Energy Dependence and Economic Growth

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Abstract

European economies' dependence on imported energy supply is one of the main problems of the region within the last 50 years. European Commission along with the World Bank emphasizes the importance of the diversification of the energy sources to renewable energy through the Climate Policies. This paper focuses on the possible solution of energy supply dependence of the region through energy productivity. Energy is one of the leading inputs in production and essential for the economic growth. This paper examines the effect of energy productivity on the economic growth for the selected energy importer countries. Standardized General Methods of Movements method is used for econometric analysis for the 1990-2015 period for 49 European and Commonwealth countries. Findings in this study shows that, when controlled for productivity being an importer does not affect the economic performance of these countries. Further, energy productivity by itself significantly improves the economic performance.

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Enerji Bağımlılığı ve Ekonomik Büyüme

Öz

Avrupa ekonomilerinin enerji arzındaki dışa bağımlılığı, son 50 yıldır bölgenin önemli sorunlarından biridir. Avrupa Komitesi, Dünya Bankası ile birlikte, iklim politikalarında enerji kaynaklarının çeşitlendirilerek yenilenebilir enerjilere dönüştürülmesinin önemini İklim Politikaları yoluyla vurgulamaktadır. Enerji üretim için ana girdilerdendir ve ekonomik büyüme için elzemdir. Bu çalışmada seçili Avrupa ülkelerinde enerji verimliliğin ekonomik büyüme üzerine etkisi incelenmiştir. Ekonometrik analizde 1990-2015 yılları arasında 49 Avrupa ve Milletler Topluluğu ülkeleri için Genelleştirilmiş Momentler Metodu (GMM) metodu kullanılmıştır. Çalışmanın bulguları verimlilik göz önüne alındığında enerji ithalatçısı olmanın ekonomik büyümeyi etkilemediğini göstermektedir. Dahası, enerji verimliliğinin kendi başına ekonomik büyümeye anlamlı bir etkisi bulunmaktadır.

Anahtar Kelimeler: Ekonomik büyüme, enerji, Avrupa, panel analizi, enerji bağımlılığı

1. Introduction

In meeting its current energy demands, the European Union is heavily dependent on imports of fossil fuels, with up to 80% imports of oil and 60% natural gas. Almost 97% of uranium used in European nuclear reactors is imported from countries including Russia, Canada, Australia, Niger, and Kazakhstan, with only 3% mined in Europe (Eurostat).

EU Energy policy was laid down in 2006 with the release of the Commission's green paper "A European Strategy for Sustainable, Competitive and Secure Energy". In launching the strategy, it was noted that Europe requires the importation of 50% of its energy for fuel and that global hydrocarbon reserves are being depleted. Investment of one trillion euros is required by 2020 in order to meet the expected energy demand and replace aging infrastructure.

One of the crucial setback against European sustainable economic growth is the rising imports of energy at rising prices. Access to energy resources will in the medium term play a more important role with the potential to risk seriously compromising EU economic growth. This explains why energy efficiency is one of the main aspects of the Europe 2020 flagship initiative for a resource-efficient. Energy efficiency is the most cost-effective and fastest way to increase security of supply, and is an effective way to reduce the greenhouse gases emissions responsible for climate change. As outlined in the Commission Communication 'A Roadmap for moving to a competitive low carbon economy in 2050', energy efficiency can help the EU achieve and even outperform its greenhouse gas emission reduction target (European Climate Foundation, 2010).

Making the EU economy more energy efficient will also have positive impacts in terms of economic growth and job creation. Energy savings free up financial resources that can be reinvested elsewhere in the economy and can help alleviate public budgets that are under strain. For individuals, energy efficiency means paying less on their energy bills. Energy poverty can be tackled strategically by taking energy efficiency improvement measures.

Finally, producing more with less energy should improve EU industries' competitiveness and give them the lead in the global markets for energy efficiency technologies. Energy efficiency and savings benefit the EU economy, the public sector, business and private individuals. For these reasons, the European Energy Strategy 2020 identified energy efficiency as one of the key priorities of EU energy policy for the following years (European Comission, 2015). The linkages between energy consumption and economic growth are explored in several studies, for example Lee (2005); Al-Iriani (2006); Lee & Chang (2005); Mahadevan & Asafu-Adjaye (2007); Huang, Hwang, & Yang (2008); Narayan & Smyth (2008); Apergis & Payne (2009).

This paper outlines the energy dependence of the 49 European and Commonwealth countries covering the period 1990-2015 and empirically shows the importance of productivity, in terms of using energy efficiently, on economic performance. Generalized Method of Movements (GMM) method is employed for the panel of 49 countries (Norway excluded) 28 EU Member countries and Norway and Switzerland also included. The findings in this suggest that, being an energy importer does not significantly affect the economic growth once the productivity is taken into account. In other words, a country may be dependent on energy imports, but once the imported energy is used efficiently, the effect of being an energy importer on economic performance would be minimal if any. Further, once energy productivity is taken into account, the effect of energy consumption by 10 times. In this case 10 increase in energy consumption, economic growth increase by 2.6. From this perspective, EU policies of energy should also emphasize the importance of efficient use of energy. There are distinct differences in terms of the way energy consumption affect economic growth between energy exporter and energy importer countries for. The energy endowment and high subsidization on energy inputs lead to low energy prices and therefore make energy as a cheap factor of production in energy exporter countries (Damette & Seghir, 2013). This further leads to distribution state benefits of energy endowments for the welfare of population and eventually contributes to economic growth of energy exporter country. Keeping recent increase in demand for energy and energy-intensive industries in view, it can be safely claimed that energy exporting countries are the energy intensive countries as well (Damette & Seghir, 2013). In countries as in this study these factors further set back the economic performance of the energy importer countries. Although not included in econometric analysis, Norway is the leading energy exporter in Europe and has significantly higher levels of energy productivity.

On the other hand, in energy importer countries technological costs increases, more financial resources are consumed which crowds out other economic activities (Chen & Galbraith, 2011). These facts stress the importance of energy productivity as a tool against the divergence between economic growth of energy importer and exporter countries. The policies in oil importer and oil exporter countries are different in relation to the nature of the macroeconomic determinant of the economic growth.

This paper is organized as follows. Section 2 outlays the energy dependency, productivity and consumption data of the region. In section 3 Methodology and Findings are represented. Section 4 concludes.

2. Energy Consumption and Dependency in Europe

This section outlays the characteristics of selected European countries in terms of energy, energy productivity and energy dependence data. This study uses balanced panel of 49 European and Commonwealth countries. 28 EU Member countries, (Norway and Switzerland are excluded) covering the period 1990-2015. Belgium, Bulgaria, Czech Republic, Denmark, Germany, Estonia, Ireland, Greece, Spain, France, Croatia, Italy, Cyprus, Latvia, Lithuania, Luxembourg, Hungary, Malta, Netherlands, Austria, Poland, Portugal, Romania, Slovenia, Slovakia, Finland, Sweden, United Kingdom, Iceland, Montenegro, Macedonia, Albania, Serbia, Turkey, Bosnia and Herzegovina, and Kosovo are the countries selected for this study.

Data in this study is obtained from the World Development Indicators (WDI) online database published by the World Bank, EUROSTAT and International Energy Agency (IEA). Annual data for real GDP in constant 2010 US dollars as a measure of economic output. Dependence on the energy is measured by the share of energy imports in total energy consumption. Labor force and real gross capital formation in constant 2010 US dollars are used as measures of labor and capital stock respectively.

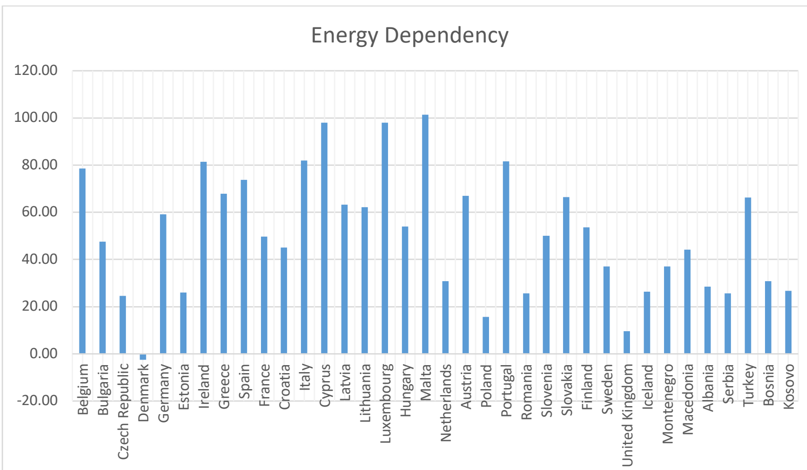
Energy consumption data are also from WDI database. Energy productivity measure is part of the EU Sustainable Development Goals (SDG) indicator set. It is used to monitor progress towards SDG 7 on affordable and clean energy and SDG 12 on ensuring sustainable consumption and production patterns. SDG 7 calls for ensuring universal access to modern energy services, improving energy efficiency and increasing the share of renewable energy. To accelerate the transition to an affordable, reliable, and sustainable energy system, countries need to facilitate access to clean energy research, promote investment in energy infrastructure and clean energy technology. SDG 12 envisions sustainable consumption and production, which uses resources efficiently, reduces global food and other waste, disposes safely toxic waste and pollutants. The indicator measures the amount of economic output that is produced per unit of gross inland energy consumption.

As defined by the Eurostat, Gross inland consumption represents the quantity of energy necessary to satisfy the energy needs of a country or a region. The ratio between net imports and gross inland consumption indicates the ability of a country or region to meet all its energy needs. In other words, it shows the extent to which a country or a region is dependent on energy imports. (Eurostat, n.d.).

In 2015 in EU-28, the highest need (gross inland consumption + international maritime bunkers) were for petroleum products, 602 Mtoe, of which 88.8 % were imported. For natural gas the needs in 2015 was 358 Mtoe, 69.1 % of it covered by imports. The production of solid fuels in EU-28 has been in decline over the last two decades as was its gross inland consumption. At EU-28 level in 2015, 42.8 % of solid fuels consumed were imported (Eurostat, n.d.).

The long trend since 1990, when import dependency was 44.3 %, shows an increased import dependency. On the aggregated level, this is increasing for all fuels, however in recent years some stabilization of this increase is evident (Eurostat, n.d.). The average energy dependencies of the each selected European countries for the 1990-2015 period are illustrated in Figure 1.

Figure 1. Average Energy Dependency of the selected European countries between 1990-2015



Note. Data retrieved from Eurostat.

Table 1. Energy Dependence in Europe

Country	1990	2000	2005	2010	2016
Belgium	75.1	78.1	80.1	78.2	76
Bulgaria	62.8	46			37.2
Czech Republic	15.3	22.8			32.8
Denmark	45.8	-35	46.7	39.6	13.9
Germany	46.5	59.4	27.8	25.5	63.5
Estonia	45.1	32.2	-50	-15.7	6.8
Ireland	68.6	84.9	60.5	60.3	69.1
Greece	62	69.5	26.1	13.6	73.6
Spain	63.1	76.6	89.7	86.6	71.9
France	52.4	51.5	68.6	69.1	47.1
Croatia	39.8	48.4	81.4	76.7	47.8
Italy	84.7	86.5	51.6	48.9	77.5
Cyprus	98.3	98.6	52.5	46.6	96.2
Latvia	88.9	61	83.4	82.6	47.2
Lithuania	71.7	59.4	100.7	100.8	77.4
Luxembourg	99.5	99.6	63.9	45.5	96.1
Hungary	49	55.2	56.8	81.8	55.6
Malta	100	100.3	97.4	97.1	100.9
Netherlands	24.1	38	62	56.4	45.2
Austria	68.5	65.4	100	99	62.4
Poland	0.8	9.9	37.8	30.2	30.3
Portugal	84.1	85.1	72	63.2	73.5
Romania	34.3	21.8	17.2	31.3	22.3
Slovenia	45.7	52.8	88.6	75.1	48.4
Slovakia	77.5	65.5	27.6	21.9	59
Finland	61.2	55.1	52.5	48.7	45.3
Sweden	38.2	40.7	65.3	63.1	31.9
United Kingdom	2.4	-16.9	54.1	47.8	35.3
Iceland	32.9	30.5	37	36.9	19.2
Norway	-437.1	-733.1	13.4	29	-633.4
Montenegro			31.1	13.9	34.7
Macedonia	47.7	39.9	-703.2	-522.8	58.7
Albania	6.6	46.6	42.1	26.3	21.1
Serbia	30	13.7	41.8	43	28.9
Turkey	52.9	65.7	50.5	30.5	74.9
Bosnia and Herzegovina			35.3	33.2	31.1
Kosovo		27.1	71.8	70.6	23.6

Note. Data retrieved from Eurostat.

Changes in the level of energy dependence during 5 year intervals can be seen from Table 2. Commonwealth countries energy dependence have increased mainly due to the fall of Soviet Union. Turkey's energy dependence has significantly increased for the past 16 years. Negative signs in Table 2 indicates that country is an energy exporter for the selected period.

Productivity indicator measures the amount of economic output that is produced per unit of gross inland energy consumption. The gross inland energy consumption is the primary energy consumption plus energy carriers employed for non-energy purposes. Countries with higher energy productivity even with higher dependence on energy still can grow at a considerable rate. The next table shows the relationship between energy productivity and the economic growth for the given period.

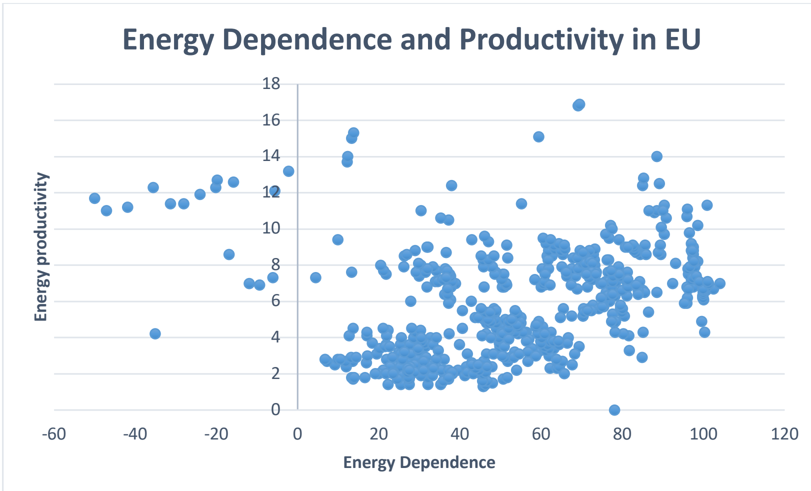
Table 3 shows the energy productivity rates of the selected countries. As seen from the table Norway is the leading exporter of energy but also has a considerably high productivity rate. Denmark, which is an energy importer has also higher level of energy productivity. Germany and Netherlands are examples of energy importers which also manage to increase their production with the same level of energy. Commonwealth countries' productivity rates are below the average of EU.

Table 2. Energy Productivity in Europe

Country	2000	2005	2010	2016
EU (28 countries)	6.5	6.7	7.3	8.4
Euro area (19 countries)	7	7.1	7.7	8.7
Belgium	5.2	5.8	6	6.8
Bulgaria	1.3	1.6	2.2	2.4
Czech Republic	2.8	3.1	3.4	4.2
Denmark	11.4	12.3	12.1	15.1
Germany	6.9	7.1	7.8	9
Estonia	2.1	2.7	2.4	2.9
Ireland	8.6	10.6	11	16.9
Greece	6.7	7.3	7.9	7.6
Spain	7	7.1	8.3	9.1
France	6.9	7	7.5	8.5
Croatia	4.2	4.5	4.8	5.4
Italy	8.9	8.6	9	10.2
Cyprus	5.9	6.7	7	7.5
Latvia	3.2	4	3.8	4.9
Lithuania	2.6	3	4.1	4.9
Luxembourg	8.4	7.4	8.7	11.4
Hungary	3.2	3.6	3.7	4.3
Malta	6.7	6.4	7	12.4
Netherlands	7.1	7.1	7.4	8.6
Austria	8.8	8.1	8.7	9.4
Poland	2.8	3.1	3.6	4.3
Portugal	6.6	6.4	7.4	7.5
Romania	2.3	2.8	3.5	4.7
Slovenia	4.3	4.5	4.9	5.6
Slovakia	2.3	2.8	3.8	4.8
Finland	4.9	5.2	5	5.5
Sweden	6.1	6.7	7.3	8.6
United Kingdom	6.9	7.7	8.7	11
Iceland	2.3	2.8	1.8	2.2
Norway	10.5	11.4	9.8	12.6
Montenegro	:	:	2.8	3.6
Macedonia	2	2	2.5	3.1
Albania	2.9	3.1	4.2	4.5
Serbia	1.4	1.7	1.9	2
Turkey	5.1	5.8	5.5	6
Bosnia and Herzegovina	:	:	:	2.1
Kosovo	:	:	1.7	2

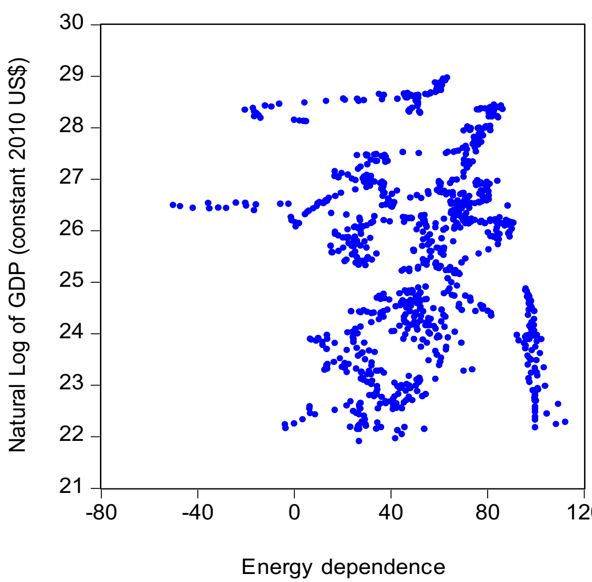
Note. Data retrieved from Eurostat.

Figure 2. Energy Dependence vs Energy productivity



Note. Data retrieved from Eurostat.

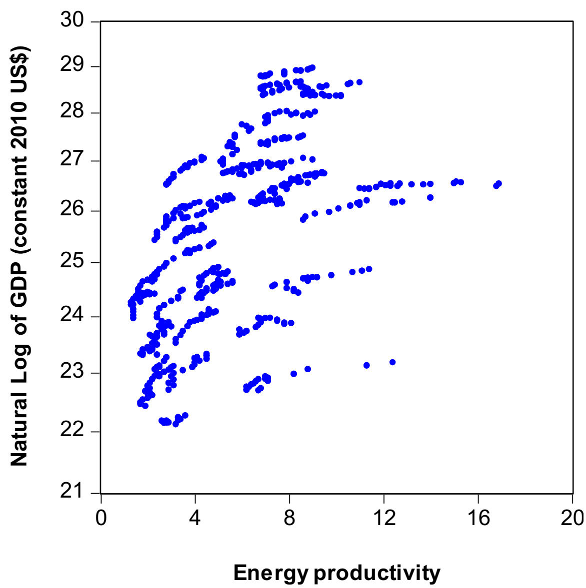
Figure 3. Energy Dependence vs Log GDP



Note. Data retrieved from Eurostat.

Figure 3 depicts the relationship between energy dependence and GDP for 49 European and Commonwealth countries between 1990 and 2015. Minus values for energy dependence indicate the country is an exporter of energy. As seen from the scatterplot, at a first glance there is no distinct positive or negative relationship. Seems more like there is another factor affecting the GDP.

Figure 4. Energy Productivity vs Natural Log of GDP



Note. Data retrieved from Eurostat.

Figure 4 shows the energy productivity GDP relationship for the selected 49 countries over the period 2000 and 2015. Although the nature of the relationship is positive, there is a distinct trend differences between countries. In other words, according to this data set, we may say for the European economies there is a positive relationship between energy productivity and GDP. However, it should be kept in mind that the countries benefit from the productivity differently, thus the magnitude of the effect differs for different countries. This is one of the reasons that country specific fixed effects in econometric analysis are being used, as will be shown in part 3.

3. Methodology and Findings

Following the literature (See, for example, among others Collins and Bosworth, 1996) a simple Cobb-Douglas production function which integrates energy as an additional factor along with the traditional physical capital and labour inputs is used in this study.

$$lnGDP_{it} = \alpha_i + \beta_0 \ln GDP(-1)_{it} + \beta_{1i} lnGCPF_{it} + \beta_{2i} lnLABOR_{it} + \beta_{3i} lnENERGYCONS_{it} + \varepsilon_{it} \quad (1)$$

$$lnGDP_{it} = \alpha_i + \beta_0 \ln GDP(-1)_{it} + \beta_{1i} lnGCPF_{it} + \beta_{2i} lnLABOR_{it} + \beta_{3i} lnENERGYCONS_{it} + \beta_{4i} lnENERPROD_{it} + \varepsilon_{it} \quad (2)$$

$$lnGDP_{it} = \alpha_i + \beta_0 \ln GDP(-1)_{it} + \beta_{1i} lnGCPF_{it} + \beta_{2i} lnLABOR_{it} + \beta_{3i} lnENERGYCONS_{it} + \beta_{4i} lnENERGYPROD_{it} + \beta_{5i} lnENERGYIMP_{it} + \varepsilon_{it} \quad (3)$$

GDP is the total output measured as Gross Domestic Product based on constant in 2010, US dollars, *GCF* is the physical capital stock as measured gross capital formation, *LABOR* is the total labour force. *ENERPROD* denotes energy productivity and *ENERDEP* is the share of imports in total energy consumption. *ENERCONS* is the total energy consumption within the economy. The subscripts i and t denote country and time respectively. All variables are in natural logarithms.

The model is estimated with Dynamic Generalized Method of Moments. This method was originally developed by Holtz-Eakin, Newey, & Rosen (1988) and Arellano & Bond (1991). Since then, similar techniques have been applied in growth research by Benhabib & Spiegel (1997, 2000), Easterly, Loayza, & Montiel (1997), and Levine, Loayza, & Beck (2000) among others. In this method, regression equation is written as as a dynamic panel data model by taking the first-differences to remove unobserved time-invariant country-specific effects. Further, levels of the series lagged two periods or more, under the assumption that the time-varying disturbances in the original levels equations are not serially correlated, are used as instruments for the right-hand-side variables in the first-differenced equations. In studying economic growth, this procedure has important advantages over simple cross-section regressions and other estimation methods for dynamic panel data models. First, estimates will no longer be biased by any omitted variables that are constant over time (unobserved country-specific or 'fixed' effects). Secondly, the use of instrumental variables allows parameters to be estimated consistently in models which include endogenous right-hand-side variables, such as investment rates, labor force and energy variables, in the context of a growth equation in this paper (Arellano & Bond 1991).

Taking the first difference of the model is

$$\Delta GDP_{it} \;=\; \alpha_i + \beta_0\,\Delta\, GDP(-1)_{it} + \Delta\beta_i X_{it} + u_{it} \qquad (4)$$

Where X_{it} stands for all the explanatory variables defined in specifications.

Panel Unit Roots Tests

GMM estimators require stationary data, so it's necessary to investigate the order of the panel series. To examine the degree of integration between variables, the panel unit roots test is used. The panel-based methods of Levin, Lin and Chu, Im Peseran, PP and ADF are employed in this paper. Table 1 shows the test results for robustness of the variables of interest in panel framework. All tests in Table 1 assumes individual intercepts. According to Table 3 majority of the test results (except for the Levin Lee Chu, for the levels of GDP, GCF, LABOR and ENERDEP) indicate that all variables are integrated in first differences that is I (1). In other words, based on the methods listed in Table 3, it can be concluded that series are generated by a stationary process.

Table 3. Generalised Method of Movements Estimates

	Levin Lin Chu		IM PESERAN		Fisher ADF		Fisher PP	
	Level	1st difference	Level	1st difference	Level	1st difference	Level	1st difference
GDP	-4.331***	-9.842***	2.336	-12.516***	72.142	301.935***	85.216	366.796***
GCF	-2.745***	-14.378***	-0.916	-16.365***	79.767	411.503***	58.876	531.651***
LABOR	-1.297*	-10.099***	3.666	-12.757***	77.176	318.500***	57.635	361.682***
ENERPROD	3.104	-17.670***	7.145	-14.057***	21.198	319.944***	18.455	396.604***
ENERCONS	0.377	-16.673***	0.309	-17.711***	74.945	452.761***	122.668	595.702***
ENERDEP	-1.863*	-19.429***	-1.024	-20.524***	101.051	468.534***	134.414	714.762***

Notes: All variables are in natural logarithms Panel unit root tests are: respectively Levine Lin Chu- the test results of Levine et. al.(2002), Fisher ADF and Fisher PP tests of Maddala and Wu(1999) Pesaran tests are of Im et al.(2003). The Levine, Fisher ADF, Fisher PP and Peseran unit roots tests examine the null hypothesis of non-stationarity. ***,** and* indicate the 1%,%5 and 10% level of statistical significance, respectively.

Table 4. Generalised Method of Movements Estimates

Dependent variable : Difference in GDP			
Independent Variables (in differences)	(1)	(2)	(3)
Lagged GDP	0,779***	0,577***	0,575***
GCF	0,130***	0,109***	0,115***
Labor	0,094***	0,035**	0,032*
Enercons	0,025***	0,270***	0,264***
Enerprod		0,053***	0,053***
Enerdep			-0,0003**
Instrument rank	300	254	254
SSR	0,896	0,219	0,213
J-Statistic	611,422	719,362	704,629
P value	0,000	0,000	0,000

Notes: Dependent variable is energy consumption. All variables are in natural log. Robust standard errors in parentheses. ***, ** and * indicate the coefficients are significant are 1%, 5% and 10% respectively.

In all specifications in Table 4 country fixed effects are employed. All variables are in differences. Coefficients, in this case show the relevant elasticities. As shown in Table 4 above, lagged GDP per capita emerges the significant determinant of economic growth at 1% level across all specifications. This finding indicates that there is not a convergence among the extended EU. Previous economic performance of the economy significantly increase the growth rate. Energy productivity coefficient is significant in all specifications and for every 1% change in productivity, economic growth would increase by about 5%.

One of the most interesting results of this study is that when controlled for productivity, the effect of energy consumption on economic growth significantly increases by nearly 13 times. In other words, 1% increase in energy consumption increases GDP growth by 2 % when productivity of use is not take into account. On the other hand, when energy productivity is included in the specification 1% increase in energy consumption increases GDP growth by almost 26%. This finding suggests that countries using energy efficiently can benefit from the same energy consumption in terms of economic prosperity by ten times.

Although the effect is marginal, imported energy has a significant negative effect in all specifications except for the case in which energy productivity is taken into account. The effect of imported energy approaches to zero and becomes insignificant.

The instruments validity and reliability are indicated by the Hansen test. Hansen test shows that we are unable to reject the null hypothesis of overall exogeneity of the instruments used in the estimation of dynamic system GMM.

In Table 4 the reported J-statistic is simply the Sargan statistic, and the instrument rank is greater than the number of estimated coefficients (6 at most), we may use it to construct the Sargan test of over-identifying restrictions (Sargan, 1958). Under the null hypothesis that the over-identifying restrictions are valid, the Sargan statistic is distributed as , where ρ is the number of estimated coefficients and κ is the instrument rank. Related p values of the Sargan test are given at the last row of Table 4. In all specifications the null hypothesis of over identifying restrictions are rejected.

The underlying assumption in the model is that, once controlled for the productivity being an energy importer does not affect the total economic output much. Countries like Germany are importers though use energy efficiently, benefit from the economic prosperity. One might argue that the factors which influence total productivity of the country's economy would also accelerate the efficient use of energy, thus the causality also goes from GDP to energy productivity also. This is a reasonable argument, but again it does not diminish the importance of energy productivity on economic growth.

4. Conclusion

The main purpose of this study is to stress the importance of productivity on energy especially for those who depend energy from the outside world. The sample of the study consists of 49 European and Common Wealth countries. Generalized Method of Movements analysis estimation results suggests that the effect of energy consumption on economic growth increases by the level of energy productivity. As the amount of production increases with the same level of energy consumed, more resources are turned into further production. According to the findings of this study, when controlled for productivity the effect of energy consumption on economic growth increases from 2 % to 26 %. In other words, once the countries use energy productively the marginal gain from energy consumption increases by 13 times. Further, the results are robust to being an importer. In other words, when we include energy dependency into equation, the effect of energy productivity on economic growth remains the same which is; 10% increase in productivity significantly increases the economic growth by 5%. Energy productivity, not only solely affect the economic growth but also increase the effectiveness of the energy consumption on economic growth.

This study stresses the importance of energy productivity for energy importer countries. Further studies should focus on the magnitude of the effect of energy productivity in a country base. This way, country specific factors could be outlined and policies regarding the productivity of energy can be outlined. The causal relationship between economic growth and energy productivity could be examined in future studies. Policies aim to increase energy productivity would be much effective once the factors causing increase in energy productivity outlined in detail for each economy.

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