THE INFLUENCE OF SOME R&D FACTORS ON THE EXPORT OF GOODS AND SERVICES, IN THE CONTEXT OF PANEL ANALYSIS

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Abstract:

The article aims to analyze the influence of factors that characterize the R&D sector on the export of goods and services, one of the factors that make a positive contribution to the gross domestic product of a country, by applying econometric models having as premise the current stage of the researchers on the approached topic.

The results will highlight the importance of the R&D activities, the innovations generated by them contributing considerably to the export, respectively to the economic growth.

Keywords: *R&D, patents, export*

JEL classification: *O3, O34, O40*

Introduction

Numerous studies suggest that R&D and exports should be complementary in assessing their impact on economic performance. In this context, Golovko and Valentini consider that the positive impact of the innovation process on increasing the competitiveness of firms is greater if they export (Golovko, E., Valentini, G., 2011,p. 362-380).

Krugman considers that the innovation process is one of the determining factors of the export (Krugman, P., 1979, p. 253-266), Girma, Gorg and Hanley believe that the export intensifies the activities of R&D (Girma, S., Gorg, H., Hanley, A., 2008, p. 750-773) and Bleaney and Wakelin consider that for the exporting firms the innovation capacity is crucial (Bleaney, M., Wakelin, K., 2002, p.3-5).

Based on a series of data that includes approximately 340 thousand firms from Portugal, 2006... 2012, Neves, Teixeira and Silva (Neves, A., Teixeira, A.C., Silva T.S., 2016, p. 125-156) confirmed the complementarity between R&D and the export of goods and services and highlighted on the basis of a model panel data, the positive impact of R&D and export on sales growth which is enhanced when both activities occur simultaneously.

Lachenmaierand and Wessmann (Lachenmaier,S., Woessmann, L., 2006, p. 317-350) believe that when firms invest considerable in R&D, the products/services become competitive and have a positive impact on the export of goods and services, and Aw, Roberts and Xu (Aw, B.Y., Roberts, M.J., Xu, D.Y., 2011, p. 1312-1344) consider that investments in R&D and exports are interdependent, both influencing firms' profitability.

Also, Filatotchev and Piesse analyze the relationship between R&D, export and sales growth of companies in the UK, Germany, Italy and France and find that both R&D activities and export intensity have a positive impact on sales growth (Filatotchev, I., Piesse, J., 2009, p. 1260-1276).

Econometric analysis by Bee Yan Aw, Mark J. Roberts, Tor Winston highlights the crucial role of R&D investments that gives Taiwanese electronics manufacturers the ability to use new

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technologies and suggests that export activity is an important mechanism for transfer technology (Yan Aw, B., Roberts, M., J., Winston, T., 2005, p. 1-24).

Description of the Problem

The analysis started from the observation that there are numerous studies that highlight the differences between EU member countries in terms of export of goods and services.

It is noted that the countries that allocate important funds to the R&D sector have a high technological level, registering a high dynamics of the innovation process, respectively of the export.

According to data provided by Eurostat, the expenditures on R&D in the EU-28 in 2017 was lower than in Japan, United States and China, according to Figure 1.

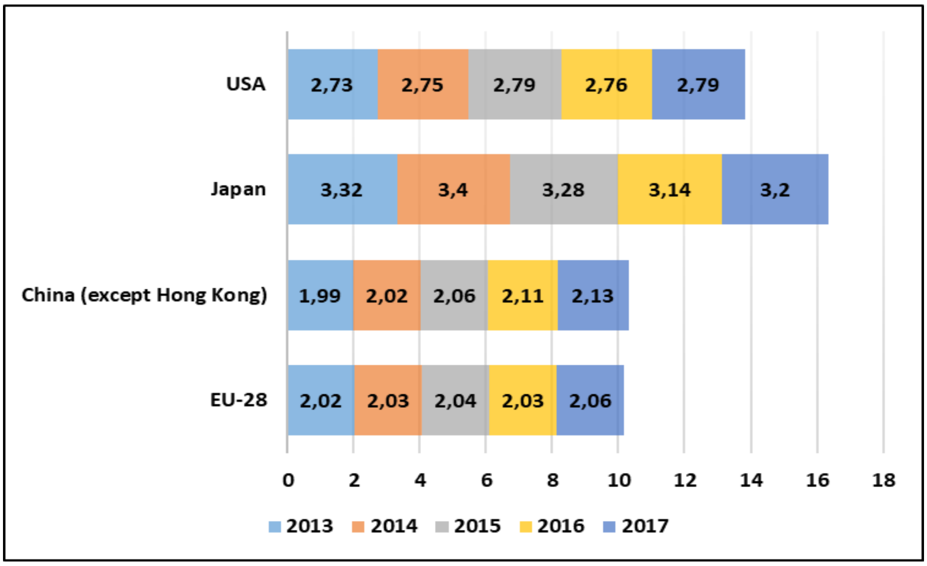

Figure 1 - R&D expenditures, 2013...2017 (% of GDP)

Source: Eurostat, Code: rd_e_gerdtot

In 2017, the EU allocated about 320 billion euros to the R&D sector, which represents 2.06% of GDP, 0.03 percentage points more than in 2016 and 0.29 percentage points more than in 2007.

Also, numerous studies highlight the relationship between some indicators of innovation performance and export performance in EU countries, R&D expenditures, human resources and the number of patents being cataloged as important causal factors for export growth.

In this context, using the EViews program, by testing the models with fixed and random individual effects, Granger causality, the variance decomposition and the impulse response function we evaluated the relationship between R&D expenditures, the number of patents and export.

Methodology and Data

Based on econometric models, we analyzed the conexion between the export of goods and services (weight in the total gross domestic product), the number of patent applications filed with the European Patent Office and the R&D expenditures (weight in the total gross domestic product).

The values are registered for some member countries of the European Union - Romania, Slovenia, Bulgaria, Poland and Hungary -, during 2007-2017, according to Table 1.

Table 1

Export of goods and services, the number of patent applications and the R&D expenditures, in some EU member countries, 2007-2017

Country	Year	Exports of goods and services (% of GDP)	Number of patent applications to the EPO	R&D expenditures (% of GDP)
Romania	2007	24.7	32.57	0.51
	2008	26.2	33.47	0.55
	2009	26	31.13	0.44
	2010	32.4	34.63	0.46
	2011	37	60.42	0.5
	2012	37.4	71.61	0.48
	2013	39.9	85.1	0.39
	2014	41.2	101.92	0.38
	2015	41	93.51	0.49
	2016	41.2	98.91	0.48
	2017	41.5	99.57	0.5
Slovenia	2007	67.9	120.11	1.42
	2008	66.3	138.91	1.63
	2009	57.3	123.25	1.82
	2010	64.3	106.26	2.06
	2011	70.2	112.13	2.42
	2012	72.9	126.72	2.57
	2013	74.2	127.88	2.58
	2014	76.2	135.09	2.37
	2015	77.1	119.09	2.2
	2016	78	112.36	2.01
	2017	83.2	114.25	1.86
Bulgaria	2007	52.4	12.17	0.43
	2008	52.5	18.65	0.45
	2009	42.3	15.83	0.49
	2010	50.2	16.97	0.56
	2011	59.1	26.38	0.53
	2012	60.8	33.82	0.6
	2013	64.9	39.82	0.64
	2014	64.9	47.44	0.79
	2015	64.1	31.88	0.96
	2016	64	31.06	0.78
	2017	67.4	29.33	0.75
Poland	2007	38.6	201.77	0.56
	2008	37.9	233.72	0.6
	2009	37.2	291.61	0.66
	2010	40.1	361.36	0.72
	2011	42.6	384.77	0.75
	2012	44.4	483.31	0.88
	2013	46.3	547.21	0.87

	2014	47.6	609.16	0.94
	2015	49.5	578.38	1
	2016	52.2	627.33	0.96
	2017	54.3	686.64	1.03
Hungary	2007	77.9	191.11	0.96
	2008	79.3	181.21	0.98
	2009	74.4	184.39	1.13
	2010	81.8	195.47	1.14
	2011	86.7	221.58	1.19
	2012	86.4	207.79	1.26
	2013	85.7	215.59	1.39
	2014	87.7	222.3	1.35
	2015	89	205.23	1.36
	2016	89.7	201.27	1.2
	2017	88.2	196.77	1.35

Source: Eurostat: [TET00003], [TSC00001], EPO: [SDG_09_40]

The linear regression model for panel data is written as:

$$y_{it} = \alpha + \beta x_{it} + e_{it},$$

in which, i = 1, 2, …, N represents the EU countries; t = 1, 2, …,T - time; α şi β - model parameters. The variables y_{it} and x_{ij} measure the recording of a phenomenon in structure *i,* at time *t.*

Panel data analysis allows the testing of models that are more complex than those based on time series analysis, a better analysis of the dynamics of structural adjustments and increases the efficiency and consistency of econometric estimates.

Jula considers that the panel model involves a joint analysis of cross-sectional observations, observations made over several time periods. The model is a balanced one if there is a record for each unit, at each time point. Otherwise, the model is an unbalanced one (Jula, D., 2014)

According to Arellano and Honore the combination of time series and cross-section data enriches the possible identifications, the economists being forced to study more closely the nature and source of identifying the parameters with potential (Arellano, M., Honore, B., 2001, p. 3229-3296).

Given this, on the panel data we built and tested the model with fixed and random individual effects and a VAR model on stationary data.

The overtake of the individual effects is achieved by decomposing the deviation e_{it} in:

$$e_{it} = \mu_i + \eta_t + v_{it},$$

in which, μ_i represents the variable that estimates the effect of variables not included in the model on the endogenous, in unit *i* (specific individual effect); η_t – the variable that estimates the effect of the variables not included in the model on the endogenous, at time *t* (the fixed effect in time); v_{it} is variable in time and between individuals.

The Fixed effects model assumes that the parameters μ_i and η_t have the null sum fixed and the estimation is done by the method of the least squares, after the addition of dummy variables.

The Random Effects model assumes that the variables μ_i, η_t and v_{it} are random, independent of each other, are not autocorrelated and are not heteroscedastic.

The VAR model (Vector Autoregressive Model) has the advantage of evaluating the response of a variable to a shock in another variable and is written as:

$$X_t = a_0 + a_1 X_{t-1} + a_2 Y_{t-1} + \varepsilon_{1t}$$

$$Y_t = b_0 + b_1 X_{t-1} + b_2 Y_{t-1} + \varepsilon_{2t}$$

in which, ε_{1t} şi ε_{2t} represents shocks, in period *t*, on variables *X* and *Y*.

It aims to evaluate the effects induced by various shocks on the variables in the system, to decompose the dispersion of the forecast error and to identify the causal relationships (the Granger test, assumes that if the previous values of the variable *Y* contribute significantly to the forecast of the current/future values of the variable *X*, then one can say that the variable *Y* is a Granger cause of *X*).

Results

To ensure the stationarity property, various transformations of the variables were performed, the Im-Pesaran-Shin Test confirming the stationarity of panel data at a level of significance of less than 5%, according to Table 2.

Table 2:

Im-Pesaran-Shin Test

Variable	The value of the statistic test	P-value
Export of goods and services (y)	-2.37804	0.0087
The number of patent applications (x1)	-2.40342	0.0081
R&D expenditures (x2)	-2.62204	0.0007

Source: the author

Several models were tested on the stationary panel data obtained, but the Hausman Test value (p value less than 0.05) confirms the validity of the model with random individual effects, in which the change of the export of goods and services depends directly, only by changing the share of R&D expenditures (see Figure 1).

Dependent Variable: EXPORT
Method: Panel EGLS (Cross-section random effects)
Date: 09/06/19 Time: 09:03
Sample (adjusted): 2008 2017
Periods included: 10
Cross-sections included: 5
Total panel (balanced) observations: 50
Swamy and Arora estimator of component variances

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	60.22254	4.853850	12.40717	0.0000
D(PATENT)	-0.008375	0.050292	-0.166527	0.8685
D(R_D_EXPAND)	-19.66644	7.970827	-2.467302	0.0173
	Effects Specification			
			S.D.	Rho
Cross-section random			10.58006	0.7374
Idiosyncratic random			6.313989	0.2626
	Weighted Statistics			
R-squared	0.098589	Mean dependent var		11.03290
Adjusted R-squared	0.060231	S.D. dependent var		7.147307
S.E. of regression	6.928719	Sum squared resid		2256.336
F-statistic	2.570241	Durbin-Watson stat		0.437936
Prob(F-statistic)	0.087234			
	Unweighted Statistics			
R-squared	0.002404	Mean dependent var		59.49400
Sum squared resid	17323.27	Durbin-Watson stat		0.057041

Correlated Random Effects - Hausman Test
Equation: Untitled
Test cross-section random effects

Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Cross-section random	11.597364	2	0.0030

Cross-section random effects test comparisons:

Variable	Fixed	Random	Var(Diff.)	Prob.
D(PATENT)	0.010349	-0.008375	0.000100	0.0611
D(R_D_EXPAND)	-20.342845	-19.666438	0.048481	0.0021

Figure 1 – The random effects model

Source: the author

We also built a VAR model in stationary data panel and identified the optimum lag according to Figure 2.

Vector Autoregression Estimates
Date: 09/05/19 Time: 12:26
Sample (adjusted): 2009 2017
Included observations: 45 after adjustments
Standard errors in ( ) & t-statistics in [ ]

	EXPORT	D(PATENT)	D(R_D_EXP...
EXPORT(-1)	0.963672	-0.368169	1.40E-05
	(0.03188)	(0.20374)	(0.00093)
	[30.2238]	[-1.80704]	[0.01509]
D(PATENT(-1))	-0.018574	0.377382	0.000294
	(0.02305)	(0.14730)	(0.00067)
	[-0.80573]	[2.56196]	[0.43858]
D(R_D_EXPAND(-1))	0.003978	3.281989	0.460690
	(4.84885)	(30.9841)	(0.14115)
	[0.00082]	[0.10592]	[3.26375]
C	3.951870	28.75210	0.008398
	(2.06045)	(13.1662)	(0.05998)
	[1.91797]	[2.18377]	[0.14001]
R-squared	0.962806	0.267677	0.213033
Adj. R-squared	0.960085	0.214093	0.155450
Sum sq. resids	568.1381	23198.20	0.481460
S.E. equation	3.722503	23.78676	0.108365
F-statistic	353.7781	4.995412	3.699578
Log likelihood	-120.9055	-204.3685	38.24366
Akaike AIC	5.551357	9.260822	-1.521941
Schwarz SC	5.711949	9.421415	-1.361348
Mean dependent	60.27778	11.56889	0.028444
S.D. dependent	18.63225	26.83170	0.117917

Determinant resid covariance (dof adj.)	89.21228
Determinant resid covariance	67.47434
Log likelihood	-286.3210
Akaike information criterion	13.25871
Schwarz criterion	13.74049
Number of coefficients	12

VAR Lag Order Selection Criteria
Endogenous variables: EXPORT D(PATENT) D(R_D_EXPAND)
Exogenous variables: C
Date: 09/06/19 Time: 10:04
Sample: 2007 2017
Included observations: 45

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-370.2279	NA	3210.877	16.58791	16.70835	16.63281
1	-286.3210	152.8971*	115.1795*	13.25871*	13.74049*	13.43831*

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Figure 2 – VAR estimation and lag selection criterion

Source: the author

The following equations resulted from the estimation of the VAR model in the panel:

$$EXPORT = 0.96367245979*EXPORT(-1) - 0.0185736046631*D(PATENT(-1)) + 0.00397750355298*D(R\_D\_EXPAND(-1)) + 3.95186994867$$

$$D(PATENT) = - 0.368169425651*EXPORT(-1) + 0.377381865997*D(PATENT(-1)) + 3.28198884607*D(R\_D\_EXPAND(-1)) + 28.7521032071$$

$$D(R\_D\_EXPAND) = 1.40084271054e-05*EXPORT(-1) + 0.000294314536653*D(PATENT(-1)) + 0.460690069954*D(R\_D\_EXPAND(-1)) + 0.008397878288$$

The model satisfies the conditions of stability, the polynomial roots of the autoregressive process being inside the unit circle, as can be seen in Figure 3.

Roots of Characteristic Polynomial
Endogenous variables: EXPORT D(PATENT) D(R_D_EXPAND)
Exogenous variables: C
Lag specification: 1 1
Date: 09/05/19 Time: 12:28

Root	Modulus
0.975144	0.975144
0.469804	0.469804
0.356796	0.356796

No root lies outside the unit circle.
VAR satisfies the stability condition.

Figure 3 – The roots of the polynomial

Source: the author

Granger causality analysis shows that the change of the share of R&D expenditures is a cause for the change of the export of goods and services (significance level greater than 5%) and the hypothesis of homoscedasticity is confirmed by the p value 0,1516, greater than 0, 05 (see Figure 4).

VAR Granger Causality/Block Exogeneity Wald Tests
Date: 09/05/19 Time: 12:35
Sample: 2007 2017
Included observations: 45

Dependent variable: EXPORT

Excluded	Chi-sq	df	Prob.
D(PATENT)	0.649193	1	0.4204
D(R_D_EXPAND)	6.73E-07	1	0.9993
All	0.651251	2	0.7221

Dependent variable: D(PATENT)

Excluded	Chi-sq	df	Prob.
EXPORT	3.265379	1	0.0708
D(R_D_EXPAND)	0.011220	1	0.9156
All	3.278315	2	0.1941

Dependent variable: D(R_D_EXPAND)

Excluded	Chi-sq	df	Prob.
EXPORT	0.000228	1	0.9880
D(PATENT)	0.192353	1	0.6610
All	0.214077	2	0.8985

VAR Residual Heteroskedasticity Tests (Levels and Squares)
Date: 09/05/19 Time: 12:40
Sample: 2007 2017
Included observations: 45

Joint test:

Chi-sq	df	Prob.
44.69708	36	0.1516

Individual components:

Dependent	R-squared	F(6,38)	Prob.	Chi-sq(6)	Prob.
res1*res1	0.112382	0.801871	0.5747	5.057208	0.5365
res2*res2	0.121613	0.876850	0.5210	5.472575	0.4848
res3*res3	0.275101	2.403514	0.0456	12.37954	0.0540
res2*res1	0.100687	0.709080	0.6443	4.530918	0.6052
res3*res1	0.205880	1.641954	0.1624	9.264609	0.1592
res3*res2	0.128368	0.932733	0.4829	5.776577	0.4487

Figure 4 – Granger heteroscedasticity test and causality

Source: the author

According to the figure below, there is no autocorrelation of the errors until lag 10 (LM Test) and their distribution is not of the normal type (Jarque-Bera Test).

VAR Residual Serial Correlation LM Tests
Date: 09/05/19 Time: 12:44
Sample: 2007 2017
Included observations: 45

Null hypothesis: No serial correlation at lag h

Lag	LRE* stat	df	Prob.	Rao F-stat	df	Prob.
1	6.160763	9	0.7237	0.681004	(9, 87.8)	0.7241
2	6.272897	9	0.7123	0.693830	(9, 87.8)	0.7127
3	3.430234	9	0.9448	0.373496	(9, 87.8)	0.9449
4	11.38864	9	0.2500	1.296060	(9, 87.8)	0.2506
5	16.15772	9	0.0637	1.888713	(9, 87.8)	0.0640
6	10.14684	9	0.3387	1.146757	(9, 87.8)	0.3393
7	14.75836	9	0.0978	1.711593	(9, 87.8)	0.0982
8	6.978830	9	0.6393	0.774939	(9, 87.8)	0.6398
9	15.82798	9	0.0706	1.846731	(9, 87.8)	0.0709
10	11.88637	9	0.2198	1.356475	(9, 87.8)	0.2203

Null hypothesis: No serial correlation at lags 1 to h

VAR Residual Normality Tests
Orthogonalization: Cholesky (Lutkepohl)
Null Hypothesis: Residuals are multivariate normal
Date: 09/05/19 Time: 12:50
Sample: 2007 2017
Included observations: 45

Component	Skewness	Chi-sq	df	Prob.*
1	-1.044170	8.177183	1	0.0042
2	0.629569	2.972677	1	0.0847
3	-0.160269	0.192645	1	0.6607
Joint		11.34251	3	0.0100

Component	Kurtosis	Chi-sq	df	Prob.
1	5.604451	12.71844	1	0.0004
2	5.807558	14.77947	1	0.0001
3	3.361500	0.245030	1	0.6206
Joint		27.74293	3	0.0000

Component	Jarque-Bera	df	Prob.
1	20.89562	2	0.0000
2	17.75214	2	0.0001
3	0.437675	2	0.8035
Joint	39.08544	6	0.0000

*Approximate p-values do not account for coefficient estimation

Figure 5 – Autocorrelation and error distribution tests

Source: the author

The analysis of the impulse functions (see Figure 6) shows that at a shock in changing the share of R&D expenditures, respectively of the number of patent applications, the export of goods and services changes.

Also, from the decomposition by variance of the variables, it turns out that after two shock periods, 6.98% of the variation in the change of the export of goods and services is due to the change in the share of R&D expenditures.

Gradually, however, the influence decreases as the distance from the moment of shock is less than the influence on the export of goods and services given by the change in the number of patent applications.

Variance Decomposition of EXPORT:

Period	S.E.	EXPORT	D(PATENT)	D(R_D_EX...
1	3.722503	100.0000	0.000000	0.000000
2	5.140367	99.27951	0.720490	6.98E-07
3	6.185278	98.60673	1.393179	9.37E-05
4	7.034521	98.12104	1.878636	0.000325
5	7.755841	97.78127	2.218125	0.000605
6	8.384262	97.53899	2.460139	0.000872
7	8.940922	97.36072	2.638178	0.001102
8	9.439846	97.22532	2.773385	0.001293
9	9.890957	97.11953	2.879021	0.001450
10	10.30161	97.03485	2.963575	0.001578

Variance Decomposition of D(PATENT):

Period	S.E.	EXPORT	D(PATENT)	D(R_D_EX...
1	23.78676	2.459826	97.54017	0.000000
2	25.39208	2.158651	97.82186	0.019488
3	25.67220	2.367877	97.59968	0.032442
4	25.77997	2.804687	97.15772	0.037593
5	25.86167	3.310814	96.64999	0.039194
6	25.93664	3.821962	96.13847	0.039566
7	26.00747	4.315493	95.64495	0.039557
8	26.07465	4.784525	95.17604	0.039436
9	26.13837	5.227790	94.73292	0.039285
10	26.19883	5.645944	94.31493	0.039129

Variance Decomposition of D(R_D_EXPAND):

Period	S.E.	EXPORT	D(PATENT)	D(R_D_EX...
1	0.108365	0.534856	0.125039	99.34011
2	0.119584	0.482941	0.629469	98.88759
3	0.121965	0.472397	0.898445	98.62916
4	0.122504	0.472968	1.001297	98.52573
5	0.122630	0.476845	1.035401	98.48775
6	0.122662	0.481971	1.046301	98.47173
7	0.122673	0.487591	1.049958	98.46245
8	0.122679	0.493333	1.051350	98.45532
9	0.122683	0.498999	1.051987	98.44901
10	0.122687	0.504490	1.052345	98.44316

Cholesky Ordering: EXPORT D(PATENT) D(R_D_EXPAND)

.Figure 6 – Analysis of impulse functions and decomposition of the forecast error dispersion

Source: the author

Conclusions

The engine of the European Union's strategy for economic growth is innovation, with member countries being encouraged to invest in the R&D sector up to 3% of gross domestic product, by 2020.

In a less developed economy, the strong intensification of the investment in R&D, the diffusion and the technological transfer represent a safe way to reduce the significant gaps and to ensure the economic growth.

There are numerous studies on the relationship between the R&D sector and the export of goods and services, one of the determinants of economic growth, but, nevertheless, the results are not always conclusive.

This article assesses whether, in the case of modest innovators where exports are the engine of economic growth, despite a noticeable gap in investment in R&D, innovation has a positive impact on export performance.

The EViews test application confirms that there is a complementarity between R&D expenditures, the number of patent applications and the export of goods and services, which means that intensifying R&D activities will lead to increased export

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