Gulzar, F. and Chaudhry, I. S. (2022). Energy Intensity, Energy Mix and Economic Performance in European Regions: A Dynamic and Heterogeneity Analysis. *Bulletin of Business and Economics, 11*(1), 153-162. Doi: https://doi.org/10.5281/zenodo.7107485

Bulletin of Business and Economics
ISSN - 2409 - 9368

ENERGY INTENSITY, ENERGY MIX AND ECONOMIC PERFORMANCE IN EUROPEAN REGIONS: A DYNAMIC AND HETEROGENEITY ANALYSIS

FATIMA GULZAR[1], IMRAN SHARIF CHAUDHRY[2]

Abstract

This study investigates the impact of energy intensity on economic performance of European countries with heterogeneity analysis which differ across regions. Applied technique is panel two step GMM from 1990-2020. This study estimated by using GMM estimation and the results have been reported on the basis of probability values of F-statistics, Hansen-J statistics and under-identification tests. 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 which shows that model is identified. Moreover, Hansen J statistics are included to check validity of instruments. Results predict that the coefficient of energy intensity is negative and statistically significant in almost all regions of Europe. The probability values of F-statistics of model reveal that the model used in the study are highly significant. Results of concerned variables in this variability of energy economic progress is same with aspect to region wise heterogeneity but South European region is slightly less energy efficient and having more energy intensities than Nordic and Central European regions. Based on the aforementioned results, here provide a set of recommendations for policy implication.

Keyword: Energy intensity, economic performance, region heterogeneity analysis, two step GMM, European counties

1. Introduction

The analysis of the Europe energy intensity would enable us to suggest an appropriate energy and sustain economic growth for better living standards in this region. Major agenda of sustainable development strategic goals of Europe is to reduces level of energy intensity and improve its utilization efficiency, until 2020. Further according to European "Energy Efficiency Plan agreement", EU member states are foreseeable to achieve 20% savings in their prime energy intake but eventually Europe achieve half of this target till end of 2020 (European Commission Energy 2020). As per previous study results suggest that energy intensity and economic progression are inter link and both influence to each other wise versa. So it may be predictable that in diverse frugalities as development proceeds applies compression on energy demand and thus rises energy intensity. On the other hand, after attaining certain development stages, it is expected that it can diminish energy intensity as both households and producers. So stages of development as developed, developing and level of income have strong relation with energy intensity (Jimenez, Mercado, 2014).

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%.

Many revisions reveled that outcomes of this relation differ with period, set of countries, include variables, on method of investigation and state production technology. So it can be ultimate that Energy intensity and the energy mix influence diverse giving to time, regions and income levels. This study accomplished with some robust findings, in connection of energy composition and intensity with economic progression through possible heterogeneous configurations. Here discover heterogeneous patterns, in concern of region, time and level of development, more including set of institutional variables. 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%.

The elements of energy intensity that were reconnoitered in previous studies are mainly: Gross Domestic Product Per Capita, prices of fuels and energy goods, energy intake per capita, CPI, and taxes but in this piece of work selected determinates are Gross Domestic Product Per Capita, urbanization, population growth, renewable and non-renewable energy resources, final energy consumption.

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 region. Nevertheless, as it is normally followed for

[1] Phd Scholar, School of Economics, Bahauddin Zakariya University, Multan, Pakistan. Email: fgulzar@gudgk.edu.pk
2 Professor and Director, School of Economics, Bahauddin Zakariya University, Multan, Pakistan, Email: imran@bzu.edu.pk

economic performance in the recent empirical growth literature, here use a closing of non-overlapping thirty-year periods of unbalanced panel data. While for evaluated and measured growth rates and other variables over thirty-year periods lagged variables are introducing in empirical model. Our sample contain a number of countries, so sample enclosed with highly heterogeneous.

Rest of this paper is establishing with following outline: Section 2 as literature review. Section 3 offers conceptual framework and hypotheses., 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 and policy recommendations.

2. Literature Review

According to Liddle (2010) indicator of energy intensity are different in different regions and countries. There are four main factors that explain nature of energy intensity (EI) in different economies is different. Firstly, it can be different because of economic structure (total share of energy intensive industries), secondly, use of energy in many segment or sectoral of economy. (shares of energy for different means of uses like transport, buildings and transport), third, efficiency in the end-use energy conversion and fuel mix. For making distinction between the non-goods imported and goods imported economies the study of efficient energy intensity (EEI) would require that help analysis to elaborate more. The empirical evidence is varied across different countries because of country's energy efficiency polices, uses of energy resources, energy consumption patterns and research and development path of country. So empirical results are different in different regions as is unidirectional, bi-directional causality to no causality. In ongoing literature discussion on relation between energy consumption and economic growth have prodigious importance.

Empirical analysis in the period of 1971-2010 based on 75 countries indicated that Energy intensity deteriorate as income upsurges. Another research work based on upsurge economy of china that assessing Energy intensity and its determinants positive connection among the energy efficiency and income per capita. The main result clarify that efficiency of energy goes improve as experience upswing in income per capita. Consequently, it can be predictable that as countries turn out to be more advanced, realms will practice additional efficient sources of energy that ultimately decrease in intensity of energy (Wu Y, 2012).

This assumption of increasing GDP and decreasing energy intensity is used in different research work that used different panel of data as definite by Soligo 2001, who used panel econometric methods to determine the influence of growth on total energy usage. Further estimation reveled the same results by using data from Asian developing countries time period of 1973 to 1990 (Galli,1998), further used a sample of 28- developed countries of OECD taking period of 1979 to 1995. Several authors have put emphasis on importance of energy economic relation through substation of capital and energy in short run (Díaz and Puch; 2004). 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). Empirical evidence confirmed that Economic growth and energy intensity increase CO_2 emissions, while financial development condenses it. There are long run relationship and variables are conintegrated (shahbaz 2013).

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).

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, 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;)
Mulder and de Groot (2011) find that energy intensity developments through 18 OECD countries and 50 economies sectors, findings explain that in most manufacturing sectors across the countries reductions in energy intensity have driven. The aggregate energy intensity dynamics will increase with variations in the sectoral composition of economy. More by within-sector Structural changes explain a considerable and increasing part of aggregate energy intensity dynamics.
Stern and Cleveland, (2000) explore the relationship between different flows of energy and economy involves aggregation. Here review the methods for aggregating energy flows and for aggregation, economic approaches using prices or marginal product. Analysis suggest that economic aggregation with marginal products are superior with respect to energy use because quality of fuels.
Wang (2013) identifies the sources that took change in level of energy intensity all over the world. Data from 1980 to 2010 was used. Problem of Spatial and temporal heterogeneity existed in data. There are five components that have attribute to change in energy intensity across the country. These are specifically as labor–energy ratio second capital–energy ratio, third is technological catch-up, fourth is technological progress and fifth is changes in output structure. Results suggest that decline in energy intensity is contribution of changing in technological progress, capital accumulation and output structure.
Chen et.al, (2018) in recent years, many scholars take attention on relationship between $PM_{2.5}$ concentrations and socioeconomic development. To analysis this relationship socio economic variables (energy consumption, energy intensity, economic growth, and urbanization) consider as explanatory variables with different level of income in selected countries. Globally countries are paneled in four categories according to different income levels. For econometric estimation balanced panel data was used. Between the selected variables and $PM_{2.5}$ concentrations presence of cointegration was experience. Results of estimated Vector Error-Correction Model in long run all selected socioeconomic variables increased $PM_{2.5}$ concentrations. Economic growth is more concerned variable that increase in $PM_{2.5}$ concentrations but improvement and reduction in energy intensity will decrease it.
Mallick (2009) had used annual data from India during 1970 and 2005 and applied granger causality test to investigate the link between energy consumption and economic growth. Economic development fuels crude oil demand and electricity use, whereas higher coal use fuels economic growth according to the findings. However, VAR results up indicating that power consumption and growth may have two-way relationship.
Overall, the review 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 regional prospect to do more investigation and find this relationship in the border sense.

3. Conceptual Farm Work and Hypotheses
It is well mentioned that energy intensity and income have a tendency to be correlated. With the comparison of low income countries (developing countries), the higher income countries (developed countries) have low tendency of energy intensity. It's well notice fact that energy intensity is premonition indicator of economic sustainability and further this one can also use as indicator of energy efficiency. Nonetheless energy intensity and economic performance relation vary with different aspect but on the other hand for assessment and determination between different regions at average level this relation is originate again. Over the past 30 years' data proposes that energy intensity for high income states to be drop, reason is that these countries are in general applying energy efficiently as compared to low and middle income states (Sadorsky, 2013).
In this perspective, Bernardini (1993) considered the theory of dematerialization although intent on Energy intensity. According to them there are three main reason that identify for decline in energy intensity. The first classify reason is as national economies develop the structure of final demand changes as pre-industrial to industrialization and formerly to post-industrial phase, per capita income rises and relocated. But when economies are at pre-industrial phase, so production goods as energy demand is low. Further as development processes reached at level of industrialization, economies face heavily upturns in energy consumption but because of industrialization labor are more employed so income generate and in this stage people utilize automobiles and household appliance at higher trend which indicate energy demand up. But in the long run ownership demand submerges, progressively controlling the consumption of materials. In such conditions countries are classified as the post industrialization stage, (according to development theory it's take off stage) so demand of services also goes up, that are less energy intensive as compared to manufacturing. This phenomenon is often cited as dematerialization of economies where preference reveled for reduction in material inputs as per unit of output.

In addition, moving further from pre-post industrialization, economies lead with technological progress that increases the energy efficiency. Auxiliary, technological progress primes and focused to usage of substitute resources, that reflects as less energy intensive. Finally, all this development defensible that with moving in economies development stages (low to high income, pre-post industrialization) supplementary experience the change in energy intensity.

Medlock (2001) also debate the different stages of economic development that shifts in structure of production and consumption which leads to changes in energy demand. Facts show that different stages of economies development have different intensity of energy. However, Galli (1998) also observe in Asia for ten emerging countries and find the trends in energy intensity that also emphasis on the process of dematerialization. Their results detect relation between development stage and energy intensity trend down in different economies with different GDP per capita.

Despite the fact there are very limited impact economic structural changes. Probable in China when dematerialization become the main factor of structural changes then energy intensity would be reducing furthermore. Although in comparison of East Asian, Japan and South Korea structural changes performance is better in China (Wu, 2012).

All the above discussion on the behalf of literature suggest that energy intensity varies across different countries and time periods with different determinates as urbanization, industrialization, income levels, development stages, and structural changes. As the objective of this paper is to highlight exploration of heterogeneity among regions in selected data set. For nexus of energy intensity and economic performance with hypothesis of energy intensity have negative impact on economic performance. Therefore, in the next sections, the empirical analyze of these conditional heterogeneity factors will estimate.

4. Data Source and Econometric Method

To conclude, the defined indication in supports of hypothesis of negative association among economic performance and energy intensity. Though, across countries the energy composition profiles give the impression to show contradictory configurations. These two clarifications center of this research, to properly identify the description of model and the partial links among economic growth and the energy variables, with respect to region. In equation (1) the last component *(XE_{it})*, includes a set of control variables. These instrumental variables include technology and policy factors as investment, inflation, urbanization and trade opens. 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 functional form will be as following:

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

the set of variables $\left(R_i, T_t, \ln\left(Y_{i,t-1}\right), \Delta EI_{i,t}\right)$ is included, as regional R_i and T_t time dummies, the $\ln\left(Y_{i,t-1}\right)$ lagged of GDP per capita income as economic performance, and the change $\Delta EI_{i,t}$ in energy intensity that is in expression (2). In addition, the rest of control and instrumental energy variables in (2). Here the term $\theta' XE_{i,t}$ is express as overall set of energy variables (fossil fuels and renewable energy) that establish as follow.

$$\theta' XE_{i,t} \equiv \theta_0 \Delta EI_{i,t} + \sum_{p=1}^{J-1} \theta_p^m \Delta m_{p,i,t} + \sum_{u=1}^{K-1} \theta_u^s \Delta s_{u,i,t} \qquad (2)$$

Here $\Delta m_{j,i,t}$ indicates yearly average changes in percentage point (p.p.). For share of prime energy intake from the source p done with aggregate primary energy.

$\Delta s_{u,i,t}$ denotes the yearly variations (in p.p.) for share of final energy intake with reference to sector *u* (energy consumer sectors mainly industrial, household and agricultural sector) over aggregate final intake. Vector of sectors "u" is here employs for cluster of all sectors of economy (as agricultural, industrial, transport, residential and service). Construction of this vector is applied, for representation of share of economic sectors and discover their variations in absolute usage of energy (Marrero,2010).

To explore the energy-growth relation between different region through theoretical framework, data is collected on both the principal and the final energy composition, with set of macroeconomic variables that gives essential supported for growth of GDP. The data with respect to region and try to evaluate the relationship among real GDP growth (as proxy of economic performance) and Energy intensity (EI) through the lenses of variance regions, Region is organized as Eastern or central, Western or central, Southern and Northern European regions. Sub region based on the United Nations official statistics. So finally assembled data set is unbalanced panel data, which is non-overlapping and based on last three decades of time, is practice in the recent empirical energy-growth estimation. Collective set of data which deals with primary energy mix variables[3] are recuperated from data source International Energy Agency (IEA; 2020). With sequence of population and GDPG (PPP adjusted in US$ 2010 prices) originate from tables of Penn World. Further controls variables in the econometric model such as investment, inflation, Trade openness, and industrialization also come from World Bank development indicators. As mentioned in equation (1), follow the dynamic panel data framework, although in dynamic panel data dealing with models of pooled and Within group (WG). Both techniques having competent with respect to

[3] Energy measure: are primary energy intake which described as TOEs. The energy inputs, as renewable energy shows hydro & biomass energies sources known as "conventional renewables" but in renewable sources of waves plants, solar, wind & geothermic are in category of "frontier renewables". Intake of these resources distinguishes as production consumption of energy; in agricultural, residential, transport, industrial, and services.

country-specific and time-invariant effects in panel data estimation but with drawback of probably correlated with regressor. Which edify some caveats as in dynamic panel models (DPM), both estimates are exaggerated by endogeneity bias. So, in the direction of omit the endogeneity a standard control in growth models is GMM method. So as a natural alternative solution of above mention problem in dynamic context, is GMM approach (Arellano, Bond, and Bover;1991-1995).

There are two GMM approaches in econometrics analysis, namely first-difference (FDGMM) and system GMM (SGMM). In case of FDGMM, may lead toward imperative finite sample bias when variables are highly obstinate as variables like GDPC and EI (that are main concerned variable of leading study in finite set of samples) so for both level and first difference, alternative particular approach is SGMM (Bover, Blundell and Bond; 1995-1998). Amongst many others also have given emphasis to the significance of exhausting SGMM when functioning thru DPD growth models (Huang 2008; Marrero 2010; and Atems and Hotaling 2018).

Hence, additional study and further investigation is needed in this context, to get strong empirical evidence on this subject, is authoritative. The present study is differing from other studies, in number of ways. First, it estimates the impact of energy intensity, non-renewable (NRR), renewable energy (RE) consumption on GDP per capita economic growth in different region, time and income level by employing a GMM model. Second, it controls a set of instrumental variables which is a vital aspect that impacts macro-economic performance of any economy, and has been rarely measured (as whole) in earlier studies. Third is, with the presence of heterogeneity and cross-section dependence it gives statistical interpretation that can result in erratic estimates and ambiguous inference, which is overlooked by prior researchers. Here EUR is use as abbreviation of European region.

An appropriate technique for estimation is most important step to get reliable results in research. The present study has used GMM estimation technique proposed by Hansen (1982) because in each model some of the variables are theoretically endogenous. So, GMM technique is the more appropriate technique as there are many explanatory variables having endogenous relationship with dependent variable. To solve this issue, GMM estimation technique is used to address biases which are caused due to unobserved cross-country effects and endogeneity problem (Campos & Kinoshita, 2003). This study has estimated the four independent models by using GMM estimation and the results have been reported based on probability values of F-statistics, Hansen-J statistics and under-identification tests. F-test is applied to evaluate the long-term significance of regression model, to check the fits of different models and to test the equality of means. To avoid the identification, different identification test is applied.

As for Under identification used Kleibergen-Paap rk LM statistic test. Next to check Weak identification practice tests are Cragg-Donald Wald (F statistic) and Kleibergen-Paap rk Wald (F statistic). Although it has never been implemented in R (estimation software), the Cragg-Donald (1993) test is a frequently used method for finding weak instruments in IV regressions. In case of over identification (which is common issue in GMM estimator) Hansen J statistic test of all instruments is applies.

5. Descriptive and Empirical Results

From 1965 to 2020, based on five years' averages share of the primary energy mix is shown in 6.1 graph. These findings reveal that oil has a bigger proportion of the primary energy mix, with 40 percent of the total share based on oil consumption to the end of 2020. It signifies that fossil fuels account are at higher share of energy intake in EUR. Gas has the second biggest share, followed by coal. These findings are depicted in Figure 1. Despite this, in EUR primary energy intake the share of coal and lignite fell from 18.0-14.4 % between 2005 to 2019. As growing practice of renewable energy (RE) for energy production, changes in national legislation, and the most recent developments in the energy market, there has been a partial drop in coal consumption.

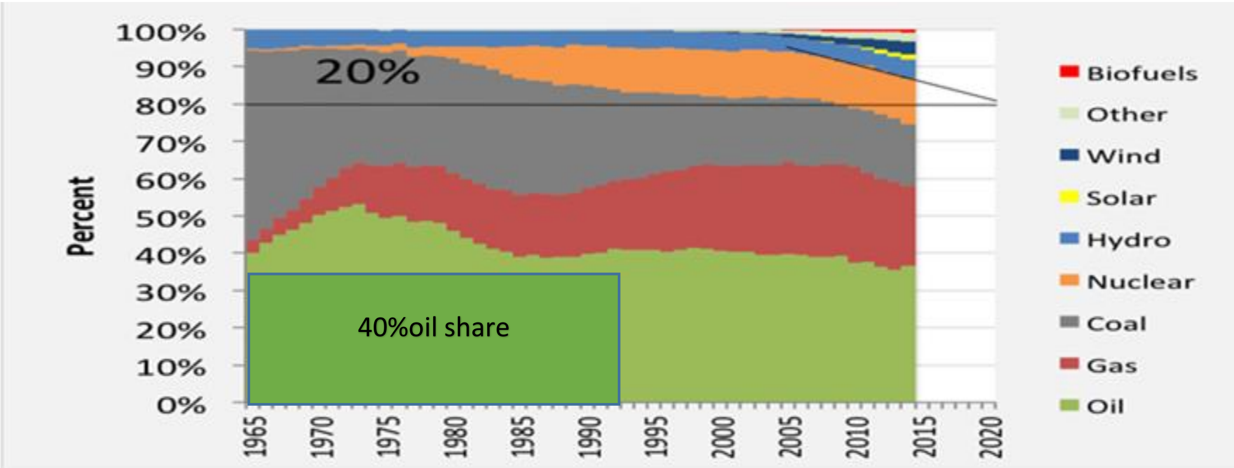

Figure 1: Year Wise Share of Primary Energy Mix

Source: Euros statistics

Between 2005 and 2019, the EU's absolute consumption of fossil fuels fell from 33.9 percent to 31.6 percent. There are also a variety of factors contributing to this reduction, such as increased biofuel usage in the transportation sector, high oil prices during the observation periods, advances in vehicle economy, and the economic downturn. Here shows the top ten European country's overall energy share in terms of renewable energy resources as a proportion of gross inland energy intake in Figure 2. On the one hand, countries like the Czech Republic have the highest renewable energy percentage, but the Czech Republic's GDP has grown while their gross inland energy consumption has fallen.

These above descriptive results indicate that if the share of renewable energy increases, then GDP will grow but energy intensity will go down. The European States established national indicative objectives in compliance with Energy Efficiency Directive (EED; 2012), which should assist the EU meet the 20 percent energy efficiency target by 2020. The goals attained as range from 20.5 % drop UK, 28.6 percent rise Estonia in primary energy consumption from 2005 levels.

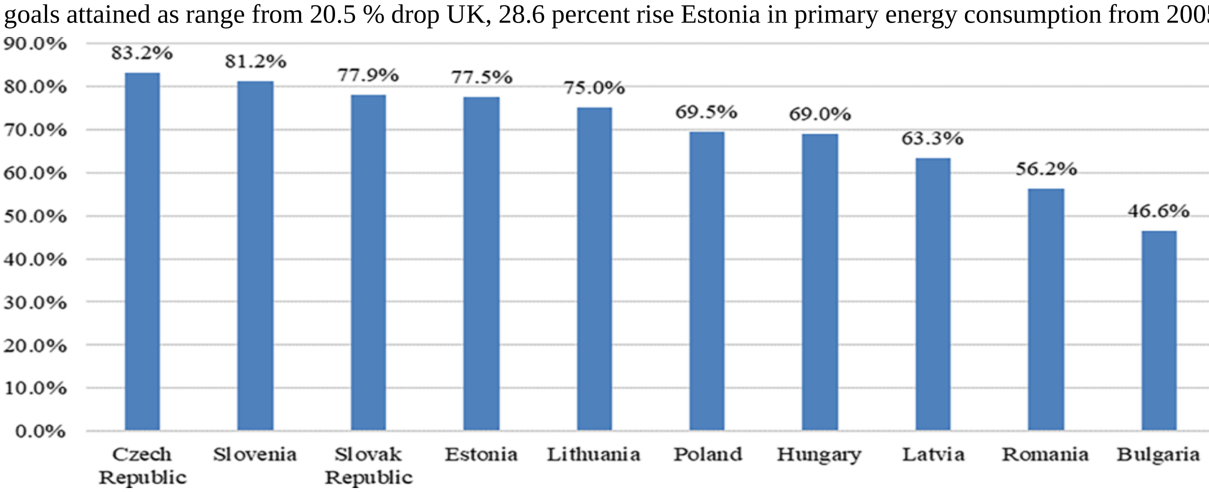

Figure 2: Country Wise Inclusive Share of Energy from Renewable Sources (% of Gross Final Energy Intake, 2019)

Source: Euro statistics

Beyond all these positive activities to reduce energy intensity and increase the usage of RE, Still, the EU's primary energy intake goes up by indicative trajectory set by the EEA, energy efficiency. Therefore, efforts to achieving 2020 targets are still ambiguous. According to energy brain pool statistic if these targets will not meet at serious note then the energy consumption will boost up rapidly. According to their statistic forecast, a view on EU energy consumption outlook in 2050 is shown in diagram 3. According to a poll conducted by the energy brain pool, solar energy consumption will reach its peak in annual peak load by the end of 2015, with wind coming in second. Gas is the third option. As a result, apprehensive sources of energy in the future will be renewable sources.

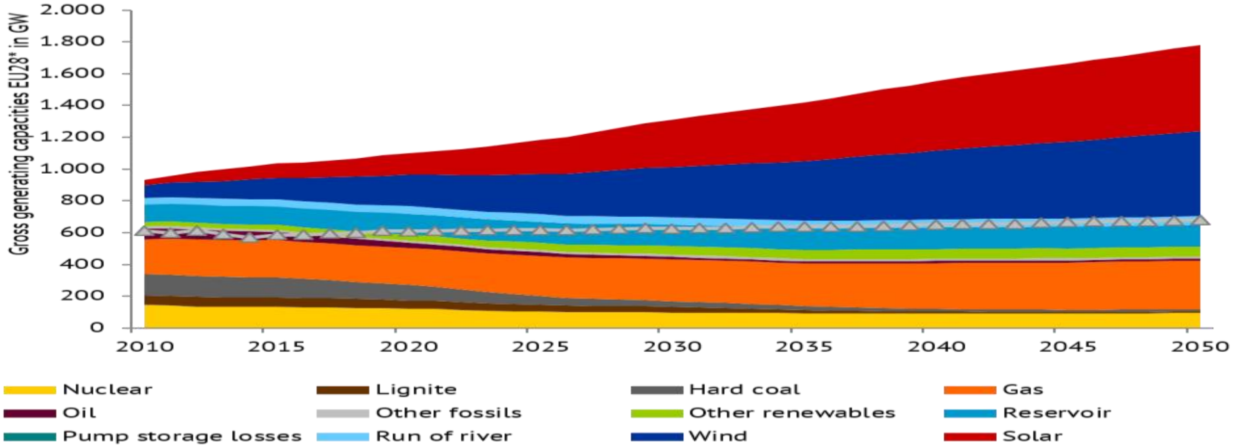

Figure 3: EU Energy Consumption Outlook 2050

Source: Energy Brain Pool Statistics

In figure 4, European countries ranking with respect to GDP is shown which will help to understand different countries economic performance. As descriptive statistics elaborate that Ukraine, Russia, and Belarus are the poorest countries in Europe, according to the graph above, with GDP growth rates ranging from -3.1 to -9.2. Monaco, Ireland, Malta, Luxembourg, and the Czech Republic are European countries with strong income and GDP growth. Their GDP growth rate ranges from 9.3 to 3.4 percent as presented in figure 4.

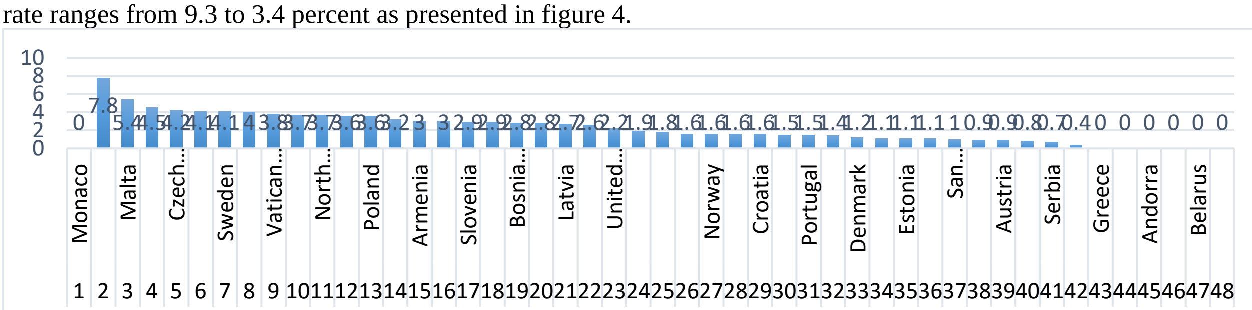

Figure 4: European Countries Ranking for Real Growth Rate (%)

Source: Author's Calculation

Region wise (south, north, west and east) subdivision of Europe is presented in table 1.

Table 1: Sub-Region of European Countries

Eastern	Western	Northern	Southern	
Russia	Germany	United Kingdom	Italy	Montenegro
Ukraine	France	Sweden	Spain	Malta
Poland	Netherlands	Denmark	Greece	Andorra
Romania	Belgium	Finland	Portugal	San Marino
Czech-Republic	Austria	Norway	Serbia	Holy See
Hungary	Switzerland	Ireland	Croatia	
Belarus	Luxembourg	Lithuania	Bosnia and Herzegovina	
Bulgaria	Monaco	Latvia	Albania	
Slovakia	Liechtenstein	Estonia	North Macedonia	
Moldova		Iceland	Slovenia	

Source: Europe Statistics

5.1 Estimated Results of Heterogeneity Patterns with Regions

This segment of research is differing in many prospects, especially in term of heterogeneity of regions as south, north, west and east, energy mix and sectoral energy intake from 1990-2020. In all cases 2-Step GMM estimation is applied. First in table 1, differentiate the following regions as southern, western, eastern and Northern Europe. Although one-step GMM statistical tests are also asymptotic but two-step GMM statistical tests have lower asymptotic variance and are more powerful in general than one-step estimators. The two-step approach is explained by the fact that a set of equations and parameters in non-linear GMM stage does not rise with number of perfectly estimated regressor, resulting in a computational simplicity that the asymptotically does not have. Estimated results with dynamics of region is presented in table 2.

Region wise results predict variability across the region. In several dimensions there are heterogeneity. Our main findings envisage that energy intensity variable (Energy. I) coefficient having negative and significant sing in all areas. Its ranging between -0.7 to -2.1. Although it's in evidence that almost all countries in Europe, they try to reduce their energy intensity level and preferred to attain international energy intensity targets. In case of fossil fuel energy consumption or traditional sources of energy, Fossil.E (FE) having negative impact on GDP growth (as proxy of economic performance) and insignificant in all case individually. These results are justified because as above mention in figure 2 countries like chez republic and Slovenia having 80% of their energy consumption in form of renewable energy sources. These are big push toward renewable as compared to fossil fuel so results are valid in form of negative magnitude toward fossil fuel energies.

Table 2: 2-Step GMM Estimation by European Region

	East Region	**West Region**	**South Region**	**North Region**
Depended variable: GDP per capita growth (GDPG) as proxy of Economic performance				
Energy. I (EI)	-0.727*** 0.000	-2.173*** 0.001	-1.350*** 0.005	0.583** 0.045
Fossil.E (FE)	-0.029 0.822	-0.024 0.803	-0.036 0.849	0.079 0.371
Renewable.E (RE)	-0.097 0.374	-0.194** 0.048	-0.278 0.148	-0.078 0.576
Industry.S (IES)	0.001*** 0.000	0.001*** 0.000	0.000 0.940	0.001*** 0.001
Agri.S (AES)	-0.003*** 0.008	0.001** 0.093	0.002 0.334	0.003* 0.074
Household.S (HES)	-0.001 0.199	-0.000 0.124	-0.000 0.804	-0.001*** 0.002
Urban (Ur)	-0.283 0.340	-0.100 0.149	-0.770*** 0.000	-0.026 0.914
lTO (TO)	-1.474 0.544	-6.621*** 0.006	2.320 0.415	2.791 0.487
Inf (IN)	-0.007*** 0.000	-0.105 0.612	-0.006 0.005**	-0.031 0.870
L1. (Inv)	0.220* 0.047	0.210** 0.007	0.041 0.532	0.010*** 0.000
Number of obs = 240 **F(10, 218) = Prob > F = 0.0000**				
Underidentification **(Kleibergen-Paap rk LM statistic)**	28.358	54.478	48.392	54.478
Weak identification **(Cragg-Donald Wald F statistic)** **(Kleibergen-Paap rk Wald F statistic)**	89.404 26.178	96.546 67.623	62.710 49.604	96.546 67.623
Overidentification **(Hansen J statistic)**	0.77	2.042	3.322	2.042

Note: Instrumented: urbanization, international trade. Included instruments: energy intensity, fossil renewable, industry agriculture, household sector, Inflation and primary education. Excluded instruments: Lag of trade lag of urbanization. Variables are significant at 1%, 5% and 10% as mention*, **&*** respectively.

Variations in the RE (especially conventional sources) and the shares of the residential sector (RES) in all European regions appear to be statistically negative. For the remainder of the regions, renewable energy accounts for a small percentage of total energy use. As a result, a negative correlation was discovered. These findings are appropriate because, while it is true that countries are shifting to renewable energy sources, switching from one consumption pattern to another comes with a cost in terms of expenditure and infrastructure. Finally, stress opposes GDP growth, which indicating a negative link between renewable energy and GDP growth. Like a result, there is inverse link among RE share and worldwide economic performance (Daz & Rodrguez, J. 2019).

Except for the southern portion of Europe, the percentage of energy in the industrial sector has a major impact in all regions, but the elasticity coefficient is quite low. Despite the fact that industrialization is an important component of economic progress, environmental quality has become a major concern for people all over the world in recent decades. As a result, countries are attempting to shift their focus away from the industrial sector and toward the service sector. On the other hand, countries in the southern region, such as Italy, Bosnia and Herzegovina, and the Holy See, have growing economies that are predominantly focused on the industrial sector.

From side of socio-economic factors like trade having negative magnitude in case of west and east region but having positive impact in southern and northern areas but west only having the significant impact on economic growth. Countries in east and west like Germany, Russia, France, Netherlands, Poland, Belgium, Czech-Republic, Switzerland, Hungary, Luxembourg, Belarus, Monaco, Bulgaria, Liechtenstein and Slovakia they are developed as well as highly emerging countries but having trade bares in form of taxes and restriction. That's can be a major reason of this variable negative sing.

Each European region has a negative association between inflation (Inf) and GDP growth. However, a significant approach to economic performance has been empirically related to the eastern and southern regions. A lot of studies reported in the literature have validated this negative magnitude. In the case of GDP growth, however, investment (In.I) plays a statistically significant influence in all regions of Europe, but its range is between 0.01 to 0.2. This positive association between economic growth and investment is justified and verified in different countries all over the world in the literature study.

Region-wise, the impact of energy intensity and other socio-economic factors on economic performance varies in magnitude because of different dynamics. These dynamics can be political, social, and moral as well. For example, eastern European countries, particularly those that have been severely impacted by the collapse of the Soviet Union, are now among the poorest and have the lowest GDP growth. For example, Ukraine, Georgia, Kosovo (partially recognized), Moldova, Albania, North Macedonia, Bosnia and Herzegovina, Belarus, Serbia ranging and Montenegro ranging from $3,540 to 7,900. These dynamic can support negative sing of trade variable in eastern and western region of Europe (2020 GNI per capita, Atlas method, current US$). As control variable Trade from developed to emerging economies having 0.6 to 1.57 coefficient values. These region wise disparity results in trade with negative sing can be responsible for trade agreements like, European Union (EU), European Free Trade Association (EFTA), Economic and Monetary Union (EMU), Central European Free Trade Agreement (CEFTA), North Atlantic Treaty Organization (NATO) and Schengen Countries because most of the poor or low per capita income countries in Europe are not part of these agreements and the pay for it in form of economic barriers.

6. Conclusion and Policy Implications

In this study the impact of heterogeneity for energy intensity and energy mix on economic performance for European countries (region wise) between 1990 and 2020 is investigated. Aside from urbanization, the association among non-renewable energy (NRE) and renewable energy (RE) usage is studied, taking into account GDP growth, the percentage of energy in industry, agriculture, and households. The long-run relationship's results are based on an adequate aggregate general production function that explicitly mentions energy use. Nonetheless in case of renewable in almost all aspect of heterogeneity (as region) 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. An in-depth look of the connection among EI and GDPG in each region is investigate (and even within countries) provide important information. Results of concerned variables in this variability of energy economic progress is also same like previous case. As South European region is slightly less energy efficient and having more energy intensities than Nordic and Central European regions. However, a comprehensive exploration of heterogeneity is beyond the bounders of elucidation and will be left to future research. 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.

References

Alam, M. J., Begum, I. A., Buysse, J., & Van Huylenbroeck, G. (2012). Energy consumption, carbon emissions and economic growth nexus in Bangladesh: Cointegration and dynamic causality analysis. *Energy policy*, *45*, 217-225.

Bataille, C., Jaccard, M., Nyboer, J., & Rivers, N. (2006). Towards general equilibrium in a technology-rich model with empirically estimated behavioral parameters. *The Energy Journal*, (Special Issue# 2).

Bernardini, Oliviero, and Riccardo Galli. "Dematerialization: long-term trends in the intensity of use of materials and energy." *Futures* 25, no. 4 (1993): 431-448.

Dıaz, A., Puch, L. A., & Guilló, M. D. (2004). Costly capital reallocation and energy use. *Review of Economic Dynamics*, *7*(2), 494-518.

Galli, R. (1998). The relationship between energy intensity and income levels: forecasting long term energy demand in Asian emerging countries. *The Energy Journal*, *19*(4).
Galli, R. (1998). The relationship between energy intensity and income levels: forecasting long term energy demand in Asian emerging countries. *The Energy Journal*, *19*(4).
Jammazi, R., & Aloui, C. (2015). RETRACTED: On the interplay between energy consumption, economic growth and CO2 emission nexus in the GCC countries: A comparative analysis through wavelet approaches.
Jing, C., Zhou, C., & Wang, S. (2018). Impacts of energy consumption structure, energy intensity, 893 economic growth, urbanization on PM 2.5 concentrations in countries globally. *Appl. Energy*, *894*(230), 94-105.
Kraft, J., & Kraft, A. (1978). On the relationship between energy and GNP. *The Journal of Energy and Development*, 401-403.
Lee, C. C., & Chang, C. P. (2008). Energy consumption and economic growth in Asian economies: a more comprehensive analysis using panel data. *Resource and energy Economics*, *30*(1), 50-65.
Liddle, B. (2010). Revisiting world energy intensity convergence for regional differences. *Applied Energy*, *87*(10), 3218-3225.
Mahmood, T., & Ahmad, E. (2018). The relationship of energy intensity with economic growth: Evidence for European economies. *Energy strategy reviews*, *20*, 90-98.
Mallick, H. (2009). Examining the linkage between energy consumption and economic growth in India. *The Journal of Developing Areas*, 249-280.
Marrero, G. A. (2009). Greenhouse gases emissions, growth and the energy mix in Europe: a dynamic panel data approach. *Documento de Trabajo*, *2009*, 16.
Medlock III, K. B., & Soligo, R. (2001). Economic development and end-use energy demand. *The Energy Journal*, *22*(2).
Mulder, P., & Groot, H. L. F. (2011). *Energy intensity across sectors and countries: empirical evidence 1980-2005*. CPB Netherlands Bureau for Economic Policy Analysis.
Payne, J. E. (2010). A survey of the electricity consumption-growth literature. *Applied energy*, *87*(3), 723-731.
Sadorsky, P. (2010). The impact of financial development on energy consumption in emerging economies. *Energy policy*, *38*(5), 2528-2535.
Sadorsky, P. (2010). The impact of financial development on energy consumption in emerging economies. *Energy policy*, *38*(5), 2528-2535.
Solarin, S. A. (2014). Convergence of CO2 emission levels: evidence from African countries. *Journal of Economic Research*, *19*(1), 65-92.
Stern, D. I. (2000). A multivariate cointegration analysis of the role of energy in the US macroeconomy. *Energy economics*, *22*(2), 267-283.
Tools, I. A. E. A. (2009). Methodologies for Energy System Planning and Nuclear Energy System Assessments. *Sustainable Energy for the 21st Century. IAEA: Viena, Austria*.
Wang, C. (2013). Changing energy intensity of economies in the world and its decomposition. *Energy Economics*, *40*, 637-644.
Wang, C. (2013). Changing energy intensity of economies in the world and its decomposition. *Energy Economics*, *40*, 637-644.
Wu, Y. (2012). Energy intensity and its determinants in China's regional economies. *Energy Policy*, *41*, 703-711.
Wu, Y. (2012). Energy intensity and its determinants in China's regional economies. *Energy Policy*, *41*, 703-711.
Zambrano Joya, D. A., Rodríguez Salazar, D. L., & Rodríguez Patarroyo, D. J. (2022). Methodology for the Design of a Hybrid Energy System with a Didactic Approach: Case Study Centro Educativo Luis López de Mesa. *Ingeniería (0121-750X)*, *27*(2).
Zeb, R., Salar, L., Awan, U., Zaman, K., & Shahbaz, M. (2014). Causal links between renewable energy, environmental degradation and economic growth in selected SAARC countries: progress towards green economy. *Renewable energy*, *71*, 123-132.
Zhang, X. P., Tan, Y. K., Tan, Q. L., & Yuan, J. H. (2012). Decomposition of aggregate CO2 emissions within a joint production framework. *Energy Economics*, *34*(4), 1088-1097.