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The Trajectory of Energy-Growth Relationships Revisited: A Multi-Sectoral Analysis with Relevance of Time Inclinations in Europe

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Abstract

This study examines the multidimensional impact of energy intensity (EI) and sectoral energy consumption on economic performance (EP). A sample of dataset includes European economies consisting of three decades from 1990 to 2020 is analyzed by employing several estimators and an inclusive estimation strategy for empirical robustness. This component of research is concerned with determining the trajectory of energy-growth relationships in order to explain changes in magnitude and intensity through time. This study is required in order to make an accurate comparison across time periods that how the change dimension is increasing or decreasing. Econometric practice is panel two step GMM. This study estimated by using GMM estimation and the results have been reported on the basis of probability values of F-statistics. The Kleibergen-Paap rk LM statistic with chi-square p-values of under-identification test are used to check the identification of the model. The chi-square probability values of Kleibergen-Paap rk LM statistics in all of the models of current study are highly significant

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which shows that model are identified. Moreover, Hansen J statistics are included to check validity of instruments. Our key findings suggest that energy intensity and energy mix on economic performance for European countries varies depending on the time era and degree of development. Results predict that economic expansion tends to be acutely susceptible to EI after 1990, and the lower the amount of income per capita, greater the sensitivity. It is also obvious that a broader approach is required.

Keywords: Energy intensity, Economic performance, European countries, Trajectory, Panel two step GMM.

Introduction

Every economy attempts to pursue economic growth, but nowadays, this objective is interspersed with energy consumption or energy demand. For economic accomplishments, energy is the essential element for producing goods and services. Various developing countries are expanding in response to the growing need for energy (IEA 2009). A rising economy needs more energy for its different economic activities. These objectors eventually generate strong interconnection relations between economic growth factors (Islam et al., 2011). Energy is accepted as an important curator for overall economic growth and other developments like industrial development. Energy is recognized as a dynamic component of economic and social development in almost all production processes, with the other production components such as labor and capital (Ghali and El-Sakka 2004).

Consequently, the importance of energy goes up, especially after the industrial revolution, and consequently, most economies increase their energy use for speedy economic progress. So, because of the transformation of industrialization and urbanization, their energy consumption increases, and ultimately, it boosts their energy demand. China is the largest energy consumer in the world. China's energy consumption has increased by more than 150 percent in the last few years. The vast majority of primary energy sources are derived from fossil fuels[i] (World Bank 2019). Perhaps it is obvious

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i Coal, crude oil, and natural gas are all considered fossil fuels in energy consumption.

that the use of fossil fuels as an energy source has resulted in numerous negative environmental consequences. A large source of greenhouse gas (GHG) emissions from stationary energy in the consumption of energy is non-renewable[ii] energy sources. Potentially, greenhouse gases are essential for the environment because they keep the earth's temperature warm.

As the structural transformation takes place in different economies, by the approach of agriculture to capital and energy-intensive industries and with a growing level of income, ultimately, economies are initiated with an increasing then decreasing rate of energy intensity. The Environmental Kuznets Curve (EKC) can be compared with an indicator of energy intensity because of its increasing and then decreasing nature. This shows the presence of EKC in the perception of energy use. It gives the impression of affiliation between income, the environment, and energy.

Cantos & Shahbaz (2017) suggest that the energy sector's innovation and efficient use of energy may be stimulated if economic development factors are combined with energy research and development (RD & D). In the energy sector, innovation is a path for economic development with efficient energy use, minimizing costs and reducing risk (Al Mamun, Sohag, 2018). In fact, in all production processes of developed and developing economies, energy products are utilized, but at this point, every economy should adopt sustainable production practices that lead to the ideologies of sustainable growth (World Economic Forum 2012).

In any economy, the measure of energy intensity is defined as the ratio of energy consumed to a country's gross domestic product. This metric is often used to assess economic performance as well as energy efficiency. The prominence of the "energy intensity indicator" in energy sector sustainability assessments is well known and causes tremendous concern. As a measure for monitoring sustainability, an energy intensity indicator is often used. The

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ii Term Non-renewable energy represents those energy sources that are energy sources that will deplete or not be replenished over our lifetimes.

Economic Energy Intensity (EEI)[iii] indicator is widely-adopted in econometric analysis of any economy to assess the economic performance of countries, even though the validity of this indicator is criticized in different studies as it is known as the white noise indicator or because of its decoupling nature.

The present economic growth trends have emerged over the last couple of decades and have been well-informed because of rising concern about the lack of sustainability. Even every economy, whether developed or developing, tries to move along a sustainable path of economic growth and efficient use of energy. As a result, at this point in the relationship, we must investigate an appropriate pattern of development (Schneider et al., 2010).Even though energy consumption is deliberated as a dynamic determinant of economic growth, we need to give keen consideration to the destructive use of this economic growth indicator for sustainable economic growth in practice.

As an example, energy intensity is frequently used to assess a country's energy efficiency. Considering the linkages between energy intensity and output, we therefore need a worthwhile approach to conjuring up effective policies to control emissions. In the literature, theoretically as well as empirically, the impact of energy intensity on economic production has been established. However, it is not well-defined (in the sense of appropriate and systematic clarification). But there are some influencing mechanisms and input-output relationships among energy and economic performance because when a unit of gross domestic product (GDP) is applied to energy consumption (with labor and capital as inputs) to contribute to economic performance or growth, that can ultimately lead to economic situation up and down. These influencing approaches are not well defined by mainstream macroeconomic theories.

[iii] The margin among primary energy consumption (e.g., tones of oil equivalent or MJ of gross energy need) and GDP is used to calculate an economy's economic energy intensity (EEI), which is described as the amount of energy required to make a certain amount of gross national product (e.g., international purchasing power parity, real dollars).

Although different main stream economists, namely, Solow 1956; Barro & Sala-i-Martin 2003; Mankiw 2006 and Aghion & Howitt 2009 also mention the energy associated constraints that are directly correlated with economic growth. In earlier studies, by using different econometric techniques, they found the relationship between consumption of energy and economic growth was either affected by each other or not (Karanfil 2009). Generally, in the literature, there are few studies that show from energy intensity, there is a chain of causation to gross domestic product (GDP), but there is certainly not strong evidence that explains why overall cuts in energy intensity adversely affect the GDP and economic performance (Payne, 2010). Further study is needed to find a proper link between these variables and measure how much improvement is essential to achieve the national goal any economy. Duro and Padilla's 2017 study emphasized the significance of energy mix variations and consumption patterns in explaining differences in energy intensity (EI) transversely states.

A lot of research has been done on the negative associations between energy intensity and economic expansion in advanced or developed economies. This study demonstrates that the negative correlation is not limited to industrialised nations. To put it another way, declining energy intensity is indeed indicative of case of emerging countries where capital expansion, rather than technical progress, is a primary driver of development, as it is in industrialised economies. Every growing economy is making efforts to link economic energy intensity, environmental quality, and economic performance dynamics to accomplish this apprehension. Researchers like Shahbaz et al. (2015) describe energy intensity and CO_2 emissions having a long-term linkage between them. With innovative technology that is used for globalization, it eventually mends energy intensity for the host country.

This relationship has been well-studied in the literature for European countries, but the empirical findings differ because of different econometric techniques, time frames, and variables. This study's results provide a conceptual and robust framework for a better understanding of these linkages in the developing and emerging economies of Europe and provide other policymaking and strategies to increase overall economic growth in different time trends. In previous literature, this study contributes on several fronts. This study's analysis deals with larger data sets. Secondly, in the analytical part, the study uses a multivariate framework. This study attempts to separate energy growth relations with different energy mixes across different regions and time trends. This study utilizes current panel techniques that allow for cross-sectional dependence and heterogeneous unobserved parameters. This study also integrated a set of control variables which are related to socio-economic conditions, institutions, policies, as well as human and physical capital. Rest of this paper is establishing with following outline: Section 2 as literature review. Section 3 objective of the study, Section 4 designates the empirical model and data used in this study. The descriptive and empirical results are performed in Section 5. As a final point, Section 6 offers our conclusion.

Literature Review

In previous literature few researches have looked at the relationship between energy intensity and economic performance and environmental quality. These studies found that energy intensity have some strong linkages with environmental quality and factors of economic growth. In earlier phase of energy literature contracts having a wide range of studies that had mixed outcomes regarding economic growth nexus and energy consumption. Since the pioneering study done by Kraft and Kraft (1978), the energy-growth relationship has been extensively examined empirically. To sustain long run economic growth a comprehensive energy plan is needed to help economic policy architects but these inadequate empirical evidences are unable to support in this perspective (Payne 2010; Ozturk 2010).

The estimated results in literature show that a unidirectional causality run from energy consumption to economic growth both in the short and the long run. It is investigated that dynamic linkage between energy consumption and economic growth though in some specific case of developing countries significantly reject the ‘neo-classical’ assumption that energy use is neutral to economic growth (Alam & Van, 2012).

Tamazian et al. (2009) using standard reduced-form modeling approach studied the impact of economic development coupled with financial development on environmental degradation for Panel data 1992-2004. As explanatory variable energy consumption and per capita GDP were incorporated for economic development, Research and Development (R&D). The study findings proposed that initial the level of carbon dioxide increased with per capita GDP and industrial share in GDP whereas curvilinear concerns explicated that the per capita carbon dioxide emissions start to decrease as economic growth rate was shown with increasing rate. In any economy to know how efficiently energy is using and added-value production, energy intensity is most promising indicator for it. In terms of energy, a high ratio of energy consumption per capita and a low energy intensity are excellent conditions for development. So energy intensity is ultimately an indicator of energy intensity. Conceivably this situation can be attaining if efficiently utilization of existing energy resource is done and less use of energy is run-through for goods and service (EMO 2012).

The International Energy Agency (IEA) (2009) reports that, the first time since 1981 the over-all energy usage is probable to drop pointedly. Yet, once economic recovery gathers pace. The energy demand would be up trend. From 1971 to 2015, for production deeds the worldwide energy demand had increased 150%.

Stern (1993) for the duration of 1947 to 1990, in US found association among energy and GDP. A multivariate adaptation of the test-vector auto regression (VAR) does permit to test causality. A VAR is estimated for causal relations amongst the variables as GDP, energy use, employment and capital stock and Granger tests are approved. The findings go on to say that there is no evidence that Granger's gross energy use causes GDP.

Lee and Chiang (2008) during the 1971–2002 duration establish a long-run causality amongst energy use to economic development in 16 Asian economies. To investigate the causal relationship between these variables panel-based error correction, heterogeneous panel cointegration and panel unit root were used and to includes capital stock and labor input applied a multivariate framework. Results formulate that with heterogeneous country effect there is positive cointegarted relationship among GDP and energy use and find out long run unidirectional causality between both of them. It means that in short run with increase in energy consumption does affect but it would in long run.

Mahmood and Ahmaad (2018) described the relationship among energy intensity and economic development. In European countries due to technological changings complementary growth the energy intensity may decreases with economic growth take pace. While analyzing the energy-growth relationship in use of energy this study eradicates the possessions of technical changes and took by trend while analyzing. The observed study indicates that in response to economic growth the energy intensity is significantly reduced even while the former is de-trended. Among economic development and intensity of energy this inverse relation is also proved in previous studies although in the energy-intensity series sluggishness is controlled from side to side taxes in environment, energy consumption and transport.

Energy consumption per output (level of energy intensity) may reduce during in consumption or production process over time, when in any economy universal technological take place and new technologies' consumption took place through financial development, these conditions are cross ponding to close association to the efficiency of energy. To measure the efficiency of energy in an economy through technological change, the autonomous energy efficiency index (AEEI) is used. This index tracks technical advancements that lower energy consumption per unit of output while remaining unaffected by price fluctuations in the economy (Bataille c., Rivers and Jaccard, 2006). Generally, the assessment of the above-mentioned studies revealed that there is a clear and important relationship between economic performance and energy intensity. These relations are investigated with different estimation techniques and methodology patterns with different data sets. But here taking a dynamic glance of this relation with heterogeneity of different time trends prospect to do more investigation and find this relationship in the border sense.

Objective of the Study

Here emphases on dynamics of Energy in particular selected time period 1990-2020. The concerned objective is analyses of heterogeneity, with Energy intensity and Energy mix in different time spans which categories as three consecutive decades. The goal of the research described in this paper is to determine whether nonrenewable and renewable energy sources have different effects on economic activity in different era of time and to try to investigate how substituting renewable energy for nonrenewable energy boosts economic growth in Europe, in diverse time spans and changes in income levels as in the developed and developing countries categories of Europe. This research further focuses on several goals as examine flexibility and variation in energy intensity, deviation of energy mix (as shifting from non-renewable to renewable sources of energy) which stimulates economic progression in different time periods in reference of European countries.

Empirical Application and Data Sources

To achieve the objective of this study selected time span is 1990-2020 and selected area of study is Europe. According to the most recent United Nations statistics, Europe's current population is 748,303,802 as of 2021. Europe's population accounts for 9.78 percent of the total global population. Europe is ranked third among world regions (roughly equal to "continents") in terms of population. Cities are home to 74.5 percent of the population in 2019. Europe is divided in developed as well as developing countries in Europe. As a result, three-decades temporal trend was established from 1990 to 2020. The first decade encompasses 1990 to 2000, the second decade encompasses 2000 to 2010, and the third decade encompasses 2010 to 2020.Economic growth is taken as proxy of economic performance as dependent variable and energy intensity as leading regressor. Energy mix is elaborated in two categories renewable and non-renewable resources. List of control variables is also included to clearly elaborate energy economic relation which are technology and policy factors as investment, inflation, urbanization and trade opens. All Data is generated from world development indicator (WDI). To explore the energy-growth relation between different time trends through theoretical framework, data is collection both the principal and the final energy composition, with set of macroeconomic variables that gives essential supported for growth of GDP. Here determines an alternative specification with the choice of macroeconomic factors to reconnoiter the sensitivity of growth-energy effects but also combined with the indirect effects of energy variables. As all conditions followed so general functional form will be as followed;

$$GY_{i,t...n} = \alpha + R_i + T_{t...n} + \beta \ln\left(\mathrm{Y_{i,t-n}}\right) + \theta' XE_{i,t} + \gamma X_{i,t} + \varepsilon_{i,t} \quad (1)$$

the set of variables $\left(R_i, T_t, \ln\left(Y_{i,t-\mathrm{n}}\right), \Delta EI_{i,t}\right)$ is always included, as regional $R_i$and $T_t$time dummies, the $\ln\left(Y_{i,t-n}\right)$lagged of GDP per capita income, and the change $\Delta EI_{i,t}$in energy intensity that is in expression (1). In addition, the rest of control and instrumental energy variables in (1). Here the term $\theta' XE_{i,t}$ is express as overall set of energy variables that establish as follow.

$$\theta' XE_{i,t-n} \equiv \theta_0 \Delta EI_{i,t-n} + \sum_{p=1}^{J-1} \theta_p^m \Delta m_{p,i,t-n} + \sum_{u=1}^{K-1} \theta_u^s \Delta s_{u,i,t-n}$$

Here further time trends, decades wise presented in below equations refers as 2, 3 and 4

$$GY_{i,t1} = \alpha + R_i + T_1 + \beta \ln\left(\mathrm{Y_{i,t-1}}\right) + \theta' XE_{i,1} + \gamma X_{i,1} + \varepsilon_{i,1} \quad (2)$$

$$GY_{i,t2} = \alpha + R_i + T_t + \beta \ln\left(\mathrm{Y_{i,t-2}}\right) + \theta' XE_{i,2} + \gamma X_{i,2} + \varepsilon_{i,2} \quad (3)$$

$$GY_{i,t2} = \alpha + R_i + T_t + \beta \ln\left(\mathrm{Y_{i,t-3}}\right) + \theta' XE_{i,3} + \gamma X_{i,3} + \varepsilon_{i,3} \quad (4)$$

At this time describing movement as

$$Z_{li} = \begin{bmatrix} \Delta Y_{i2} & 0 & 0 & \cdots & 0 & \cdots & \\ 0 & \Delta Y_{i2} & \Delta Y_{i3} & \cdots & 0 & \ldots & 0 \\ . & . & . & \cdots & . & \cdots & . \\ 0 & 0 & 0 & \cdots & \Delta Y_{i2} & \cdots & \Delta Y_{iT-1} \end{bmatrix}; U_i = \begin{bmatrix} u_{i3} \\ u_{i4} \\ \vdots \\ u_{iT} \end{bmatrix}$$

Following that, the course of the most recent situations can be expressed as follows:

$$E(Z'_{li} U_i) = 0$$

These above moment conditions with GMM estimator will be:

$$\widehat{\alpha_l} = \frac{Y'_{-1} Z_l W_N^{-1} Z'_l Y}{Y'_{=1} Z_l W_N^{-1} Z'_l Y_{-1}} \text{with qi} = (\Delta \text{Yi}', \text{Yi}')'$$

This moment condition estimator is called ($qi = (\Delta yi', yi')'$) GMM system estimator.

The following mathematical expression is applied to present the entire set of linear moment conditions:

$$E(Y_i^{t-2} \Delta u_{iL}) = t = 3, \ldots\ldots, T$$
$$E\left(U_{it} \Delta Y_{i,t-n}\right) = t = 3, \ldots, T$$

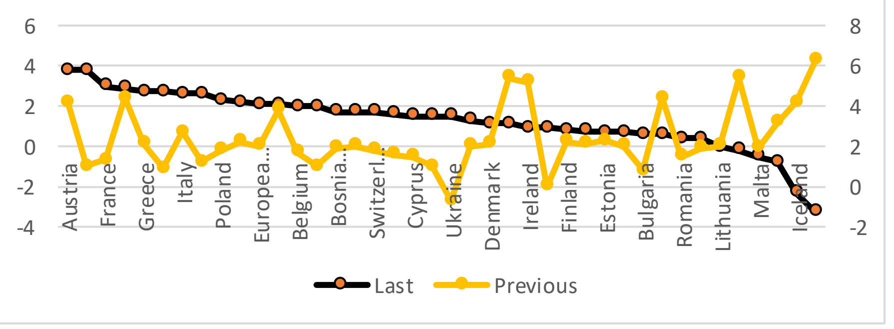
Descriptive and Empirical Results

This component of the research is concerned with determining the trajectory of energy-growth relationships in order to explain changes in magnitude and intensity through time. This section of the study is required in order to make an accurate comparison across time periods and establish if the change dimension is increasing or decreasing.

Make a differentiation across time periods to see if the mid-1980s oil price crisis had an effect on the energy-growth link. The decade of the 1990s was picked. For better sympathetic of the econometric technique and its results (in the form of figures), here is a descriptive analysis of the variables involved. GDP growth is a crucial metric for assessing economic performance. This economic development indicator is tied to practically every aspect of the economy.

As shown in Figure 1, the GDP growth trend toward the last and previous values with respect to countries is still increasing in Austria, Norway, Portugal, Turkey, Italy, and other countries, while it is negative in Ukraine, Moldova, and ice land. These findings indicate that GDP growth is both increasing and dropping.

Figure 1: In European countries last and previous trend of GDP

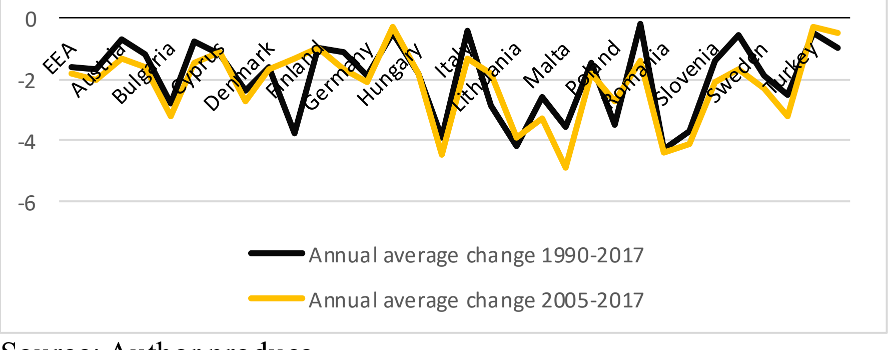


Source: Author produced

During this time, the rate of decline of EI in Europe was relatively constant. 1990 and 2005, the economy grew at a relatively fast pace, although gross inland energy consumption grew at a slower pace. However, the decade from 2005 to 2015 was marked by slower economic development and lower gross inland energy intake. As a result, the rate of fall in EI in both cases is quite similar.

Next figure is establishing in context of annual average change in energy intensity in different era of time. Results from 1990 and 2015, EI was reduced by 1.7 % annually in Europe and 1.6 percent in EEA member countries. In 2015, EI in the second quarter of 2018 was 35% lower than it was in 1990, and it was 34% lower in EU participating nations.

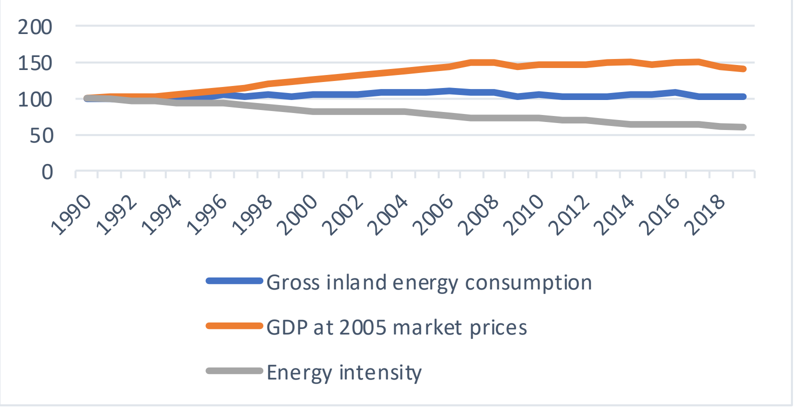
Figure 2: Annual average change in European energy intensity from 1990 to 2020



Source: Author produce

Between 2005 and 2015, the energy intensity of all European member countries declined. As to deviations in their economic structure, the highest decreases were seen in central and east region of Europe (e.g. Lithuania, Romania, and Slovakia) Iceland, Liechtenstein, Norway, Switzerland, and Turkey are all part of the Europe. These time wise trending is explaining in figure 4.

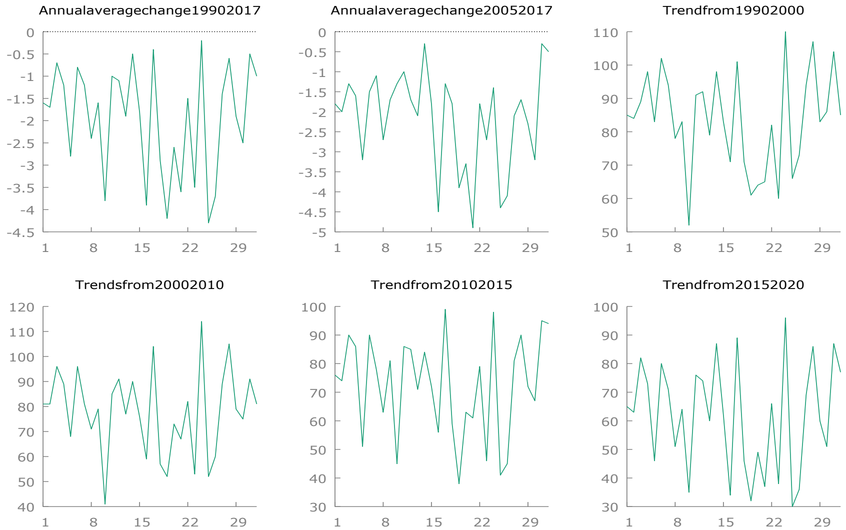
Figure 3: Trends in energy consumption, GDP and energy intensity relative to Europe in 1990-2018



Source: self-generated

Figure 4: Trend in Average energy intensity in Europe from 1990-2020

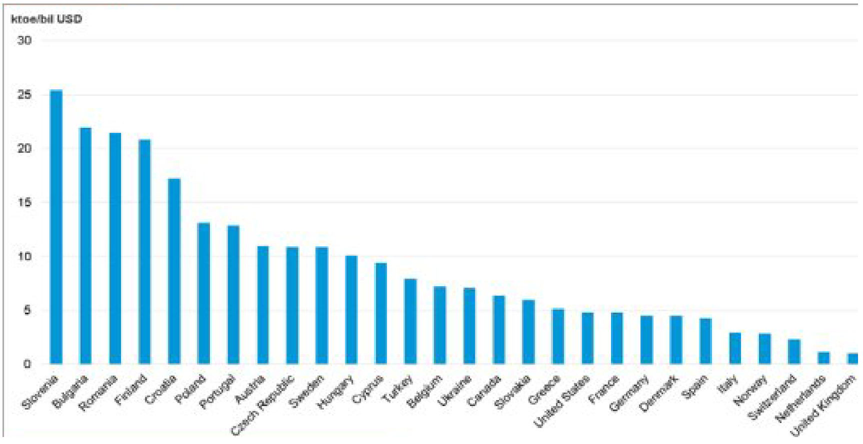
Source:



Author generated

Since 1990 and 2005, Europe had a relative decoupling of economic growth from gross inland energy consumption (as above diagrams shows), with energy consumption growing at a slower rate than GDP. Since the peak in gross inland energy intake in 2005/2006, there has been an absolute decoupling of economic growth from gross inland energy consumption. Despite a ten-point increase in the economy, gross energy intake in the Eurozone was 11.2 percent lower in 2015 than it was in 2005. Furthermore, in 2014 and 2015, both GDP (2.2%) and gross national energy intake (1.2%) increased in the Europe. The energy intensity declined as GDP expanded faster than gross inland energy consumption (1.0 percent). Surprisingly, after 1990, the sensitivity of growth to EI improved (in absolute terms) ranging as -0.2 to-1.45.

Figure 5: Renewable energy intensity of European economies (renewable energy consumption as a percentage of GDP)



Source: Euro. Statistic

A combine comparison of GDP, Gross inland energy consumption and energy intensity is presented in figure 4. Movements from 1990-2018 showing increasing then decreasing values in all above mention variables. These decline in energy intensity and energy consumption can be justified as Energy efficiency gains — both for end users and for energy production — and also shown a rise in RE in the energy portfolio and structural alterations in the economy (see figure 5), all of these contributed to the observed decrease in energy intensity. The latter comprises a shift in industrial sectors from energy-intensive to less energy-intensive, higher-value-added industries, as well as an increase in the contribution of services to GDP.

After given a deep glance of imaginative and eloquent analysis with respect to energy intensity, GDP growth, energy consumption and renewable sources of energy in different time periods. Now a 2-step GMM estimation is done with context of time period. Here examining set of variable is same as use in previous estimation. Again relationship between energy intensity and economic performance is examine (with energy mix and control variables) in three different time decade. Time wise econometric estimation result is presented in table 1.

Table 1: 2-Step GMM estimation with Time periods

Depended variable: GDP per capita growth (GDPG) as proxy of Economic performance

GDPG	1900-2000	2000-2010	2010-2020
Energy.I	-1.457***	-0.507***	0.202***
	0.005	0.002	0.000
Fossil.E	0.290	-0.048	-0.048
	0.214	0.364	0.364
Renewable.E	-0.598*	-0.170***	-0.170***
	0.034	0.002	0.002
Industry.S	0.002***	0.010***	0.020***
	0.000	0.000	0.000
Agri.S	-0.005	-0.001**	-0.001**
	0.206	0.013	

			0.013
Household.S	-0.010	-0.020**	-0.330***
	0.986	0.045	
			0.045
Urban	0.727	-0.330***	-0.330***
	0.291	0.000	
			0.000
Tran.S	-0.104	-1.576	-1.576
	0.978	0.246	
			0.246
L1.	0.020**	0.030**	0.120**
	0.041	0.015	
			0.015
Number of obs = 134 **F(10, 94) = 5.31** **Prob > F = 0.0000**			

Under identification

(Kleibergen-Paap

rk LM statistic)	**14.616**	**113.539**	**113.539**
Weak identification			
(Cragg-Donald Wald F statistic)	24.217	313.940	313.940
(Kleibergen-Paap rk Wald F statistic)	12.685	52.004	52.004
Over identification			
(Hansen J statistic)	2.995	0.028	1.107

Note: Instrumented: Urbanization, lto. Included instruments: Energy.I, Fossil.E, Renewable.E, Industry.S, Agri.S House hold. S. Further Excluded instruments: L.lto L2.lto L3.lto L2. Urban. Variables are significant at 1%, 5% and 10% as mention*, **&*** respectively.

Outcomes of estimation elaborate energy intensity having negative impact on economic performance in first two era of time from 1990-2010, because between 1990 and 2015, all countries experienced a decoupling of GDP growth from gross national energy intake, either in absolute or relative terms. But in case of 2015-2020 energy intensity having positive impact. These positive impact is justified because after 2015, there were significant differences in EI among the Europe associate nations.

The countries with the uppermost EI were Bulgaria, the Czech Republic, and Estonia. The countries with the lowest EI were Denmark and Ireland (Eurostat). Surprisingly, after 1990, the sensitivity of growth to EI enhanced (in absolute terms) from-0.5 to-1.4.

Furthermore, the share of fossil fuel in the energy mix after 1990 has a negative impact on economic performance until 2020, but it appears to be positive in the early 1990s. After 2000, the results can be justified and interpreted by using an environmentally friendly energy source (to overcome the environmental damage). According to Mich and Papie (2014), trends of causality exist based on nations' degrees of confidence in EU energy policy objectives. These authors suggest that the greater the reduction in global emissions, the lower the energy intensity and the higher the proportion of renewable energy consumption over overall energy consumption.

Renewable energy sources and economic performance in all period of time having negative sing as previous estimation also have. The renewable share's coefficient likewise rises from -0.5 to -1.17. Again this negative relation is appropriate with previous suggestion that adaptation of new techniques is not a free lunch. These editions in the economy's structure and an increase in RE (in the power mix) are also time-consuming and costly.

Sectoral energy consumption in different sector of economy and economic performance have the same magnitudes as in literature observe. In different period of time practical in above (table 1) estimations Household and agriculture and transport having negative impact. Industrial sector and economic growth have positive impact.

In case of control variable which is investment but magnitude of investment is also as accepted (positive). The investment coefficient likewise increases from 0.02 to 0.12. Despite the circumstances in Europe after 2000, economies such as Germany, Estonia, Poland, Turkey, and Norway have made significant progress toward development which require additional investment.

Conclusion

In this chapter the impact of heterogeneity for energy intensity and energy mix on economic performance for European countries between 1990 and 2020 is investigated. Aside from urbanization, the association among nonrenewable and renewable energy (NRE) and (RE) usage is studied, taking into account GDP growth, the percentage of energy in industry, agriculture, and households. The study's main contention is that the relationship concerning with growth and EI varies depending on the time era. The long-run relationship's results are based on an adequate aggregate general production function that explicitly mentions energy use. Results predict that economic expansion tends to be acutely susceptible to EI after 1990, and the lower the amount of income per capita, greater the sensitivity. It is also obvious that a broader approach is required.

Those with higher incomes have lower energy intensity than countries with lower incomes because energy intensity is inversely related to GDP growth. Share of non-renewable energy sources having positive impact in start of 1990s but then in next phases of time trend it become negative. Nonetheless in case of renewable in almost time periods time having negatively correlated with depended variable. Other factors, such as share of energy in urbanisation and industrialisation, may have an impact on economic performance in addition to energy intensity. These variables in long run estimation with two-step GMM, having significant but negative impact on economic performance. For the reason that economic performance is complicated by the fact that urbanization not only increases economic activity by increasing the absorption of consumption and production, but it also contributes to economies of scale and the opportunity to increase efficient use of energy.
Industrialisation, or the introduction of innovative tools for processes to manufacture products, improves manufacturing activity of any nation, which requires more energy than traditional or conventional means of agriculture or manufacturing. This means that, while industrialization requires more energy for the production process, it also improves economic performance. However, a comprehensive exploration of heterogeneity is beyond the bounders of elucidation and will be left to future research.

Finally, if variables such as energy intensity and main energy configuration are adjusted in the regression analysis, then verdict suggests that share of energy, in the residential, agri. and transport sector is negatively connected with economic performance while the industrial sector having positive impact. Our estimates range between -0.5 and -1.5, implying that economies with per year rise of 1 p.p in the share of the residential sector (compared to the primary sector) have lower value of GDPG between -0.5 and -1.5 percentage points. These finding implies that neither the growing importance of energy intake in services, mostly perceived in developed countries, nor the increasing energy intake in industry. So it can be interpreted that, if in any case Europe is able to take advantage of maximum prospective of energy efficiency or decline in EI in the next few decades, this region may not only reap substantial economic gains (in terms of cost savings) but also ensure cleaner environment for its inhabitants. According to the study outcomes description, momentous affirmative returns in this account are accessible even with the already prevailing technologies.

As a result, the overall evidence derived from the study's main findings suggests that policymakers should emphasis further on urban planning as well as clean energy development in the long run. It is expected to make a significant contribution not only to reducing non-renewable energy use but also to climate change mitigation.

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