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Productive Efficiency of the European Union Member Countries: An Economic Assessment in Post-Brexit Perspective

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ABSTRACT

This study used a modified Cobb-Douglas production model to estimate and test production input co-efficient for Group 28 (including the U.K), Group 27 (excluding the U.K) and individual European Union member countries by using the data of 31 years from 1990 to 2020. Results indicate that the log-linear C-D production model fits the data very well in terms of capital, male and female labour force elasticities, measuring the return to scale, standard errors and economies of scale for Group as well as for individual member countries. Results showed EU 28, EU 27 and from the list of member countries only United Kingdom, Slovak Republic, Slovenia, Czech Republic, Malta, Cyprus, Poland, Hungary, Estonia, Finland, Germany and Netherland are on increasing return to scale, only France is a constant return to scale (as value 0.99, close to 1) and remaining countries are on decreasing return to scale. The study also finds that the United Kingdom as an individual performing increasing return to scale so U.K separation (Brexit) from EU will not harm the U.K and even EU itself, as EU is on increasing return to scale after including/excluding U.K. Study also finds that EU as a group of 27 member countries exhibits increasing return to scale, which is a symbol for overall EU growth and development and suggestion for East Asian and South Asian countries to make a trading bloc or union like European Union.

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1. Introduction

Productive efficiency is the ability of an organization to produce a specific level of output at minimum cost. For productive organization the output and factor inputs must be clearly specified, and a specific technology be adopted. The efficiency can be divided into technical component and price efficiency. Technical component reflects the physical efficiency of input-output production transformation. The economic efficiency refers to the optimal factor allocation.

Economic integration is considered as an effective policy for reducing higher tariff and non-tariff barriers to trade. This allows the businesses to export more and makes goods and services cheaper for consumers as well. United Kingdom (UK) was the largest trade partner of the European Union (EU) and it made up 18% of the EUs, single market. Brexit effects on trade

and economic activities may be substantial regulatory benefits. The main economic benefit of leaving the EU would be a lower net contribution to the EU budget.

EU is a composition of 27-member countries (after exclusion of the U.K) and having a common set of policies on economic, political and social issues. Even France and other Western European countries want a peaceful relationship with West Germany in order to rebuild Europe's political, economic, and social institutions, which had crumbled during WWII (Hussain, 2017). Brexit, according to German Chancellor Angela Merkel, is a "terrible day for Europe" (The Economist, 2016). EU has now become an extremely integrated market in the world globe. European Commission in 2020 The European Union's GDP was estimated to be around $15 trillion (nominal) in 2020 representing around 1/6 of the global economy and creating 227.4 million jobs in the process.

Business, Innovation and Skill department (BIS, 2010) while presenting the house of lord report said that "EU countries trade twice as much with each other as they would do in the absence of the single market program". European Commission in 2007 also reported that services have additional gain up to 1 per cent of EU GDP, energy up to 0.8 per cent, financial markets up to 1.1 per cent and tax co-operation at 0.2 per cent (Ilzkovitz, Dierx, Kovacs, & Sousa, 2007). The aim of this study is to determine the influence of UK exist from EU on selected aspects of economic integration.

2. Literature Review

Moroney (1967) uses the C-D production model for measuring the return to scale in US manufacturing industries. Mok (2002) uses the C-D production function for investigating the industrial productivity in China. Hajkova and Hurník (2007) used the C-D production model for testing whether the Czech Republic labour share has gradually increased by taking the data from 1995-2005. Bockerman and Maliranta (2007) used the C-D production model for measuring regional productivity growth in Finland. Aiyar and Dalgaard (2009) found that C-D specification performed reasonably well for cross-country productivity accounting. M. Z. Hossain and Al-Amri (2010) use the C-D production model on some selected manufacturing industries from Oman over the period 1994-2007. Mishra and Ansari (2013) used a general form of the C-D production model and drive a conceptual model for retail productivity.

In order, for measuring the productive efficiency in EU member countries C-D production function is used. The study has the aim to investigate the productive efficiency of EU member countries on an individual as well as group basis through the return to scale method by using the modified Cobb-Douglas production model. Apostolov (2016) used the Cobb-Douglas production function and measures the effects of foreign direct investment in southeast European Economies. Z. Hossain, Bhatti, and Ali (2004) have reviewed recently used production models in literature and found that the Cobb-Douglas production model is most suitable for measuring the production process. The prime objective of this research was to estimate the production input co-efficient of EU member countries in pre and post- Brexit perspective.

Dhingra et al. (2017) examined the costs and benefits of UK leaving the EU and argued that exist of UK would give a greater freedom for determining its own policies in national interest. The Brexit may possibility affects the wage inequality. UK trades much less with other core countries of EU such as Belgium or Germany. UK has a strong national identity and regional integration shifted too much power to the union to other countries and tensions may also arise. EU may be going to more fragile as economic value is proportional to its size.

3. Data and Methodology

The research study uses the fitted modified Cobb-Douglas production model by using the time series data taken from 28 EU member countries. The data of 31 years' time period 1990-2020 was collected from the official reports of the Bank of England and World Bank. The collected data was analyzed by using the STATA 12 Statistical package.

Cobb-Douglas production function was introduced by Charles W. Cobb and Paul H. Douglas in the 1920s. Cobb-Douglas function is widely used for the study of technological and production behaviour of firm, industry or nation over time by using time series data or for several firms, industries or nations at one point in time by using cross-section analysis. Antony (2009); Hajkova and Hurník (2007); M. Z. Hossain and Al-Amri (2010) and Mishra and Ansari (2013), amongst others, have used the log-linear Cobb-Douglas production model in their research studies.

The methodology adopted for this research is empirical as well as experimental while using the C-D production model. Early, many researchers have used modified C-D production models in their research studies. Moroney (1967) used C-D improved KPN (K-Capital, P-Production workers, N-Nonproduction workers) model for measuring productivity through the return to scale in the US manufacturing industry. Hansen and Knowles (1998) used an improved form of the C-D production model for OECD high-income countries. They use the K3L (K-Capital, L1-Primary education, L2-Secondary education, L3-Tertiary education) model for measuring productivity. Feng and Serletis (2008) use the C-D production model and make KLEM (K-Capital, L-Labor, E-Energy, M-Material) model for measuring productivity in the manufacturing sector. Apostolov (2016) uses the C-D production model to find the effects of foreign direct investment in Southeast European economies.

Now, by using the above references, proposed study model for EU member countries while assuming capital, male and female employed labor force can be written as:

$$Q = f\left(K^{\alpha}, L_M^{\beta}, L_F^{\gamma}\right) \tag{1}$$

It can also be written as,

$$GDP = f(GCF, EMLF, EFLF) \tag{2}$$

Where,
GDP = Gross Domestic Product (Constant Local Currency Units)
GCF = Gross Capital Formation (Constant Local Currency Units)
EMLF = Employed Male Labor Force
EFLF = Employed Female Labor Force

Now, above functional form can also be written as follows,

$$GDP = A.GCF^{\alpha}.EMLF^{\beta}.EFLF^{\gamma} \tag{3}$$

After taking the log and arranging the above equation, we can write it as,

$$lnGDP = lnA + \alpha lnGCF + \beta lnEMLF + \gamma lnEFLF + \varepsilon_i \tag{4}$$

Where ε is the error term and $\alpha, \beta \,\&\, \gamma$ represents the output elasticities of capital, male employed labor force and female employed labor force respectively. Sum of $\alpha, \beta \,\&\, \gamma$ measures the return to scale.

$$if \begin{cases} \alpha + \beta + \gamma > 1 & Increasing\ Return\ to\ Scale \\ \alpha + \beta + \gamma < 1 & Decreasing\ Return\ to\ Scale \\ \alpha + \beta + \gamma = 1 & Constant\ Return\ to\ Scale \end{cases}$$

Now, from equation (1), we can find the marginal products.

a. Marginal Product of Capital

$$MPK = \frac{\partial Q}{\partial K} = \alpha . A . K^{\alpha-1} . L_M^{\beta} . L_F^{\gamma} \quad (5)$$

b. Marginal Product of Male Labor Force

$$MPL_M = \frac{\partial Q}{\partial L_M} = \beta . A . K^{\alpha} . L_M^{\beta-1} . L_F^{\gamma} \quad (6)$$

c. Marginal Product of Female Labor Force

$$MPL_F = \frac{\partial Q}{\partial L_F} = \gamma . A . K^{\alpha} . L_M^{\beta} . L_F^{\gamma-1} \quad (7)$$

4. Results and Discussion

Table 1 present the summary of descriptive statistics of the data. Mean values for Gross Domestic Product (constant local currency) is 1.84e+12, Gross Capital Formation (constant local currency) is 4.462+11, employed male labour force is 4676801 and employed female labour force is 3741196.

Table 1
Summary of Descriptive Statistics

Variables	Obs.	Mean	Std. Dev.	Minimum	Maximum
GDPCL	868	1.84e+12	5.56e+12	3.60e+09	4.10e+13
GCFCL	868	4.46e+11	1.45e+12	4.35e+08	1.11e+13
EMLF	868	4676801	5951808	97667	2.36e+07
EFLF	868	3741196	4776576	38637	2.05e+07

Source: Authors' data analysis results, 2022

Figure 1 presents the graphs of Gross Domestic Product (constant local currency) for group of EU 28 member countries. Although all 28-member countries have different GDP levels, but all have the same pattern for increasing GDP in the European Union. Figure 2 presents the graph of Gross Capital Formation (constant local currency) for 28 EU member countries. Figure 3 and Figure 4 presents the graphs for employed male labor force and employed female labor force for all 28 EU member countries.

Results for EU Panel and individual Member countries are presented in table 2. The estimated results are demonstrating that the EU Group of 28 (with the U.K) and EU Group of 27 (without the U.K) and member countries like the United Kingdom, Slovak Republic, Slovenia, Czech Republic, Malta, Cyprus, Poland, Hungary, Estonia, Finland, Germany and Netherland are on increasing return to scale, only France is a constant return to scale as a value close to 1 (0.99) and remaining countries are on decreasing return to scale. The United Kingdom as an individual performing increasing return to scale so UK separation from EU will not harm the UK itself and even does not harm the EU region as after the Exclusion EU 27 Group still exhibits increasing return to scale. Now to check whether panel and individual country production exhibit what economies of scale, for these purposes we have calculated, where *AC* is the average cost showing the economies of scale. It is observed that the countries with an increasing return to scale also exhibits economies of scale as AC is less than 1.

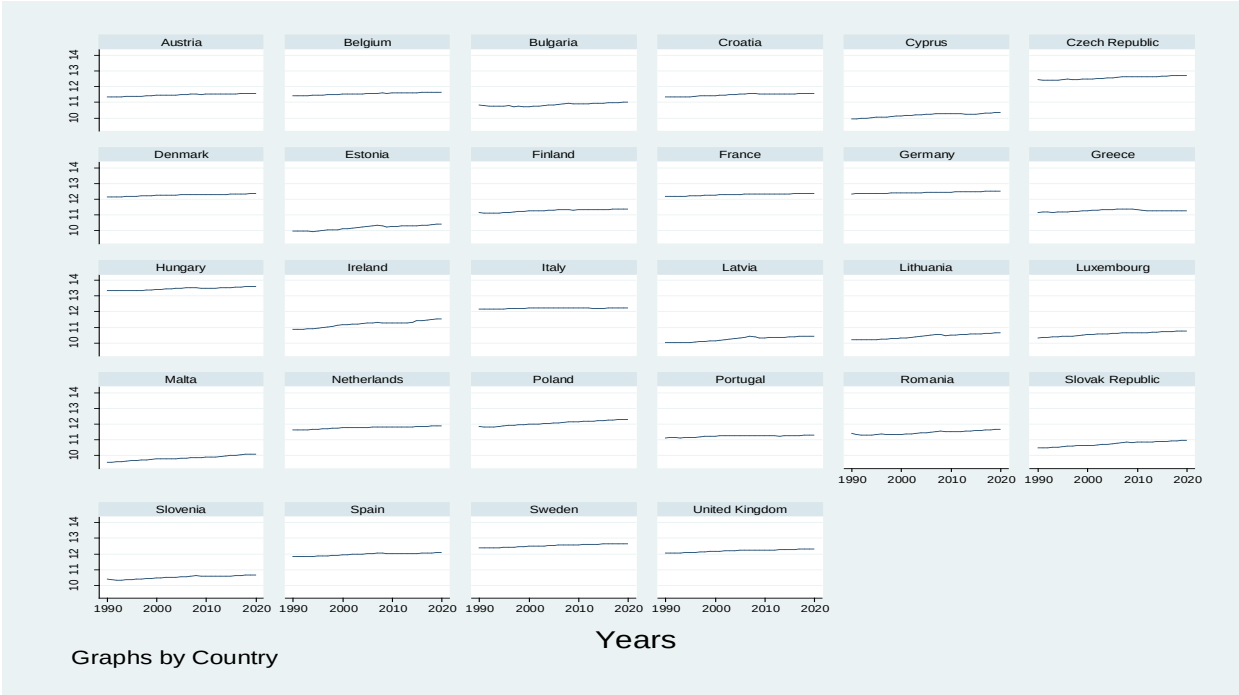

Figure 1: GDP (constant local currency) of 28 EU member countries.

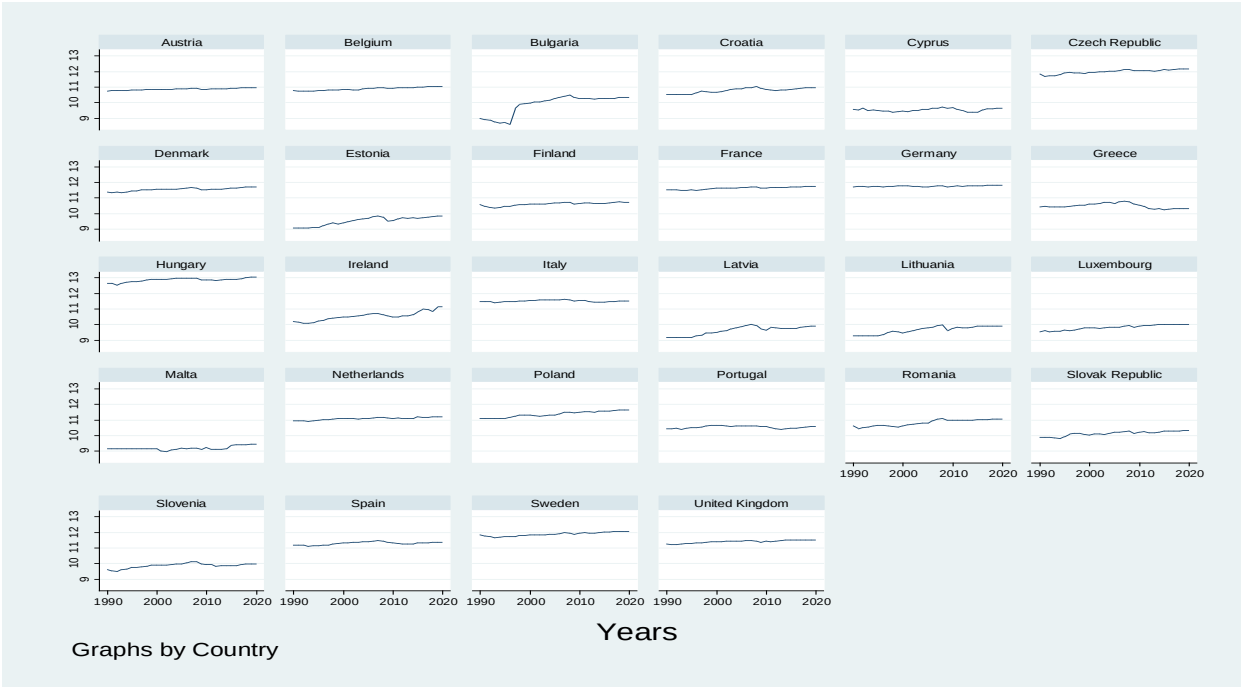

Figure 2: Gross Capital Formation of 28 EU member countries

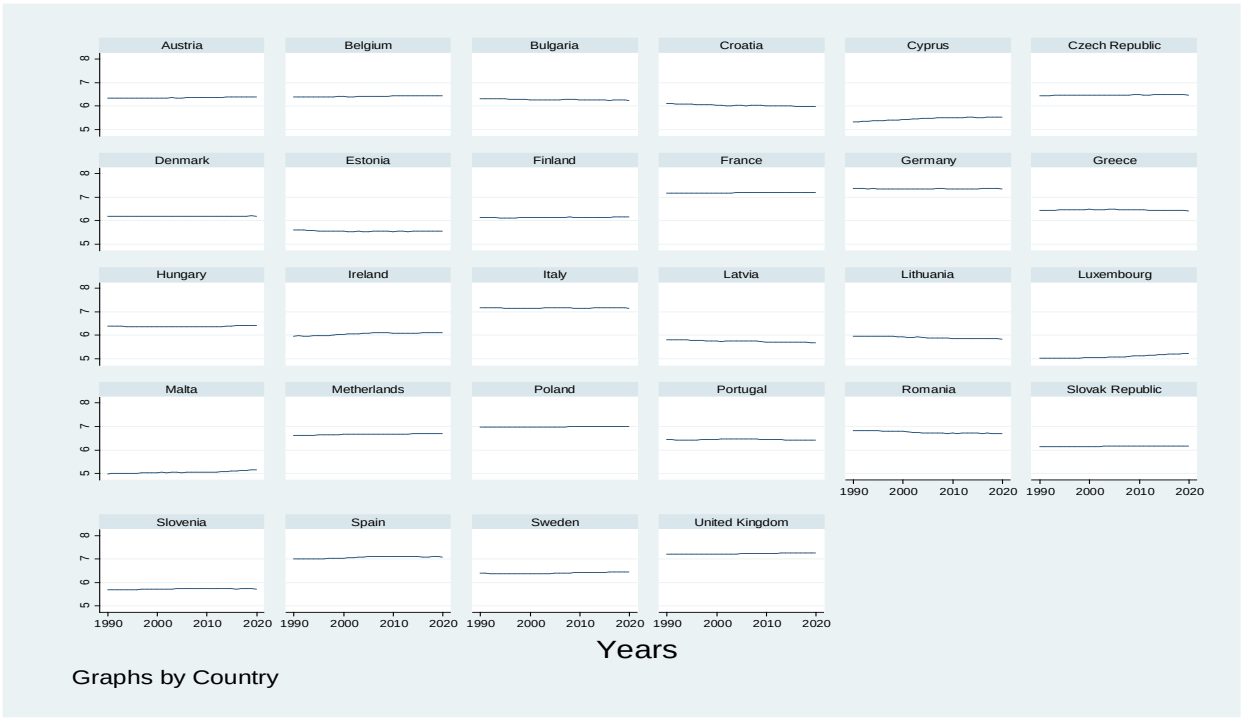

Figure 3: Employed Male Labour Force of 28 EU member countries.

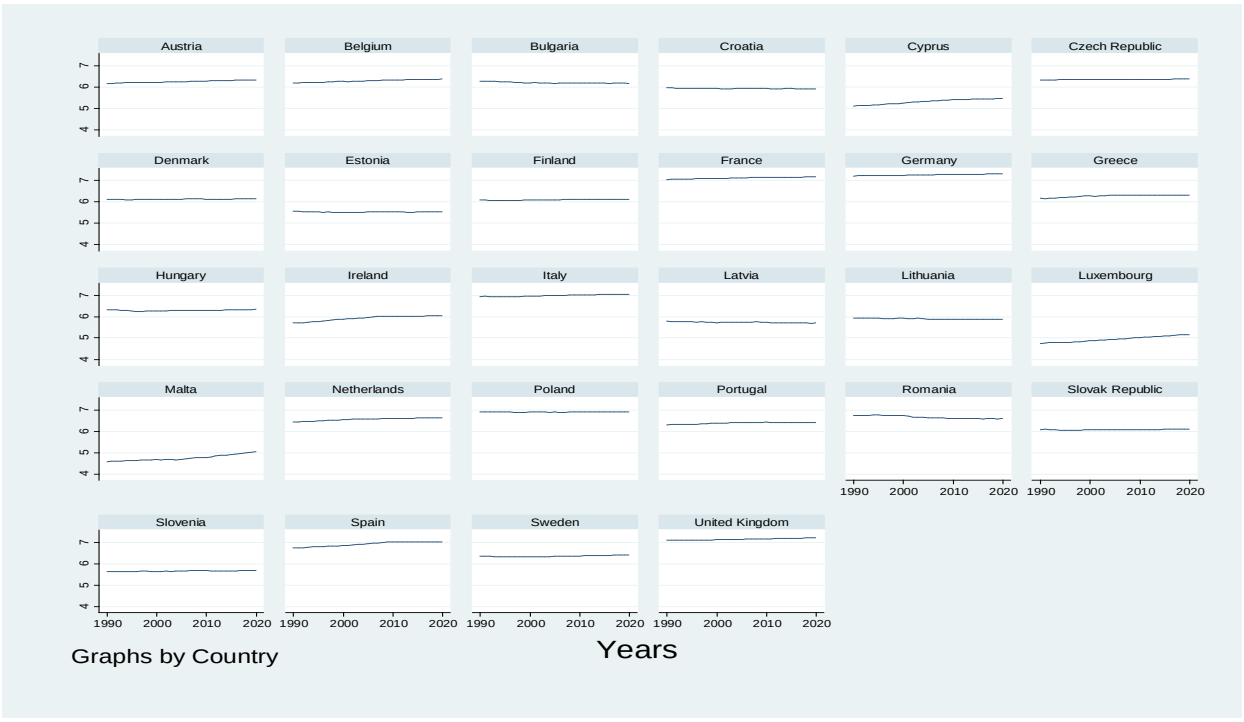

Figure 4: Employed Female Labour Force of 28 EU member countries.

The value of =0.8994 for the EU Panel of 28 countries means that a 1 per cent increase in the quantity of capital used (holding male and female employed labour force constant) results in a 0.8994 per cent increase in GDP of EU, same as for other coefficients. Now, by increasing all three inputs at the same time by 1 per cent GDP leads to a rise by $\alpha + \beta + \gamma = 0.8994 - 0.0762 + 0.1920 = 1.0151$ per cent in EU 28 and GDP leads to rise by $\alpha + \beta + \gamma = 0.9018 - 0.0847 + 0.1903 = 1.0074$ per cent in EU 27 which means the EU panel exhibits increasing return to scale. Here, it is a strong motivation for East Asian and South Asian countries that they have to make trading blocs and unions like European Union.

4.1 Managerial Implication and Limitations

Using the proposed modified C-D production model, any country can compute its productive efficiency. In case of a poor score, the country would also be able to know the responsible factors. The study also suffers from few limitations. First: only 31 years of data is considered for study which is not much enough. Second: factors other than capital and labour which also contribute to the production process are not studied in this research article.

5. Conclusion and Policy Implications

In this study, a modified C-D production model is used for measuring capital, male and female labour force elasticities, return to scale, standard errors and economies of scale for EU 28 Group, EU 27 Group and individual member countries. A modified log-linear C-D model was used for the time 1990-2020. Results showed EU 28, EU 27 and from the list of member countries only United Kingdom, Slovak Republic, Slovenia, Czech Republic, Malta, Cyprus, Poland, Hungary, Estonia, Finland, Germany and Netherland are on increasing return to scale, only France is a constant return to scale (as value close to 1) and remaining countries are on decreasing return to scale. The remaining countries Ireland, Portugal, Romania, Sweden, Austria, Spain, Luxemburg, Greece, Belgium, Latvia, Croatia, Denmark, Italy, Bulgaria and Lithuania are on decreasing return to scale and also facing dis-economies of scale. The United Kingdom as an individual performing increasing return to scale so UK separation from EU will not harm the U.K and even will not harm EU Group of 27. Results also showed that EU 27 as a Group is performing well as they are on increasing return to scale. Now, there is a suggestion for East Asian and South Asian countries to make a joint venture and create trading blocs and unions like European Union.

Although UK has moved away from close integration with its neighbors, but it also gain a potential to re-negotiate trade deals directly with non-EU countries. Tax revenues tend to grow more strongly, and more public services will be available to citizens.

Table 2
Results of modified C-D production model for EU Group and Individual member countries

Sr. No.	Scale	Country/Union	Capital Elasticity (α)	Male Labor Elasticity (β)	Female Labor Elasticity (γ)	Return to Scale (α+β+γ)	SE(α)	SE(β)	SE(γ)	$AC = \frac{1}{\alpha+\beta+\gamma}$	TFP	R^2
1	Increasing Return to Scale	EU 28 with UK	0.8994***	-0.0762	0.1920***	1.0151	0.0072	0.0684	0.0668	0.9851	1.0511***	97.69
2		EU 27 Without UK	0.9018***	-0.0847	0.1903***	1.0074	0.0074	0.0694	0.0677	0.9927	1.0807***	97.65
3		United Kingdom	0.4498***	-0.2057	1.1536***	1.3977	0.0563	0.4018	0.3128	0.7155	0.3083	98.49
4		Slovak Republic	0.4664***	5.3088***	-0.0491	5.7261	0.0931	1.0151	0.6666	0.1746	-26.3906***	94.01
5		Slovenia	0.1105	0.5383	4.5222***	5.1710	0.0734	1.0406	1.1033	0.1934	-19.2606***	89.22
6		Czech Republic	0.5078***	2.0331*	1.1765	3.7174	0.0823	1.0422	0.7065	0.2690	-14.1491**	91.78
7		Malta	-0.1953**	2.4627***	0.4103*	2.6777	0.0783	0.6953	0.2336	0.3735	-2.7851	95.81
8		Cyprus	0.1139***	2.3841***	-0.3932*	2.1048	0.0292	0.3358	0.1940	0.4751	-1.8088***	98.62
9		Poland	0.8252***	-1.0057	2.2154**	2.0349	0.0460	0.8900	1.1046	0.4914	-5.7029	96.90
10		Hungary	0.5238***	-0.9005	2.3385***	1.9618	0.0338	0.5337	0.3695	0.5097	-2.2532	94.29
11		Estonia	0.5750***	-0.1511	1.4518	1.8757	0.0287	0.7214	0.8959	0.5331	-2.4819	96.95
12		Finland	0.4927***	-2.0010**	3.0644***	1.5561	0.0724	0.7653	0.6815	0.6426	-0.3739	96.04
13		Germany	0.2875***	-0.6199**	1.5428***	1.2104	0.0501	0.2609	0.0551	0.8262	2.3993	98.77
14		Netherland	0.2417***	-0.0079	0.9423***	1.1761	0.0330	0.3182	0.1085	0.8503	2.9654**	99.52
15	CRTS	France	0.3238***	-0.4984**	1.1599***	0.9853	0.0334	0.2417	0.1058	1.0149	3.8414***	99.38
16		Ireland	0.3457***	-0.7298**	1.2472***	0.8631	0.0274	0.3579	0.1764	1.1586	4.6012***	99.03
17	Decreasing Return to Scale	Portugal	0.2151***	-0.6988***	1.3356***	0.8519	0.0213	0.0926	0.0342	1.1738	4.9421***	98.72
18		Romania	0.3463***	3.3494***	-2.9381***	0.7576	0.0824	0.7879	0.5813	1.3200	4.6814	95.09
19		Sweden	0.7827***	0.9146	-0.9429	0.7544	0.0807	1.0801	1.0025	1.3256	3.3675**	94.53
20		Austria	0.5196***	-1.1312***	1.2337***	0.6221	0.0845	0.2778	0.1428	1.6075	5.2862***	98.30
21		Spain	0.3658***	-0.6611***	0.7666***	0.4713	0.0179	0.1006	0.0319	2.1218	7.2049***	99.60
22		Luxemburg	0.3160***	-1.1140***	1.2071***	0.4091	0.0660	0.1947	0.1576	2.4444	7.1873***	99.05
23		Greece	0.3678***	-0.9541***	0.9576***	0.3713	0.0271	0.2232	0.0394	2.6932	7.5475***	97.28
24		Belgium	0.3760***	-0.9480*	0.9385***	0.3665	0.0829	0.4955	0.1784	2.7285	7.6149***	98.57
25		Latvia	0.3878***	-2.6286***	2.4154***	0.1746	0.0310	0.5451	0.8091	5.7274	7.7937***	96.41
26		Croatia	0.3194***	-1.3171***	1.0971**	0.0994	0.0363	0.2572	0.4466	10.0604	9.4614***	96.63
27		Denmark	0.5558***	-1.4243***	0.8803***	0.0118	0.0355	0.5011	0.2939	84.7458	9.2524***	95.87
28		Italy	0.3148***	-1.0334***	0.4987***	-0.2199	0.0197	0.1305	0.0228	-4.5475	12.5121***	97.57
29		Bulgaria	0.1132*	-4.0776	2.7792	-1.1852	0.0640	2.5283	2.3775	-0.8437	18.0314**	44.42
30		Lithuania	0.2007***	-1.9896***	-0.7483	-2.5372	0.0503	0.3476	0.6453	-0.3941	24.6512***	97.95

CRTS = Constant Return to Scale, *** = Significant at 1 per cent, ** = Significant at 5 per cent, * = Significant at 10 per cent

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