significant evidence that the level of aggregate exports affects economic growth, but this relationship is both time and country specific. Thus, although countries that employ policies to encourage exports experience higher economic growth, on average, this positive relationship is stronger in some countries than in others, and even absent or negative in some instances. For a more thorough analysis, we also identify the group of developed G7 countries and that of developing CEE economies and estimate the relationship in comparative perspective. Results confirm that the positive impact of exports on growth is generally higher for CEE countries, for which exports seem to be the main factor to exert a positive influence on growth as opposed to the developed G7 economies, which seem to depend more on investments for growth.*

Keywords. *Exports, economic growth, mixed model.*

JEL Classification: E60, F40, C10

1.Introduction and related literature

The study of international trade effects on economic growth dates back to the year 1776, when Adam Smith initiated a series of studies, their main goal being the relationship between trade and economic growth. After the Second World War,

through protectionism policies, and also because of the ideology of autarkic development, matters (approaches) began to change, and in the '70s, because of the failure of the aforementioned actions, the international trade has been finally regarded as a true engine (determinant) of economic growth. Thus, a plethora of theoretical studies and empirical applications have appeared which treated international trade as a fundamental explanatory variable of economic growth. All these studies are based on: improved resource allocation, according to the competitive advantages; a stimulation of technological development due to an increasingly competitive environment; an increase in new jobs compared to development strategies strictly based on the internal (domestic) market.

The role of international trade in economic growth represents an important topic in economics science. Therefore, given the theme's importance, we can identify two main doctrinal approaches: the first one, the particularistic („nationalist") that emphasizes foreign trade's role in the development and growth of national economy. This specifics of this approach, which takes into consideration 20th century's geopolitical structure and economy, are that of the nation-state as the main actor of international politics and national economy and the main entity of the world's economy – economic interdependencies represent connections between national economies, especially through commercial relations. Within this approach there are a couple of theoretical interpretations, expressing specific national interests such as: *the role of exports for economic growth* – this approach is based on multiplier's idea as stated by Keynes (Rochon et al., 2008); the *open economy vs. closed (autarkic) economy thesis* (Palloix, 1969); *the leftist, Marxist perspective* – particularly the foreign trade in centralized economy (Boltho, 1971); *the tiermondist perspective* – the place of developing countries in international trade (Balassa, 1977); (Morrison, 1976); *the perspective of small and medium countries* (Basile, 1972).

The second approach, the „globalist" one, appeared after the nineties and it emphasizes the fact that free marked is (lies) in the center of the globalization process and highlights multinational corporations' role, the liberalization of trade and investments. Among the studied themes there are: the influence of international trade on economic growth in the context of globalization for the largest economies (Dritsakis, 2006); the influence of foreign trade on economic growth in the context of globalization for developing countries. The main research topics are the globalization process and the competitiveness of developing countries (Mejia, 2011); the unequal distribution of the effects (benefits) of being part of the global market (Vos and Ganuza, 2006).

The relation between exports and economic growth is scrutinized both from the theory of international trade perspective as well as from the perspective of economic

growth theory. Regarding the theory of international trade, there are multiple stages in its evolution (Cho et al., 2000; Borbely, 2006):

a) The traditional theory is centered on explaining international specialization through two main components: Ricardo's theory – specialization as a function of productivity levels given by different technologies; the H-O theory that explains specialization by different endowment with inputs. The specialization-based approach introduces the concept of comparative advantage that enjoys a limited explanatory capacity regarding intersectoral and intra-industry trade. The main limit of the traditional, classic theory of international trade is its capacity (or lack thereof) to explain the intra-industry trade.
b) The new theory of international trade has as main aim to explain intra-industry trade using models that take into account the economies of scale, product differentiation and imperfect competition.
   An important component of the new theory is the analysis of multinational companies' influence on international trade flows, with the emphasis on the role of foreign indirect investments.
c) The theory of competitive advantage, elaborated by M. Porter, which changes the perspective from specialization to competitiveness, from comparative advantages determined by national inputs (resources, capital, labour) to competitive advantages created by exploiting national inputs.
d) Spatial approaches that take into account the placement of inputs in a particular economic environment and the way in which this placement influences the possibilities of capitalization of those inputs. Sometimes called „the new new theory" of international trade, this approach includes the theory of growth poles (F. Peroux), gravitational models, cluster-type models and new economic geography type models.

After the 2008 – 2009 crisis, there was much criticism regarding the process of globalization, new developments in the theory of international trade (new theory, new new theory, economic geography) and a recurrence of various particularistic approaches.

A recent study (Ostry, et al, 2016) highlights the negative effects of neoliberalism, a political ideology based on two principles: the first one, increased competition through deregulation and opening of the domestic market; the second principle, privatization and the limiting government's capacity to reach fiscal deficits and accumulate debts. In the paper there are analyzed the complex connections between economic growth and the free movement of capital, the authors showcasing that, if foreign direct investments are an engine of economic development, the same couldn't be said about other financial flows (e.g. short-term speculation, bank flows), the latter

not contributing to increasing wealth, on the contrary they lead to bubbles and crisis. Also, austerity policies are criticized, the authors highlighting that high debt is not necessarily a barrier for economic growth.

Ever since from the start (beginning) the theoretical studies have shown that there is a positive relation between international trade and economic growth. Many studies pointed out mainly to the static effects of international trade on economic growth. For example, in 1984 Baldwin showcased that these static effects have a limited significance. New models were developed, for instance endogenous growth models, which constituted a premise for future research.

Lately, the relationship between exports and economic growth has been the subject of many studies based on simple correlation analysis, multi-country qualitative studies – there are analyzed protectionist policies vs. free trade (Balassa, 1971), robust studies sensitivity analyses, cross-country regressions analysis – it is studied the relation between export increase and economic performance (Ballasa, 1985), simultaneous equations „channels" models.

To conclude, there are three periods dedicated to studying the relation between exports and economic growth, during the first period (between 1930 and 1960) there has been the *theoretical foundation* – the Keynesian theory regarding the concept of multiplier in order to explain the different connection in the framework of macroeconomic demand; the *concrete approach* (1970 – 1990) from the three perspectives; the *globalist approach* after 1990.

Data

We employ annual values for GDP per capita and Exports as a percentage of GDP for 186 countries for a 65 years period running from 1950 to 2015. The total number of observations is different among countries, depending on the starting year for data collection. Overall, the database consists in 7626 annual observations for each indicator for the 186 individual countries. The source of data is World Development Indicators (WDI) of the World Bank.

Table 1 defines the indicators employed in the current study and presents their respective WDI codes employed for data collection.

Table 1. Data definition and coding

Indicator	*Definition*	*WDI Code*
GDP per capita (constant 2005	GDP per capita is gross domestic product divided by midyear population. GDP is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated	NY. GDP .PCA P.K

US$)	without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. Data are in constant 2005 U.S. dollars.	D
Exports of goods and services (% of GDP)	Exports of goods and services represent the value of all goods and other market services provided to the rest of the world. They include the value of merchandise, freight, insurance, transport, travel, royalties, license fees, and other services, such as communication, construction, financial, information, business, personal, and government services. They exclude compensation of employees and investment income (formerly called factor services) and transfer payments.	NE.EXP.GNFS.ZS

Studying the relationship between the level of exports and economic growth as given by the most recent observations (generally for year 2014) for the full sample of 186 countries, we notice that among countries in top right corner (i.e. those that present high values for both the importance of exports in GDP and for GDP growth) we encounter Luxembourg, Singapore, Hong Kong, Macao, Netherlands, Belgium, United Arab Emirates etc. At the opposite end (i.e. low exports' level in the overall economy and low economic growth) we find Burundi, Afghanistan, Central African Republic etc. Next, we subset the data sample and subtract two groups of countries: G7 economies and 13 smaller Central and Eastern European economies. Table 2 presents the two sub-samples used in subsequent quantitative investigations.

Table 2. G7 and CEE countries

	G7	*CEE*
Members	Germany France Italy Japan United Kingdom United States Canada	Bulgaria Hungary Poland Romania Albania Bosnia and Herzegovina Croatia Czech Republic Moldova Serbia Slovak Republic Slovenia

Figures 1 through 2 present a time evolution for the two variables of interest (GDP per capita and the importance of exports in the economy) for the two sub-samples of countries, i.e. the developed G7 economies and the developing or frontier

economies in the Central and Eastern European area. We detect both a higher GDP per capita and a smaller weight of exports in the overall economy for the G7 countries and this difference has been present throughout the decades.Among the G7 group, US has the highest GDP per capita throughout the analysis period, with a level of 46405.25 USD in 2014 and Italy the lowest, with 28707.24 USD in 2014. For the CEE group, the highest GDP per capita (19172.41 USD) is reported for Slovenia in 2014, while the lowest in encountered in Moldova, equal to 1190.7 USD in 2014. The weight of exports in the economy is generally higher for the CEE economies than for G7. Its level varies in 2014 between a maximum level of 45.72% in Germany and a minimum level of 13.44 % for the United States in the case of G7 countries. For the CEE economies, the percentage varies between the maximum level of 91.85% for the Slovak Republic and a minimum of 28.24% in the case of Albania.

a b

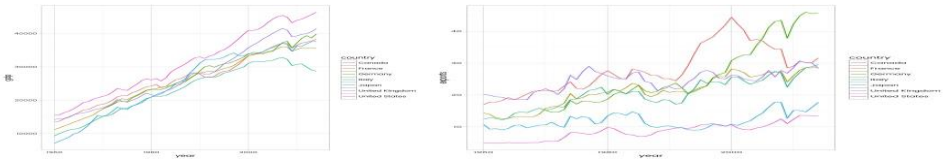


Figure 1. GDP per capita (USD) -a and the importance of exports in the economy (%) -b, G7 countries, 1960-2014

a b

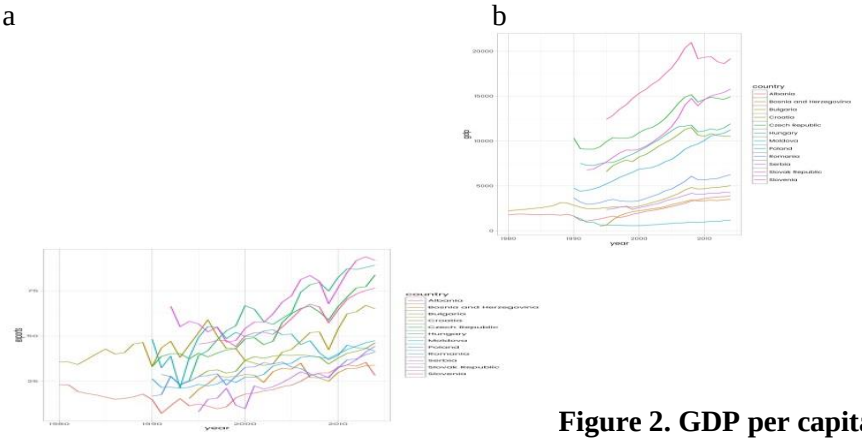


Figure 2. GDP per capita (USD)–a and the importance of exports in the economy (%) -b, CEE countries, 1960-2014

Finally, Table 3 presents descriptive statistics for the full data sample (all countries, whole period), showing that the lowest level for the importance of exports in the economy (0.005%) through the 1960-2014 period has been encountered in the case of Iraq in 1995, as the country was subject to economic sanctions which were imposed in August 1990 and severely deteriorated living conditions in the country, and the highest level (over 230%) for Singapore in 2008. For GDP per capita the lowest level has been registered in China (83.33 USD) in 1962 and the highest (87772.69 USD) in Luxembourg in 2007.

Table 3. Descriptive statistics

	Exports (% of GDP)	GDP per capita
nbr.val	7626.00	7626.00
nbr.null	0.00	0.00
nbr.na	0.00	0.00
min	0.01	83.33
max	230.27	87772.69
range	230.26	87689.35
sum	273782.50	62382940.00
median	29.44	2566.06
mean	35.90	8180.30
SE.mean	0.30	140.39
CI.mean	0.59	275.20
var	688.50	150303700.00
std.dev	26.24	12259.84
coef.var	0.73	1.50

Method

Further, we employ the LMM method to investigate if the importance of exports in the overall economy of a country impacts its economic growth. We are interested in the direction of impact, the power of impact and also the variability in time and across countries of this relationship.

In a Linear mixed-effects model (LMM) an outcome variable is contributed to by additive fixed and random effects. Thus, the response vector $\mathcal{Y}$ is taken conditionally on the random effects and is modeled as the sum of a fixed effects term X and a random effects term, Z as follows:

$$\mathcal{Y} = \underbrace{X\beta}_{Fixed} + \underbrace{Zb}_{Random} + \varepsilon \quad , \tag{1a}$$

where$\mathcal{Y}$ is the *n*-by-1 response vector conditional on b, the random effects vector, n is the dimension of the response vector, *X* is an *n*-by-*p* fixed-effects design matrix and β is a *p*-by-1 fixed-effects vector.

Otherwise put, for i= 1, a Linear mixed-effects model (LMM) can be expressed as:

$$\mathcal{Y}_{ij} = \beta_1 x_{1ij} + \ldots \beta_p x_{pij} + b_{i1} z_{1ij} + \ldots b_{iq} z_{qij} + \varepsilon_{ij} \tag{1b}$$

where:

- $\mathcal{Y}_{ij}$is the value of the response variable for the *j*th of n_i observations in the *i*th of M groups or clusters.
- $\beta 1, \ldots, \beta p$ are the fixed-effect coefficients, which are identical for all groups.
- $x_{1ij},\ldots,x_{pij}$ are the fixed-effect regressors for observation j in group i.
- $b_{i1}, \ldots, b_{iq}$ are random effects for group *i*, assumed to have a multivariate normal distribution. The random effects are different in each group. The b_{ik} are thought of as random variables, not as parameters, and are similar in this respect to the errors ε_{ij}.
- $z_{1ij}, \ldots, z_{qij}$ are the random-effect regressors.
- $\varepsilon_{ij}$is the error for observation *j*in group*i*. The errors for group *i*are assumed to have a multivariate normal distribution.

In a LMM the *conditional* distribution of Y given B = **b** that has the following form (Bates et al., 2015):

$$(\mathcal{Y}|\mathcal{B} = b) \sim \mathcal{N}\,(X\beta + Zb + \varepsilon, \sigma^2 W^{-1}), \tag{2}$$

where***Z*** is an *n*-by-*q* random-effects design matrix for the q-dimensional vector-valued random effects variable, $\mathcal{B}$ whose value we are fixing at *b*; *b* is a *q*-by-1 random-effects vector and ε is the n-by-1 observation error vector.

In a LMM, the Random-effects vector, *b*, and the error vector, *ε*, are independent from each other and have the following prior distributions:

$$b \sim \mathcal{N}\,(0, \sigma^2 D(\theta)) \tag{3}$$

and

$$\varepsilon \sim N(0, \sigma^2 I), \quad (4)$$

where D is a symmetric and positive semidefinite matrix, parameterized by a variance component vector θ, I is an n-by-n identity matrix, and σ^2 is the error variance.

In fitting a mixed-effects model the fixed effects coefficients, β and the variance of the random effects, σ_b^2 are both estimated.

For the current investigation, we intend to calibrate a LMM with GDP per capita as a response variable and exports as a percentage of GDP as the main explanatory factor using the R software.

In the R syntax, formulas for the LMM implementation take the form:

resp ~ expr,

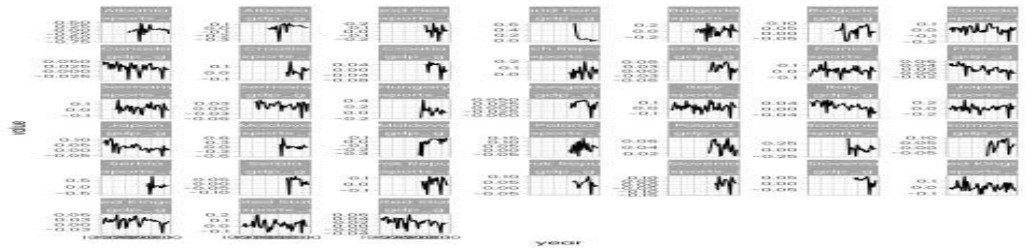
where *resp* determines the response variable and *expr* is an expression that specifies the columns of the model matrix. Random-effects terms are shown in the following manner:

resp ~ FEexpr + (REexpr1 | factor1) + (REexpr2 | factor2) + ...

where *FEexpr* is an expression determining the columns of the fixed-effects model matrix, **X**, and the random-effects terms, (REexpr1 | factor1) and (REexpr2 | factor2), determine both the random-effects model matrix, **Z** and the structure of the relative covariance factor.

As a preliminary step, we take the difference in logarithms of the two indicators for two consecutive years, thus estimating the growth rate of the two variables while stationarizing the series. Figure 3 presents the growth rates of GDP per capita and exports as % of GDP for a selection of CEE and G7 countries over the analysis period. It is apparent that all countries (with the exception of Poland) experienced a decrease in GDP per capita during the last global economic crisis; also, CEE countries present a higher volatility of the importance of exports in the overall economy.

Figure 3. Growth rates of GDP per capita and exports as % of GDP, selected CEE and G7 countries



Next,we define our fixed and random factors as follows:

- the fixed variable of interest is the annual rate of change in the importance of exports in GDP;
- other fixed factors included in the model's specification are the previous year's weight of exports in the country's GDP (i.e. the lagged value of exports as a percentage of GDP), the absolute value of exports in the first year for which the data is present for each country, and also a linear time trend is included in the equation;
- we control for the fact that each country has a different starting year for its data by including the starting value of exports as a fixed factor.
- in a first investigation the intercept is allowed to vary by year and by country;
- subsequently, both intercept and slope coefficients are allowed to vary by year and by country.

Intra Class Correlation (ICC)

Before calibrating the LMM model, we first investigate whether random effects should indeed be considered for the current datasample and thus we estimate the Intra Class Correlation (ICC),which is a measure of reliability, or dependence among individuals (Kreft & DeLeeuw, 1998). To assess the ICC, we follow Starkweather (2010) and we create a null model, whichwould include just the intercepts (fixed and random) and the random effect for the highest-level variable(i.e. country). Next, we estimate how much of the total random effect variance estimates is explained country's variance estimate. Results confirm that random effects are indeed present in our data sample, with a value for the ICC of 87.29%. Thus, we can proceed with a LMM approach to investigate the importance of exports for the economic growth at a global level.

There are several statistical software packages containing routines for Linear mixed-effects models or LMMs. These include, for instance, SAS, SPSS, STATA, S+, and R.

The major advantage of R is that it is a freely available, dynamically developing, open-source environment for statistical computing and graphics.

Therefore, in this investigation we will calibrate Linear Mixed Effects Modeling with package lme4 in R to our dataset. The lme4 (Linear Mixed Effects version 4; Bates & Maechler, 2010) is designed to analyze linear mixed effects models through three primary functions, i.e. function lmer for linear mixed models, function glmer for generalized (non-Gaussian) linear mixed models, and function nlmer for non-linear mixed models. For the current research we employ a linear mixed model and thus, the lmer function. A similar investigation is found in Ellis (2015), but there the function lme from the nlme package is employed.

The two models we calibrate will have the following expressions:

#*Random intercept model (Model 1)*– the slope coefficients are fixed for all countries,

```
model1<-lmer(gdp_growth ~ ordered(first_year) + exports_growth + exports(-1) + first_export_value + year + (1|year) + (1|country)), data=186countries, REML = TRUE, verbose = FALSE)
```

only the intercept varies by country and by year

In equation form,model 1 is written as:

```
GDP_growth = FirstYear + Exports_growth + Exports(-1) + ExportsValueFirstYear + Year + (1|year) + (1|country)
```

In the above specification, (1|g) is the R software syntax for a random intercept. In other words, the model assumes an intercept that's different for each year of the analysis period and each of the 186 countries; "1" stands for the intercept. The first model, including (1 | g), is the simplest possible mixed-model formula, where each level of the grouping factor, g, has its own random intercept.

Linear mixed effects model (Model 2)– both intercept and slope coefficients for the growth rate of the importance of exports in GDP vary by year and by country, while the slope coefficient for the absolute importance of exports in GDP in the first year of data varies by country

```
model2 <-lmer(gdp_g ~ exports_g + exports(-1) + first_export_value+ year + (exports_g|country) +(exports_g|year) + (first_export_value|country)
, data=186countries, REML = TRUE, verbose = FALSE)
```

In equation form,model 2looks as follows:

```
GDP_growth = Exports_growth + Exports(-1) + ExportsValueFirstYear + Year + (Exports_growth|country) +(exports_growth|year) + (ExportsValueFirstYear |country)
```

This time, in the above model specification, (x|g) is the R software syntax for both a random intercept and a random slope for the factor x. In other words, Model 2 assumes that the factor *Exports_growth* is different for each year of the analysis period and each of the 186 countries, and the factor *ExportsValueFirstYear*varries by country

In both model specifications, the REML = TRUE argument is used to specify that the Restricted Maximum Likelihood criterion is used instead of the log- likelihood criterion for optimization of parameter estimates, while the verbose = FALSE argument suppresses the iteration history. The restricted maximum likelihood estimation (REML) is a modification of maximum likelihood estimation that is more precise for mixed-effects modeling.

Results and discussion

In both models, the specification of the fixed factors (FE1,...,FE4) determines the columns of the fixed-effects model matrix, X, while the random-effects terms, (RE1 | factor1, RE2 | factor2,...,) determine both the random-effects model matrix, Z and the structure of the relative covariance factor.

Coefficients of Model 1's fixed effects factors (presented in Table 4) provide a first indication of the quantum and direction of the relationship of interest. We thus find evidence that on average, for the 186 countries included in the analysis, the impact of a change in exports as a percentage of GDP on GDP growth is positive and significant, and this impact lasts past the subsequent year. For instance, a one unit increase in the predictor Change in the importance of exports in GDP (exports_growth) corresponds to a 2.93% increase in the outcome GDP growth. Likewise, a one-unit increase in the predictor Previous year's weight of exports in the country's GDP (exports(-1)) corresponds to a 2.19% increase in the outcome GDP growth.

Other findings show that the value of exports as a percentage of GDP in the first year for which the data is present in each country is not an explanatory factor for GDP growth. Also, the growth rate of GDP is not simply related to time.

Table 4: Coefficients of the fixed-effects factors for Model 1

Fixed effects:			
	Estimate	Std.Error	t Value
(Intercept)	0.389347	0.2422794	1.607
exports_growth	0.0293407	0.0036051	8.139*

exports(-1)	0.0219214	0.0035748	6.132*
first_export_value	-0.0005029	0.001856	-0.271
Time trend (t)	-0.0001864	0.0001217	-1.532

*significant at 5%
**for space economy reasons, the coefficients for the factor "first_year"are not presented
***estimations with R software (this table and throughout the paper)

As we have seen that random effects are present for our dataset, we are most interested in results of the LMM investigation as specified in Model 2, where we allow for by-country and by-year variation of exports as a percentage of GDP and also by-country variation of the value of exports as a percentage of GDP in the first year.

Table 5 provides estimates for the random effects in the form of variances and standard deviations showing what proportion of the random effect variance is attributable to each random effect. Results attest that the effect of the change in export's weight in GDP is quite substantial.

Table 5: Random effects emerged from LMM

Random effects:				
Groups	Name	Variance	Std.Dev.	Corr
country	(Intercept)	0.0009312	0.03052	
first_export_value		0.0001159	0.01077	-1
country.1	(Intercept)	0.0001364	0.01168	
exports_growth		0.0132514	0.11511	-0.07
year	(Intercept)	0.0001567	0.01252	
exports_growth		0.004152	0.06444	-0.07
Residual		0.0029767	0.05456	

Next, Table 6 reports the estimates of the fixed effects in the LMM model. The intercept is the mean of the outcome (GDP growth) when all the predictors have a value of zero, while the fixed effects coefficients are interpreted as the average impact of each fixed factor across the 186 countries, where in each case a specific random impact is added. Overall, the impact of a change in exports as a percentage of GDP on GDP growth remains positive (and even slightly increases) and significant in the subsequent year (2.4%), but loses its statistical significance (although it remains

positive) beyond that. Again, neither time trend, nor impact of the first year's exports as % of GDP is encountered.

Table 6: Fixed effects coefficients emerged from LMM

Fixed effects:			
	Estimate	Std. Error	t value
(Intercept)	0.4272652	0.243686	1.753
exports_growth	0.0214065	0.0137933	1.552
exports(-1)	0.0239369	0.0034021	7.036*
first_export_value	-0.0004491	0.0018739	-0.24
t	-0.0002046	0.0001226	-1.669

* significant at 5%

While Table 6 provides an indication of overall effects of the fixed factors on GDP growth, Appendix 1 identifies country-specific coefficients, where each column shows the size of the particular effect for a particular country. Thus, while the overall impact of a change in exports as a percentage of GDP on GDP growth was 2.1% as per the table above, any particular country has a value that is lower or higher than that, with a reasonable number of countries seeing a negative impact. The value for the exports, growth parameter plus the exports(-1) parameter provides an overview of the overall impact, for each country, of the changing importance of exports in the economy on GDP growth. As can be seen from the last column in Appendix 1 this combined value is generally but not always positive.

For the subsample of countries that we have focused on throughout this study (G7 and CEE countries), Table 7presents country-level effects of the two factors of interest. Interestingly, with the exception of Romania and Moldova, we report a positive value of the cumulative effect of the importance of exports on GDP growth for all countries.

Table 7: Country-level effects for the changing importance of exports in the economy on GDP growth

Country	**(Intercept)**	**Exports growth**	**Exports (-1)**	**Cumulative impact**
Moldova	0.4664	-0.1953	0.0239	-0.1714
Romania	0.4278	-0.0336	0.0239	-0.0096
United States	0.4278	-0.0240	0.0239	0.0000
Japan	0.4414	-0.0190	0.0239	0.0050
United Kingdom	0.4269	-0.0080	0.0239	0.0159
Italy	0.4276	0.0150	0.0239	0.0389
Hungary	0.4261	0.0198	0.0239	0.0437
Bulgaria	0.4195	0.0321	0.0239	0.0560
Germany	0.4271	0.0340	0.0239	0.0579
France	0.4277	0.0357	0.0239	0.0597

Poland	0.4055	0.0358	0.0239	0.0598
Czech Republic	0.4249	0.0422	0.0239	0.0662
Slovak Republic	0.3938	0.0472	0.0239	0.0711
Slovenia	0.4266	0.0474	0.0239	0.0713
Croatia	0.4282	0.0474	0.0239	0.0713
Serbia	0.4332	0.0746	0.0239	0.0985
Canada	0.4273	0.0800	0.0239	0.1040
Albania	0.4169	0.1693	0.0239	0.1932
Bosnia and Herzegovina	0.4402	0.2497	0.0239	0.2736

Model diagnostic

The last section of the LMM output simply provides the correlations among the fixed effects variables, which is a useful instrument to assess multicollinearity. As we can see in our output (Table 8), the predictors are not related and therefore we conclude that multicollinearity is not a concern.

Table 8: Correlation of Fixed Effects

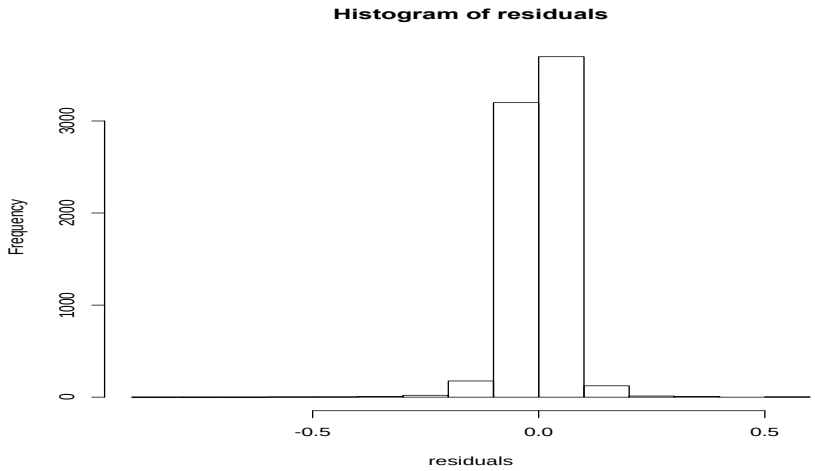
	(Intr)	**e_g**	**e(-1)**	**f_e_v**
exports_growth	-0.002			
exports(-1)	0	0.01		
first_export_value	0.004	0.01	0.022	
t	-1	0.001	0	-0.027

Finally, we check for model's specifications by extracting and summarizing the residuals, as well as plotting them. We verify that residuals are approximately normally distributed around a mean of zero (see Table 9 and Figure 4)

Table 9. LMM residuals statistics

Min.	**1st Qu.**	**Median**	**Mean**	**3rd Qu.**	**Max.**
-0.8337	-0.0205	0.00213	0	0.02316	0.583

Figure 4. Histogram of LMM residuals



The Histogram of residuals attests that the LMM employed for previous calibrations is well specified. We notice that it indicates that random error is indeed normally distributed, suggesting that the model's underlying assumptions have not been violated.

Conclusion

We take a LMM approach to assess the impact of exports on economic growth and encounter a positive relationship between the two factors, confirming conventional wisdom that countries that encourage exports experience higher economic growth, on average, but the role of exports in the growth process is not apparent in all cases.

Furthermore, this positive relationship is stronger for CEE countries than for G7 countries, with the exception of Romania and Moldova, in which cases we report a negative relationship, and Canada, the G7 country where a high positive relationship is encountered. Except for these cases, for all CEE countries the relationship between aggregate exports and growth is stronger. The specification of LMM in this research accounted for by-country and by-year variation in overall GDP growth.

Although theoretically the participation in the international market through international trade should allow a country to achieve a higher growth rate, it seems that, on one hand, a country may need to first meet other criteria before being able to benefit from positive externalities such as knowledge spillovers and economies of scale, and one the other hand there are cases where there seem to be other factors (most probably Investments) that completely take over the influence that exports exert

on growth. In addition, a further investigation should deal with export structure by products and destinations and the link between these sub-sets of export data and economic growth.

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Appendix 1

Country	***Interc.***	***Exports_ growth***	***Exp(-1)***	***Cum. impact***	***Country***	***Interc.***	***Exports_ growth***	***Exp(-1)***	***Cum. impact***
Afghanistan	0.4149	-0.0930	0.0239	-0.0690	Lao PDR	0.4790	-0.0657	0.0239	-0.0418
Albania	0.4169	0.1693	0.0239	0.1932	Latvia	0.3839	-0.0576	0.0239	-0.0337
Algeria	0.4311	0.0949	0.0239	0.1188	Lebanon	0.4238	-0.1045	0.0239	-0.0805
Antigua and Barbuda	0.3980	-0.0133	0.0239	0.0106	Lesotho	0.4373	0.0172	0.0239	0.0411
Argentina	0.4201	-0.1311	0.0239	-0.1071	Liberia	0.5100	0.4891	0.0239	0.5130
Armenia	0.4034	-0.0686	0.0239	-0.0447	Libya	0.4479	0.6001	0.0239	0.6241
Aruba	0.4731	0.0288	0.0239	0.0527	Lithuania	0.3862	0.0806	0.0239	0.1046
Australia	0.4266	0.0127	0.0239	0.0367	Luxembour	0.4156	0.0877	0.0239	0.1116
Austria	0.4238	0.0236	0.0239	0.0475	Macao SAR, China	0.3648	0.0897	0.0239	0.1137
Azerbaijan	0.4066	0.1464	0.0239	0.1703	Macedonia, FYR	0.4325	0.0245	0.0239	0.0484
Bahamas	0.4437	-0.0831	0.0239	-0.0591	Madagascar	0.3789	0.0974	0.0239	0.1213
Bahrain	0.4471	-0.0755	0.0239	-0.0516	Malawi	0.4329	-0.0241	0.0239	-0.0002
Bangladesh	0.4215	0.0429	0.0239	0.0668	Malaysia	0.3868	0.0180	0.0239	0.0419
Barbados	0.4427	-0.0076	0.0239	0.0164	Maldives	0.4091	0.1265	0.0239	0.1505
Belarus	0.4046	0.0233	0.0239	0.0472	Mali	0.4211	-0.0668	0.0239	-0.0429
Belgium	0.4232	0.0529	0.0239	0.0768	Malta	0.3797	0.0830	0.0239	0.1070
Belize	0.4166	-0.0261	0.0239	-0.0021	Mauritania	0.4227	0.0769	0.0239	0.1008
Benin	0.4016	0.0555	0.0239	0.0794	Mauritius	0.3905	-0.0447	0.0239	-0.0208

Bermuda	0.4536	0.0261	0.0239	0.0501	Mexico	0.4262	-0.0973	0.0239	-0.0733
Bhutan	0.4488	0.0287	0.0239	0.0526	Moldova	0.4664	-0.1953	0.0239	-0.1714
Bolivia	0.4208	-0.0365	0.0239	-0.0126	Mongolia	0.4234	-0.0882	0.0239	-0.0643
Bosnia and Herzegovina	0.4402	0.2497	0.0239	0.2736	Montenegro	0.4198	0.0302	0.0239	0.0542
Botswana	0.3829	0.1654	0.0239	0.1894	Morocco	0.4241	-0.1064	0.0239	-0.0825
Brazil	0.4313	-0.0282	0.0239	-0.0043	Mozambiqu	0.4387	0.1316	0.0239	0.1555
Brunei Darussalam	0.4741	0.1632	0.0239	0.1871	Namibia	0.4381	0.0152	0.0239	0.0391
Bulgaria	0.4195	0.0321	0.0239	0.0560	Nepal	0.4219	0.0212	0.0239	0.0451
Burkina Faso	0.4235	-0.0097	0.0239	0.0142	Netherlands	0.4233	0.0074	0.0239	0.0314
Burundi	0.4118	0.0080	0.0239	0.0319	New	0.4295	-0.0187	0.0239	0.0053
Cabo Verde	0.4270	0.0375	0.0239	0.0614	Nicaragua	0.4453	-0.0642	0.0239	-0.0403
Cambodia	0.4311	0.0592	0.0239	0.0832	Niger	0.3683	-0.0681	0.0239	-0.0442
Cameroon	0.4385	0.0166	0.0239	0.0406	Nigeria	0.4098	0.0220	0.0239	0.0460
Canada	0.4273	0.0800	0.0239	0.1040	Norway	0.4177	0.0091	0.0239	0.0330
Central	0.4637	-0.0561	0.0239	-0.0321	Oman	0.4293	-0.1306	0.0239	-0.1067
Chad	0.4158	0.0425	0.0239	0.0665	Pakistan	0.4286	-0.0043	0.0239	0.0197
Chile	0.4336	-0.1256	0.0239	-0.1017	Palau	0.4358	-0.0260	0.0239	-0.0021
China	0.5382	-0.0207	0.0239	0.0033	Panama	0.4110	0.0527	0.0239	0.0766
Colombia	0.4278	-0.0123	0.0239	0.0117	Papua New Guinea	0.4248	0.0444	0.0239	0.0684
Comoros	0.3892	0.0376	0.0239	0.0615	Paraguay	0.4284	0.0508	0.0239	0.0748
Congo, Dem. Rep.	0.4387	0.0346	0.0239	0.0585	Peru	0.4299	-0.0999	0.0239	-0.0760
Congo, Rep.	0.4309	-0.0057	0.0239	0.0182	Philippines	0.4218	-0.0166	0.0239	0.0074
Costa Rica	0.4243	-0.0249	0.0239	-0.0009	Poland	0.4055	0.0358	0.0239	0.0598
Cote	0.4584	-0.0261	0.0239	-0.0022	Portugal	0.4322	0.0204	0.0239	0.0443
Croatia	0.4282	0.0474	0.0239	0.0713	Puerto Rico	0.4106	0.0490	0.0239	0.0729
Cuba	0.4127	0.1584	0.0239	0.1823	Qatar	0.4390	0.0600	0.0239	0.0840
Cyprus	0.4056	0.0306	0.0239	0.0546	Romania	0.4278	-0.0336	0.0239	-0.0096
Czech Republic	0.4249	0.0422	0.0239	0.0662	Russian Federation	0.4299	0.0111	0.0239	0.0350
Denmark	0.4303	-0.0175	0.0239	0.0064	Rwanda	0.4206	-0.0542	0.0239	-0.0303
Djibouti	0.4730	0.0657	0.0239	0.0897	Samoa	0.4268	0.0096	0.0239	0.0335
Dominica	0.4033	0.1227	0.0239	0.1466	Saudi	0.4470	0.1077	0.0239	0.1316
Dominican	0.4137	0.0006	0.0239	0.0246	Senegal	0.4264	0.0236	0.0239	0.0475
Ecuador	0.4272	-0.0192	0.0239	0.0047	Serbia	0.4332	0.0746	0.0239	0.0985
Egypt, Arab Rep.	0.4267	-0.0228	0.0239	0.0011	Seychelles	0.4258	-0.0094	0.0239	0.0145
El Salvador	0.4382	0.0897	0.0239	0.1136	Sierra	0.4493	0.0836	0.0239	0.1075
Equatorial	0.2771	0.4949	0.0239	0.5188	Singapore	0.3663	0.0897	0.0239	0.1137
Eritrea	0.4118	0.0231	0.0239	0.0470	Slovak Republic	0.3938	0.0472	0.0239	0.0711
Estonia	0.3878	0.0645	0.0239	0.0884	Slovenia	0.4266	0.0474	0.0239	0.0713
Ethiopia	0.4277	-0.0183	0.0239	0.0056	Solomon Islands	0.4483	0.1769	0.0239	0.2008

Euro area	0.4267	0.0341	0.0239	0.0581	South Africa	0.4410	-0.0043	0.0239	0.0197
Fiji	0.4350	0.0165	0.0239	0.0404	Spain	0.4341	-0.0064	0.0239	0.0175
Finland	0.4243	0.0506	0.0239	0.0745	Sri Lanka	0.4077	0.0055	0.0239	0.0295
France	0.4277	0.0357	0.0239	0.0597	St. Kitts and Nevis	0.3964	0.0037	0.0239	0.0277
Gabon	0.4366	-0.1009	0.0239	-0.0769	St. Lucia	0.4127	-0.0823	0.0239	-0.0584
Gambia	0.4455	-0.0260	0.0239	-0.0021	St. Vincent and the Grenadines	0.4006	0.0842	0.0239	0.1081
Georgia	0.4575	-0.1398	0.0239	-0.1159	Sudan	0.4247	0.0265	0.0239	0.0504
Germany	0.4271	0.0340	0.0239	0.0579	Suriname	0.4499	0.0861	0.0239	0.1101
Ghana	0.4418	0.0171	0.0239	0.0411	Swaziland	0.4153	0.0122	0.0239	0.0362
Greece	0.4281	-0.0585	0.0239	-0.0346	Sweden	0.4273	0.0503	0.0239	0.0742
Grenada	0.4026	-0.0076	0.0239	0.0163	Switzerland	0.4395	0.0404	0.0239	0.0644
Guatemala	0.4214	0.0293	0.0239	0.0533	Syrian Arab Republic	0.4246	-0.0491	0.0239	-0.0251
Guinea	0.4478	0.0504	0.0239	0.0743	Tajikistan	0.4875	0.0305	0.0239	0.0544
Guinea-Bissau	0.3890	0.0245	0.0239	0.0484	Tanzania	0.4312	0.0003	0.0239	0.0243
Guyana	0.4458	0.0257	0.0239	0.0497	Thailand	0.4315	-0.0530	0.0239	-0.0291
Haiti	0.4008	0.0676	0.0239	0.0916	Timor-Leste	0.4248	-0.0248	0.0239	-0.0008
Honduras	0.4322	0.0589	0.0239	0.0828	Togo	0.4471	0.0944	0.0239	0.1183
Hong Kong SAR, China	0.3820	0.0965	0.0239	0.1204	Tonga	0.4270	-0.0225	0.0239	0.0015
Hungary	0.4261	0.0198	0.0239	0.0437	Trinidad	0.4245	0.0179	0.0239	0.0418
Iceland	0.4136	-0.0978	0.0239	-0.0738	Tunisia	0.4236	0.0198	0.0239	0.0437
India	0.4526	-0.0415	0.0239	-0.0176	Turkey	0.4334	-0.0522	0.0239	-0.0283
Indonesia	0.4344	-0.0216	0.0239	0.0023	Turkme	0.4023	0.0923	0.0239	0.1162
Iran, Islamic Rep.	0.4257	0.1237	0.0239	0.1476	Uganda	0.4360	0.0338	0.0239	0.0577
Iraq	0.4324	-0.0595	0.0239	-0.0355	Ukraine	0.4583	-0.1526	0.0239	-0.1287
Ireland	0.4003	0.0294	0.0239	0.0534	United	0.5059	-0.0202	0.0239	0.0037
Israel	0.4333	-0.0149	0.0239	0.0090	United Kingdom	0.4269	-0.0080	0.0239	0.0159
Italy	0.4276	0.0150	0.0239	0.0389	United States	0.4278	-0.0240	0.0239	0.0000
Jamaica	0.4492	-0.0187	0.0239	0.0052	Uruguay	0.4268	-0.0788	0.0239	-0.0549
Japan	0.4414	-0.0190	0.0239	0.0050	Uzbekistan	0.4186	0.0515	0.0239	0.0755
Jordan	0.4236	-0.0949	0.0239	-0.0709	Vanuatu	0.4345	0.1074	0.0239	0.1314
Kazakhstan	0.3871	0.0334	0.0239	0.0573	Venezuela	0.4491	-0.0620	0.0239	-0.0381
Kenya	0.4332	-0.0146	0.0239	0.0094	Vietnam	0.4845	0.0251	0.0239	0.0490
Kiribati	0.4677	0.1110	0.0239	0.1349	West Bank and Gaza	0.4279	0.0300	0.0239	0.0539
Korea, Rep.	0.5077	-0.0630	0.0239	-0.0390	Yemen,	0.4235	-0.0242	0.0239	-0.0003
Kuwait	0.4769	0.1138	0.0239	0.1378	Zambia	0.4125	0.0508	0.0239	0.0747
Kyrgyz Republic	0.4487	0.1144	0.0239	0.1383	Zimbabwe	0.4506	-0.0249	0.0239	-0.0010