Journal of Academic Research in Economics

Volume 11 Number 2 July 2019

ISSN 2066-0855

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CONTENTS

DYNAMICS AND DETERMINANTS OF ENERGY INTENSITY: EVIDENCE FROM PAKISTAN

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Abstract

The study investigates the effect of income, institutional quality, urbanization and industrialization on energy intensity in Pakistan using vector error correction model. It finds poor institutional quality and industrialization behind high energy intensity in Pakistan while income per capita and associated urbanization playing a significant role in reducing energy intensity. Good governance practices and better quality of institutions can play an effective role in increasing the efficiency in the use of energy thus reducing overall energy intensity. Moreover, investment in apposite technical and general education, in addition to enhancing research and development activities can help make Pakistan an innovation based economy and increase its productivity and eventually become an energy efficient economy.

Keywords: Energy Intensity, Income per capita, Industry, Urbanization, Institutional Quality
JEL Classification: Q43, O11, E02.

1. INTRODUCTION

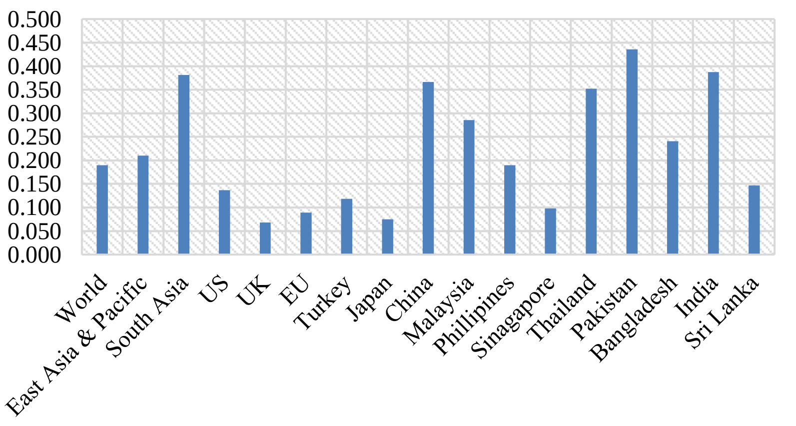
Efficiency in the use of energy in itself is a major source of environment friendly energy security. Efficient use of energy reduce supply demand gap, thus reducing investments in energy infrastructure and lowers fossil fuel dependency. In Pakistan energy demand is on the rise[1]. Whereas energy supply has failed to keep up with the rising demand owing to lack of sufficient indigenous energy resources, inconsistent supplies, inefficient tariff structures along with untargeted subsidies and above all, significant and increasing import dependency. Importing energy to meet its demand drains the local economy and leaves the supply system extremely vulnerable, that most of the time is beyond the control of financial managers in the country.

[1] Since 1971 energy demand is growing at the rate of 4 percent per annum (Pakistan Energy Yearbook, Various Issues). It is expected by 2025 it will grow further at the rate of 4 percent to 6 percent (Estimated).

In addition, a large section of Pakistan's population is not supplied with commercial energy and they have to rely on biomass energy particularly in rural areas. According to one estimate rural population is burning biofuels to realize 94 percent of its domestic energy needs (Colbeck, *et al.*, 2010)); and about 30 percent of the population is without electricity (Saeed, *et al.*, 2015). The limited access to commercial energy combined with widespread shortages and rising demand inhibits economic growth and employment generation. In this scenario, efficient usage of energy can leads to considerable improvements in supply in Pakistan, thus reducing the supply demand gap and mitigating energy security concerns.

In Pakistan, energy intensity (measured as ratio of energy consumption to GDP) is greater than the world average more than twofold. Further, it is about six times greater than UK and about five times greater than Japan (Figure 1). As compared to Pakistan, both India and China have remained more energy intense until late 1990s. However, their energy intensity declined sharply and now for each dollar of GDP Pakistan consume 5 percent more energy than both of these countries (World Development Indicators Database). In Pakistan, losses and inefficiencies of the supply chain, obsolete technologies, inefficient appliances/ machinery and energy wastage at the consumer end are major contributors to the high energy intensity.

Figure 1: Energy Consumption per US $ of GDP (kg of oil equivalent per year 2010 US $ in 2014)



Source: World Development Indicators Database

Pakistan has the potential to save around 11.16 MTOE (Malik, 2012). In Pakistan with limited resources, in order to overcome supply side deficiencies and to ensure energy security, energy conservation is a less expensive option as compared to exploiting and building new sources of energy. So far this area has not been given priority in our energy strategies and plans.

For mainstreaming the issue of energy efficiency into energy policy it is of utmost importance to ascertain the elements responsible for high energy intensity in Pakistan. For instance, Pakistan is on a high growth path with rising per capita income along with a certain rise in the demand for energy. It is important to investigate whether this rise in income has any influence on the efficient use of energy or energy intensity. Likewise, urbanization and industrialization, the two most important features of economic development, are also expected to rise with an associated impact on the efficient use of energy resources. Additionally, institutional quality, i.e., the existence and implementation of environment and energy conservation legislations is extremely important from the perspective of alleviating energy intensity.

So far the empirical literature on Pakistan has focused on energy consumption, that is, to study causality between energy consumption and growth; to study factors responsible for rising energy consumption or demand; or to forecast future energy demand (e.g., Siddiqui, 1999; Khan and Qayyum, 2009; Mahmood, *et al*., 2016; Jamil and Ahmad, 2010; Javid and Qayyum, 2014; Nawaz, *et al.*, 2014; Khan, 2015; and Khan and Abbas, 2016). There are very few studies which investigates energy intensity and their main focus is on the decomposition analysis (Alam and Butt, 2001; Akbarullah, *et al*., 2014; and Mirza and Fatima, 2014). Only Mahmood and Kanwal (2017) examines the causal relationship between energy intensity and economic activity (GDP) in Pakistan and Mirza and Fatima (2014) besides decomposition analysis investigate the role of prices, income, capital-labor ratio and temperature on energy intensity indices.

Lack of sufficient evidence for Pakistan qualifies the need for a detailed study on energy intensity. Secondly, empirical literature in general investigating the relationship between institutional quality and energy intensity is scarce. Suslov (2008) is the only one who explicitly investigates the relationship between institutional quality and energy intensity. However, its focus is mainly on the market economies and some of the socialist countries. On the whole there is little known about the impact of institutional quality on energy intensity in developing countries in general and in Pakistan in particular. It is therefore important to explore how income per capita, industrialization, urbanization and institutional quality impact energy intensity. As efficiency in the energy use is one significant way to mitigate the energy security concerns.

Perhaps this is the first comprehensive attempt to investigate the role of institutional quality, industrialization, urbanization, and per capita income (proxy used for economic development) behind high energy intensity for Pakistan. It uses the existing data from 1971-2017. It is intended to provide guidelines to policy makers in mitigating concerns regarding energy security issues through reducing energy intensity. The findings in the study will also be useful for other developing countries.

The paper is organized in a following way. Section II of the paper set out the conceptual framework while going through the relevant literature. Section III is the discussion with reference to Pakistan. In Section IV methodology and data are explained. In Section V results are reported. In Section VI results are assessed in the light of ground realities. Finally, Section VII concludes the discussion.

2. LITERATURE REVIEW

2.1. ENERGY INTENSITY AND ECONOMIC DEVELOPMENT

It is argued that energy consumption is likely to increase with economic development as countries move from labor intensive agriculture to capital and energy intensive industry. However, with the continuity of structural changes, countries eventually stepped into less energy intensive and information based services sector. In other words, energy intensity initially increases then decreases with increase in income (Deichmann, *et al*., 2018).

In this context, Bernardini and Galli (1993) deliberate on the theory of dematerialization[2] while focusing on energy intensity. They identify three reasons[3] for the fall in energy intensity as income rises. First, the structure of final demand changes as national economies develop (their per capita income increases) and moved from pre-industrial phase to industrialization and then to post-industrial phase. In pre-industrial phase demand is met by low energy and material intensity. In the second stage of development, that is industrialization, energy consumption goes up. As income rises in this stage, automobiles and household appliance ownership add up to the rising energy intensity phase. But ultimately demand for these energy consuming appliances steeps, thus, gradually limiting the consumption of materials. Countries then enter the post industrialization stage where demand for services goes up, which are normally less energy intensive as compared to manufacturing. The outcome of this evolution is a reduction in energy intensity of GDP. This chain of development stages is often discussed in literature as dematerialization, the process which allows for reduction in material inputs per unit of output. Second, technological progress increases the efficiency with which energy is used. Third, technological developments result in the use of alternate materials which are less energy intensive.

Medlock III and Soligo (2001) has discussed the changes in the structure of consumption and production in different stages of economic development that alters the demand for energy, while Galli (1998) has examined the trends in energy intensity for ten emerging countries in Asia, and its findings validate the process of dematerialization. Sadorsky (2013) found higher income countries have lower energy intensity as compared to lower income countries. Energy intensity for high income countries is falling for the past 30 years, as these countries are generally more efficient at using energy as compared to low and middle income countries.

China has been in focus in the recent literature for its declining energy intensity in the last few decades (Fisher-Vanden, *et al.*, 2004; Zhang, 2009; Li and Yao, 2009; Wu, 2012; Elliot, *et al.*, 2014; and Zhao and Wang, 2015). Over the years,

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[2] Originally, it was Malenbaum (1978) to show empirically how resource intensity of minerals changed with increases in income per capita. Later, this concept was used for energy intensity by Bernardini and Galli (1993).

[3] Also cited in Galli (1998), Sadorsky (2013) and Elliot, *et al*. (2014).

China has developed remarkably with an annual economic growth rate of 9.9 percent (Zhao and Wang, 2015). The main factor responsible for the cut in energy intensity is the progress in efficiency while there is limited role of structural changes. It is expected that China's energy intensity can further be lessened when structural alterations takes the lead in the process of dematerialization. China would then perform better as compared to other East Asian countries Japan and South Korea (Wu, 2012). Zhang (2009) reports increase in per capita income, time trend and capital-labor ratio as important factors behind the reduction of China's energy intensity. Whereas, Elliot, *et al*. (2014) finds a minor role of urbanization in reducing energy intensity, and industrial activity is the main contributor to energy intensity in China.

Empirical literature has also talked about cross-country convergence of energy intensity, where majority of studies have confirmed the convergence of energy efficiency across countries (cited from Deichmann, *et al.*, 2018; p. 2). Technological advances is playing an effective role in reducing the global energy use and carbon emissions due to economic growth. Increasing total factor productivity is associated with rising energy efficiency, while abundance of fossil fuel reserves are responsible for lower energy efficiency (Stern, 2010).

Jacobs and Šlaus (2011) takes the argument further, that is, only shift towards services with less emphasis on material resources does not guarantee sustainable energy supplies for development. Technological changes, public knowledge and allegiance, government policy and cultural transformation are all very important in the context of saving energy. According to Jacobs and Šlaus (2011) the transformation towards services is more ostensive in high income countries, while fully developed service economy in these countries would have minimal effect on increasing energy consumption in the developing world. However, development of highly sophisticated IT and financial sectors in emerging countries like India suggests the possibility that these countries might be able to evade some of the unwarranted energy demands of industrialization.

In the transition period, higher education and more emphasis on research and development activities are very crucial. Education brings environmental, energy and economic awareness. Thus, more knowledge of energy conservation to the general public and more efforts from them to use energy resources more efficiently. So, as income per capita increases, not only technological progress, higher education and accompanied public awareness are also significant in increasing energy efficiency.

It is argued that energy consumption is likely to increase with economic development as countries move from labor intensive agriculture to capital and energy intensive industry. However, with the continuity of structural changes, countries eventually stepped into less energy intensive and information based services sector. In other words, energy intensity initially increases then decreases with increase in income (Deichmann, et al., 2018).

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In the transition period, higher education and more emphasis on research and development activities are very crucial. Education brings environmental, energy and economic awareness. Thus, more knowledge of energy conservation to the general public and more efforts from them to use energy resources more efficiently. So, as income per capita increases, not only technological progress, higher education and accompanied public awareness are also significant in increasing energy efficiency.

2.2. ENERGY INTENSITY AND INSTITUTIONAL QUALITY

The impact of institutional strength on energy intensity is important. Fredriksson, et al. (2004) develops a theoretical model of corruption and its impact on the efficient usage of energy. The study foresees that corrupt policy makers and their association with interest groups diminish the effectiveness of energy policy. The study reports a robust relationship between corruption and energy intensity of production sectors.

Existence of a robust association between the quality of institutions and economic policies and between quality of institutions and income per capita has been identified in the literature (e.g., Rodrik, 1997 and Sachs, 1999). For countries in transition, the length of transformation period is determined by efficient government institutions in a country as well as by its ability to develop sound market institutional framework (Suslov, 2008). Suslov (2008) while examining factors responsible for higher energy intensity in the socialist countries in contrast with the market economies reports the importance of strong economic institutions and economic agents in implementing energy conservation measures.

2.3. ENERGY INTENSITY AND URBANIZATION

No country has grown to middle income and then to high income status without industrialization and urbanization (vibrant cities). Urbanization is often seen as a sign of economic development. In Europe, during the industrial revolution of the 18th and 19th centuries a number of developments occurred that allowed cities to grow. Empirical evidence for Europe has shown that economic growth leads to urbanization, with industrialization being the most important aspect of it (Bairoch and Goertz, 1986). In the Asia-Pacific region, the share of urban population has been rising steadily for the last 25 years. High level of urbanization in Asia-Pacific is associated with economic development. High income countries have an average urban populace of 75 percent, while the less developed countries have an average urban populace of 27 percent in the Asia-Pacific region (ESCAP, 2014).

Urbanization precedes to an ample absorption of human resources, economic activities, and resource utilization in cities6. There is considerable growth in energy demand and a modification in the fuel mix in urbanization. That is, with increase in urban production cash income of the average migrating individual or family is expected to rise. Higher incomes shift urban consumers away from traditional fuels towards modern energy sources_ partly due to the purchase and use of energy appliances and partly due to their capability to buy more expedient fuels (Jones, 1991). Urbanization is associated with increased demand for transportation and other infrastructure, thus more demand for energy. Basically, change in lifestyle and consumption patterns of urban residents with rise in per capita income effects energy

[6] Although cities inhabit just 2 percent of earth's surface, they consume almost 75 percent of world's resources (Madlener and Sunak, 2011).

intensity (for details see Sardosky, 2013, Madlener and Sunak, 2011, and Eliot, et al., 2014).

The impact of urbanization mechanisms varies substantially not only between developed and developing countries but also among the developing countries (Madlener and Sunak 2011). The effect of urbanization on energy intensity is difficult to predict as it leads to increase in economic activity through an increase in both consumption and production. While at the same time it results in economies of scale in production, thus more opportunities for energy efficiency (Jones, 1989 and 1991; Dhakal, 2004; Sadorsky, 2013; Eliot, et.al., 2014). Additionally, high population density and increased consumption levels create space for improved efficiency in the use of natural resources. As an engine of economic growth cities offer opportunities for innovation, knowledge and technology (Dhakal, 2004).

As urbanization is linked with rising per capita income, so is its linkage with educational attainment of urban populace. In other words, a high per capita income is indicative of high standard of living in terms of increased education, increased consumption, increased technology, and across the board improvements in all facets of life within a country, thus more demand for a better environment and improved efficiency in the use of energy.

There are several studies that have explored the effect of urbanization on energy intensity. For instance, Jones (1989, 1991) finds not only income per capita and industrialization but rate of urbanization as important factor behind energy intensity. Parikh and Shukla (1995) find a positive and significant elasticity of energy intensity with respect to urbanization. O'Neill, et al. (2012) evaluate urbanization channels for energy consumption and carbon emissions in India and China, while Ghosh and Kanjilal (2014) confirms the existence of relationship between energy consumption and economic activity and in turn between economic activity and urbanization.

2.4. ENERGY INTENSITY AND INDUSTRIALIZATION

The impact of industrialization on energy use is much more evident than that of urbanization. Industrialization is a process which tends to increase industrial activity that increases the demand for energy and leads to a rise in energy intensity. However, some industries are predominantly more energy intensive, e.g., petroleum refining, primary metals, chemicals, and paper and allied products (Jones, 1991). The impact of changes in industrial composition on energy use depends on the structure of production. This is because identical products can be made by different processes with varied energy intensities. Secondly, industrial aggregation can camouflage considerable product variation, resulting in variations in energy intensity. Third, routine care and operational techniques differ across countries. Finally, there is significant 'learning by doing' in the energy usage of industry and commercial sector (cited from Jones, 1991, p. 627).

Thus it is imperative to analyze the impact of industrialization on energy intensity for each country separately. Rühl, *et al*. (2012) while exploring the process of industrialization in the last two centuries highlights the importance of specialization of the fuel mix, in addition to accelerating convergence of both the sectoral and technological composition of economies for improving energy efficiency. Whereas, Sultan (2012) investigates main drivers of energy intensity in the textile and clothing sector in Mauritius and finds lower energy intensity for export-oriented enterprises and enterprises with foreign ownership because of their competitive environment.

Sadorsky (2013) confirms the role of industrialization in increasing energy intensity and of income in reducing energy; while he finds a mixed impact of urbanization on energy intensity for an unbalanced panel of 76 developing countries.

Few studies have also focused on energy prices (Fisher-Vanden, *et al.*, 2004; Metcalf, 2008; and Mirza and Fatima, 2014). That is, with an increase in energy prices cost of production goes up. Producers as well as other consumers may respond by improving energy efficiency. On the contrary, Mulder *et al.* (2013) based on his findings raised concerns about the efficacy of price instruments in improving energy efficiency.

3. SITUATION ANALYSIS PAKISTAN

In this paper for estimation purposes sample selected is 1971 to 2017. This is the period with rising per capita income indicative of economic development and a corresponding increase in the demand for energy (Figure 2).

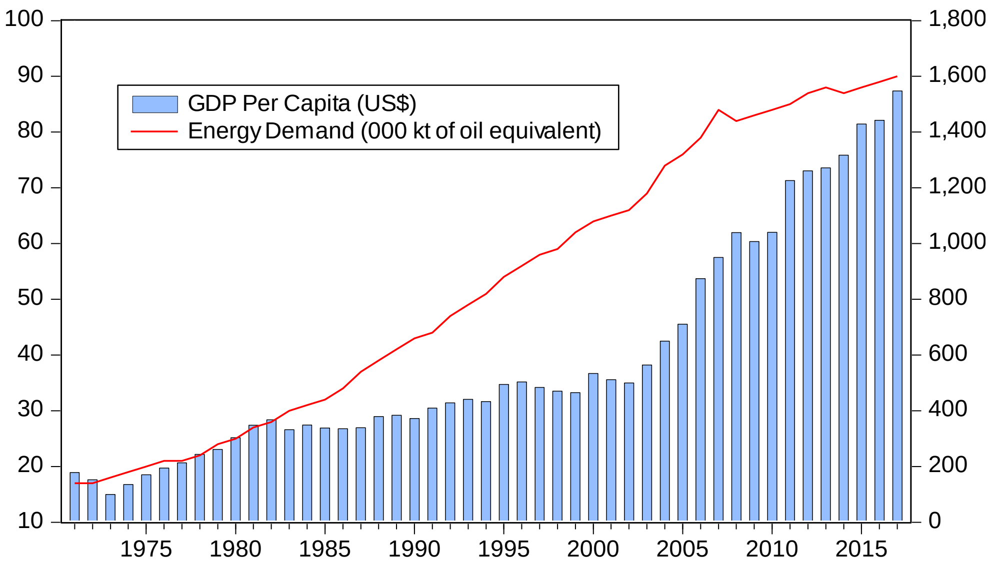

Figure 2. *GDP per Capita and Energy Demand*

Source: World Development Indicators Database.

Since 1971, the demand for energy in Pakistan has grown many folds (from 17 thousand kilotons of oil equivalent in 1971 to 90 thousand kilotons of oil equivalents in 2017). With significant reliance on fossil fuels as its primary energy source, it is not going to be sustainable[7]. In the last ten years or so, energy supply has failed to keep up with demand. The energy demand and supply deficit is getting wider with time. During 2016-17, besides an un-served energy, these deficits were met by oil imports of around 24 million tons of oil equivalent (MTOE) and coal imports of 5 MTOE. The cost of these imports in the year 2016-17 surpasses US $ 9 billion (coal imports not included). Increased reliance on imported energy place substantial pressure on the economy as external account deficit goes up and country's balance of payments position gets deteriorated. The impact of rising energy imports is even more severe when there are limited foreign exchange reserves.

In the period under study, Pakistan has experienced high energy intensity by world standards (Figure 1). Undoubtedly, energy intensity is following a declining trend but extremely slowly and with some temporary disruptions in several years (Figure 3).

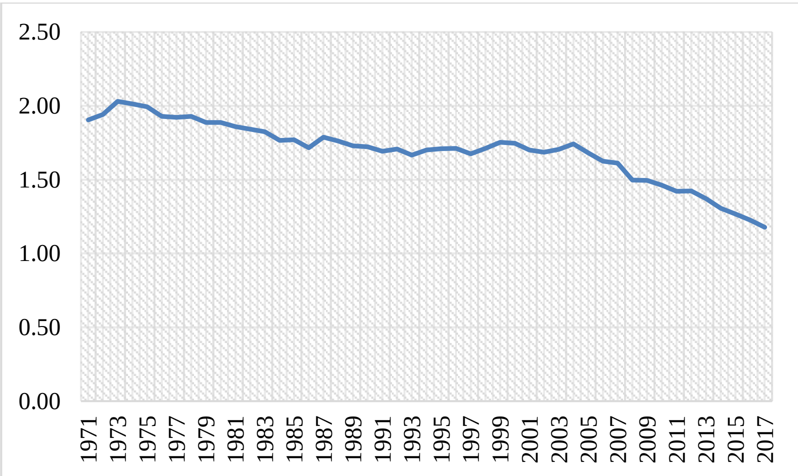

Figure 3. *Energy Intensity (Energy use in kg of oil equivalent per billion Rs GDP at constant prices of 2000)*

Source: World Development Indicators, World Economic Outlook and Pakistan Energy Yearbook.

But when we look at industrialization, Pakistan has not experienced a sharp industrial growth in the last four decades. Industrial value added remained in the range of 18 to 25 percent in the sample period (1971-2017). However, in terms of per capita GDP, over the past four decades, Pakistan has experienced a spectacular performance as its per capita GDP has increased from 178 US$ in 1971 to 1548 US$ in 2017 at an annual growth rate of 5 percent. Pakistan's GDP at current domestic

[7] Existing gas resources are depleting, and about 86 percent of oil consumption is based on imports.

prices with an annual growth rate of almost 16 percent increased from Pakistani Rupees 51 billion to Rupees 31963 billion from 1971 to 2017. The remarkable growth in per capita GDP can surely be attributed to its services sector. The share of agriculture in GDP has declined by about 9 percentage points (from 32 percent in 1971 to 23 percent in 2017). The entire subsequent decline in the share of agriculture in GDP (in the presence of almost stable industrial share) has been picked up by the services sector. Thus, contributing to decline in energy intensity but marginally. Why the decline is so marginal despite such a huge share of services sector in GDP? It could possibly be because of institutional weaknesses, structure of production in our industries or rising urbanization in Pakistan.

Urbanization rate in Pakistan was 25 percent in 1971. With an annual growth rate of 0.82 percent it increased to 36 percent in 2017. Pakistan is one of the fastest urbanizing countries in South Asia. Whereas, quality of institutions in Pakistan can be judged from its ranking in Global Competitiveness Report 2017-18, Pakistan's performance is extremely pathetic and ranked at 115 out of 137. First pillar in global competitiveness index is 'institutions', in which Pakistan is ranked at 90 because of its dismal performance in terms of weaknesses in property rights, transparency in government policy making, corrupt practices, inefficient legal framework and government regulations, wastefulness of government resources etc. Similarly, in terms of Economic Freedom of World (EFW) Index (also measuring institutional quality), Pakistan is ranked at 132 in a group of 162 countries in 2016.

Additionally, according to human development report 2018 Pakistan is ranked at 150 out of 189 countries and is at the lower margin of medium human development category; with quality of education dismally low. As discussed earlier, education level of a country along with research and development activities can influence the level of energy intensity. With more education comes more environmental, energy, and economic awareness. Thus, people with high level of education would have more awareness of energy conservation and efficient use of available resources. With more research and development activities, more technologically efficient structure of production.

As the objective in this study is to highlight factors that would help in reducing energy intensity to secure its future energy needs. Therefore, in the next sections we will empirically analyze those factors.

4. METHODOLOGY AND DATA

So far major part of empirical evidence is drawn from the cross-country analysis. In a cross-country regression methodology because of its inadequate theoretical details, modest quality of data and inapt econometric methodology we cannot come up with convincing results. The most compelling evidence can come from the case studies demonstrating factors affecting energy intensity. Further as Blanchard (1992) has pointed, because of heterogeneity among developing countries, energy consumption dynamics can only be analyzed at the level of individual countries. Therefore, in this study an attempt is made to model factors affecting energy intensity in Pakistan.

4.1. MODEL SPECIFICATION

We explore the relationship between income per capita used as a proxy for economic development, urbanization, industrialization, quality of institutions and energy intensity. The model adopted for current analysis is inspired from the studies of Sadorsky (2013) and Eliot, et.al. (2014). But some modifications are made in the light of discussion in Section 2 and situation analysis of Pakistan in Section 3. Education is not included separately in the model because of data limitations[8], but it is assumed that its impact would be captured in other explanatory variables like income per capita, urbanization and industrialization. Energy prices is also ignored because of the unavailability of specific energy price index[9].

The econometric model is specified as follows:

$$EI_t = ß_0 + ß_1\, Y + ß_2\, Ur + ß_3\, Ind + ß_4\, Ins + \mathcal{E}_t \tag{1}$$

Where, EI is energy intensity; Y is income per capita; Ur is urbanization level; Ind is industrialization; Ins is institutional quality; t represents time; B_0 to β_4 are parameters; and Ɛ is the residual error term. All variables are used in log form to eliminate the effects of heteroscedasticity in the time series. The above function becomes:

$$Ln\, EI_t = ß_0 + ß_1\, Ln\, Y + ß_2\, Ln\, Ur + ß_3\, Ln\, Ind + ß_4\, Ln\, Ins + \mathcal{E}_t \tag{2}$$

It is proved in the literature that energy efficiency by and large improves as economy develop. In the light of this, the coefficient of the income variable (i.e., income per capita) is likely to be negative. For Pakistan being a developing economy industrialization is assumed (in the light of existing evidence) to play a significant role in increasing energy intensity. Institutional quality is assumed to play a positive role in reducing energy intensity. However, for Pakistan given the quality/ level of our institutions, this variable may behave differently. For urbanization, with various factors/ channels associated with it, its' impact may or may not be negative. We assume rising urbanization to accompany rising income per capita, high standard of living and high level of education attainment. Thus, this variable is expected to have a decreasing impact on energy intensity.

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[8] Education Index data is available from 1981 onwards. Its inclusion would have made econometric problems.

[9] Fuel price index as well as electricity prices were tried as proxy for energy prices, but both proxy variables were not only insignificant but have effected other variables. Therefore, ignored in the final reported equation.

4.2. ESTIMATION TECHNIQUE

For estimation purpose we employ cointegration and vector error correction models (VECM). Johansen Maximum Likelihood method is used here to test for long run cointegration. It is a combination of the Maximum Eigenvalue (max) test and the Trace test derived from the following expressions:

$$\lambda \text{ trace (r)} = -T \sum_{r+t}^{n} Log \ (1 - ƛ_i) \tag{3}$$

$$\lambda \max (\mathrm{r}, \mathrm{r}+1) = -T \, Log \ (1 - ƛ_{r+1}) \tag{4}$$

Where $ƛ_i$ is the estimated eigenvalue of the characteristic roots, r = 0, 1, 2…, T is the number of observations. For the first trace test, the null hypothesis test if the number of different co-integrated vectors is equal or less r in contrast to the alternative. For the second max test, the null hypothesis test the number of cointegrating vectors r in contrast to the alternate r + 1 cointegrating vectors. The results of cointegration test helped in applying the VECM which gauges the long run association between the dependent and independent variables.

Whereas, the VECM is based on following set of equations:

$$\Delta EI_t = \alpha_1 + \sum_{i=0}^{i} \beta_{10} \ \Delta EI_{t-i} + \sum_{i=0}^{i} \beta_{20} \ \Delta Y_{t-i} + \sum_{i=0}^{i} \beta_{30} \ \Delta Ur_{t-i} +$$

$$\sum_{i=0}^{i} \beta_{40} \ \Delta Ind_{t-i} + \sum_{i=0}^{i} \beta_{50} \ \Delta Ins_{t-i} + \varepsilon_{1t} \tag{5}$$

$$\Delta Y_t = \alpha_1 + \sum_{i=0}^{i} \beta_{11} \ \Delta \mathrm{EI}_{t-i} + \sum_{i=0}^{i} \beta_{21} \ \Delta Y_{t-i} + \sum_{i=0}^{i} \beta_{31} \ \Delta Ur_{t-i} +$$

$$\sum_{i=0}^{i} \beta_{41} \ \Delta Ind_{t-i} + \sum_{i=0}^{i} \beta_{51} \ \Delta Ins_{t-i} + \varepsilon_{2t} \tag{6}$$

$$\Delta Ur_t = \alpha_1 + \sum_{i=0}^{i} \beta_{12} \ \Delta \mathrm{EI}_{t-i} + \sum_{i=0}^{i} \beta_{22} \ \Delta Y_{t-i} + \sum_{i=0}^{i} \beta_{32} \ \Delta Ur_{t-i} +$$

$$\sum_{i=0}^{i} \beta_{42}\ \Delta\, Ind_{t-i}\ +\sum_{i=0}^{i} \beta_{52}\ \Delta\, Ins_{t-i}\ +\ \varepsilon_{3t} \qquad (7)$$

$$\Delta\, Ind_t\ =\ \alpha_1 + \sum_{i=0}^{i} \beta_{13}\ \Delta\, \mathrm{EI}_{t-i} + \sum_{i=0}^{i} \beta_{23}\ \Delta\, Y_{t-i} + \sum_{i=0}^{i} \beta_{33}\ \Delta\, Ur_{t-i}\ +$$

$$\sum_{i=0}^{i} \beta_{43}\ \Delta\, Ind_{t-i}\ +\sum_{i=0}^{i} \beta_{53}\ \Delta\, Ins_{t-i}\ +\ \varepsilon_{4t} \qquad (8)$$

$$\Delta\, Ins_t\ =\ \alpha_1 + \sum_{i=0}^{i} \beta_{14}\ \Delta\, \mathrm{EI}_{t-i} + \sum_{i=0}^{i} \beta_{24}\ \Delta\, Y_{t-i} + \sum_{i=0}^{i} \beta_{34}\ \Delta\, Ur_{t-i}\ +$$

$$\sum_{i=0}^{i} \beta_{44}\ \Delta\, Ind_{t-i}\ +\sum_{i=0}^{i} \beta_{54}\ \Delta\, Ins_{t-i}\ +\ \varepsilon_{5t} \qquad (9)$$

The VECM determines the speed at which the variables adjust to a long-run equilibrium. The speed of adjustment is referred to as the error correction term. The above VECM can be used to decide the number of cointegrating vectors that are linearly independent of each other. In the equations Δ is the first difference operator and ε_t is the error term.

The optimum lag length of the first difference regression is chosen by the Schwarz Bayesian Criteria (SBC).

4.3. DATA

Annual data for all the variables is obtained from World Development Indicators database and Pakistan Energy Yearbook. Energy Intensity is defined as energy consumption per unit of GDP. An income variable is per capita gross domestic product (GDP) at the constant prices of 2000. Urbanization is defined as the share of urban population in total population. For industrialization, industrial value added as a percent of GDP is generated. To examine the impact of institutional quality on energy intensity, Fraser Institute's Economic Freedom of the World Index (EFW) is used as a proxy for institutional quality. Missing values in the series of EFW are generated via interpolation. The sample selected for the current analysis ranges from 1971 to 2017.

5. RESULTS

5.1. UNIT ROOT TESTS

As a first step we examine the time series properties of all the variables: energy intensity, income per capita, urbanization rate, industrialization level, and institutional quality. For this purpose, we apply Augmented Dickey-Fuller (ADF) tests and Phillips and Perron (PP) tests. Table 1 shows result for ADF tests and PP tests in both their level and differenced forms.

Table 1*. Unit Root Test (Augmented Dickey Fuller (ADF) and Phillips and Perron (PP))*

Variables	ADF			PP		
	Level	**First Difference**	**Second Difference**	**Level**	**First Difference**	**Second Difference**
Energy Intensity	-0.111	-9.863***	-7.203***	-0.383	-11.346***	-46.995***
Urbanization	-2.338	-0.801	-5.366***	-9.803***	-0.919	-5.393***
Industry	-2.727*	-7.877***	-11.000***	-2.822*	-8.438***	-39.888***
Per Capita GDP	-0.524	-9.951***	-7.114***	-0.123	-20721***	-44.458***
Institutional Quality	-0.596	-4.258***	-6.688***	-0.781	-4.056***	-10.216***

Note: * greater than 10% critical value, ** greater than 5% critical value, *** greater than 1 % critical value, thus rejecting null hypothesis of having a unit root.

According to ADF test results all variables except industry have unit roots in level form; all the other variables have no unit root in level form. However, in the first difference all variables are stationary except for urbanization, which is stationary in the second difference. More or less same results hold in the case of Phillips and Perron (PP) test except for urbanization which is stationary in level form.

As we can see data series are either integrated of I (0) or I (1) in different models, simple regression analysis can lead to spurious results. Taking first difference of the series which are I (1) or second difference of series which are I (2) leads to loss of long run information. Therefore, the problem of spurious results can be handled by identifying possible stationary linear combinations of variables. This leads us to examine co-integration between variables. Co-integration test will determine the long-term equilibrium relationships. However, there may be disequilibrium in the short run. Therefore, the error term can be pondered as equilibrium error. This error term can be interpreted to tie the short run behavior of the dependent variable to its long run behavior (Engle and Granger, 1987). Thus, in the next step the study will apply the cointegration test and then estimate a VECM to examine whether the long run relationship exists between the variables or not.

5.2. COINTEGRATION TEST

According to the Johnson Maximum Likelihood, the null hypothesis of at least one co-integrating relationship between energy intensity and the right hand sight variables (in eq. (2)) cannot be rejected at the 5 percent level, because the estimated statistic is greater than the critical value for both the Trace test and Max-eigenvalue test (Table 2). Thus, suggesting a stable long run relationship between energy intensity and all the explanatory variables.

Table 2. *Estimation of Co-integrating Vectors*

Hypothesized No. of CE(s)	**Trace Statistic**	**Critical Value (5%)**	**Probability**
None*	98.34	69.82	0.0001
At most 1*	51.58	47.86	0.0214
At most 2	29.31	29.80	0.0569
At most 3	10.16	15.50	0.2688
Hypothesized No. of CE(s)	**Max-Eigen Statistic**	**Critical Value (5%)**	**Probability**
None*	46.76	33.88	0.0009
At most 1	22.27	27.58	0.2067
At most 2	19.15	21.013	0.0926
At most 3	9.84	14.26	0.2228

Note: Both Trace Test and Max-Eigen Test indicate at least 1 co-integrating equation at 0.05 level.

For selection of appropriate lag length, we used Schwarz Bayesian Criteria (SBC); it shows the optimal lag length of 1.

5.3. ESTIMATION OF VECTOR ERROR CORRECTION MODEL (VECM)

When variables are cointegrated, there is a long-term equilibrium relationship between them so VECM is estimated to gauge the short run adjustment of the cointegrated equilibrium relationship. A negative and significant coefficient of the error correction term indicates that any short term fluctuation between variables will give rise to a stable long run relationship between variables. The coefficient of error correction term provides the speed with which variables return to its equilibrium position in the long run. Results are reported in Table 3.

Table 3: VECM Results

Variables	**∆ Ln (Intensity)**
Error Correction Term	-0.45 (-2.76)**
∆ Ln (Intensity(-1))	-1.11 (-1.98)
∆ Ln (GDP per capita (-1))	-0.85 (-1.42)
∆ Ln (Urban(-1))	-2.23 (-0.43)
∆ Ln (Industry(-1))	-0.27 (-1.30)
∆ Ln (Institutions(-1))	-0.51 (-1.23)

*Note: *** Significant at 1 % critical level.*

This model contains significant error-correction term. Its coefficient measures the speed of adjustment in current energy intensity. However, its small value (-0.45) indicates that energy intensity converges to its equilibrium level at a very slow speed.

From above estimations, we find that even though the relationship between economic development (per capita income), industrialization, urbanization, institutional quality and energy intensity will deviate from the equilibrium state in the short term after being disturbed by uncertainties, however, in the long run it is obvious to attain an equilibrium relationship.

5.4. LONG RUN RELATIONSHIP

The co-integration vector represents the dynamics and adjustment of the variables in the long-term equilibrium. The results of the long run relationship amid energy intensity, income per capita, urbanization rate, industrialization, and institutional quality in Pakistan are reported in Table 4.

Table 4. *Long- run relationship between energy intensity and influencing factors*

Energy Intensity	**GDP per capita**	**Urbanization**	**Industry**	**Institutional quality**
1.000	-0.46	-1.87	1.39	1.03
t-statistic	-2.84***	-3.77***	7.87***	4.05***

*Note: ** Significant at 5 % critical level, and *** significant at 1 % critical level.*

That is, in the long run, there is a negative association between energy intensity and level of economic development (income per capita) in Pakistan. With increase in income, intensity in the use of energy goes down in line with the phenomenon of "dematerialization" as described in Bernardini and Galli (1993). The estimated coefficient of income elasticity is negative and significant. Similarly, we find a positive and significant coefficient of industrialization, pointing towards rising intensity in the use of energy with an increase in industrial activities. This elasticity is also greater than unity. For urbanization coefficient is negative and highly significant and greater than unity. Further, poor quality of institutions for sure are responsible for rising energy intensity in Pakistan. Positive and highly significant coefficient of institutions is consistent with economic literature, which highlights the significance of strong institutions for reducing energy intensity in the emerging countries (Suslov, 2008).

For robustness check, we estimate equation (2) using OLS (Newey-West method). The estimated equation displays reasonable adjusted R2, and no indication of econometric problems as exhibited by the p-values of the diagnostic tests (Jarque–Bera (JB) for normality of residuals and the Ramsey RESET test for functional specification; p-values of JB and Ramsey RESET tests are found to be 0.43 and 0.25 respectively. These tests corroborate the validity of the estimated equation.

6. ASSESSMENT OF RESULTS

6.1. IMPACT OF INCOME PER CAPITA ON ENERGY INTENSITY

Coming back to long run results as reported in Table 4. Starting with income per capita as a determinant of energy intensity we find rising income in Pakistan playing a significant role in easing energy intensity. In Pakistan (unlike developing countries in East Asia where manufacturing played a critical role in different stages of development), we observe a shift from agriculture based economy to service based economy; while manufacturing has remained almost stagnant. The shift towards services has an impact on rising per capita income and so on reducing energy intensity to some extent. However, lack of attention towards manufacturing has its impact too in terms of weakening growth trend since 1960s. Moreover, whatever growth took place in Pakistan is consumption led growth under the influence of exchange rate management policies, financial inflows in the form of foreign aid, and remittances (Sánchez-Triana, et.al., 2014), which unquestionably is not sustainable. This has added to industrial woes significantly. Empirical evidence confirms that no country has grown to middle income and then to high income status without industrializing and urbanizing. Pakistan undoubtedly, is urbanizing (under the influence of services sector growth besides other factors) but not industrializing.

6.2. IMPACT OF URBANIZATION ON ENERGY INTENSITY

As discussed in Section II, the impact of urbanization on energy intensity could be positive or negative depending upon its development as well as on the energy management systems. In this study, its impact is negative and significant (Table 4). Since urbanization is accompanied with rising income per capita, it implies high standard of living and high level of education attainment. This result suggests that increased consumption levels of energy resources in Pakistani cities is creating space for improved efficiency in the use of energy resources with more knowledge and awareness. Thus, this variable is having a decreasing impact on energy intensity.

Pakistan has not been able to manage its fast paced urbanization initially. Most of the urbanization was either unplanned or irrationally planned. However, in the last couple of years, especially with China Pakistan Economic Corridor (CPEC), economic opportunities and rising economic growth have persuaded rural populaces to migrate to urban areas to improve their well-being. As a result, the impact of urbanization on energy intensity in Pakistan has changed now10. Rising urbanization is accompanied with cutting reliance on resource and energy dependent industries. Urbanization inhales less energy than in the past, as the intensity holds a downward trend vis-à-vis rising urbanization.

[10] We have also estimated our model for different samples, impact of urbanization was insignificant prior to 2013.

6.3. IMPACT OF INDUSTRIALIZATION ON ENERGY INTENSITY

Share of industry in GDP has remained almost constant since 1971. But at the same time, it is not only the largest energy consuming sector with a share of 35 percent but also adding to energy intensity significantly (Table 4). Its positive impact on overall energy intensity in Pakistan is much larger than the negative impact of rising per capita income (its coefficient in estimated normalized equation is much larger than the coefficient of per capita income).

Manufacturing sector in Pakistan is led by resource based and low technology activities[11]. Theses industrial activities are not only highly energy intensive, they are susceptible to high rate of energy losses throughout various production procedures causing higher energy bills as well as losses in productivity[12]. Undoubtedly, there are opportunities for saving energy in nearly the entire industrial sector of Pakistan. It is estimated that about 22 percent of energy can be saved without any loss in production[13].

Energy efficiency in industry is strongly linked with competitiveness[14]. At the national level, competitiveness will be enhanced when industry consumes less energy. Energy use in the industrial sector depends primarily on technology utilized, plant maturity, sector concentration, capacity utilization and the composition of subsectors. Currently, there is a little awareness and even less expertise in terms of energy saving practices and skill development to achieve best energy management practices.

In Pakistan, undoubtedly research and development (R&D) organizations are in great numbers. However, their output is leaned towards the supply side only as there is no real demand from industry. The state of science and technology in Pakistan is far below compared to many emerging economies[15]. China is a success case in terms of declining industry energy intensity. For China, R&D activities have a great contribution in the decline of firm-level energy intensity (Fisher-Vanden, et.al, 2004).

Pakistan has the potential for industrial expansion. It can increase its competitiveness by employing energy-efficient production techniques in new industrial activities. Improvement in energy efficiency is indispensable to promote future growth of Pakistan's manufacturing sector.

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[11] Besides textiles and food, chemicals and chemical products, cement, iron and steel, and pulp and paper are major industrial sub-sectors.

[12] http://www.smeda.org/index.php?option=com_content&view=article&id=18&Itemid=120

[13] www.pisd.com.pk

[14] For details on Pakistan's industrial competitiveness see Sánchez-Triana, et.al. (2014).

[15] Pakistan is ranked at 120 and 111 for higher education & training and technological readiness respectively in Global Competitiveness Report, 2017-18.

6.4. IMPACT OF INSTITUTIONAL QUALITY ON ENERGY INTENSITY

Another important result in this study is the positive and highly significant coefficient of institutional quality (EFW Index used as proxy). Higher ratings of the EFW index (used here as proxy for institutional quality) is linked to more rapid growth and higher income levels. As discussed earlier, evidence has proven the importance of better institutions not only for higher income, but also for improving energy efficiency. It is argued that a country whether rich or poor in natural resources, but its policies if support the four pillars of economic freedom_ rule of law, restrained government, regulatory effectiveness and open markets are more prosperous not only in terms of rising economic growth and innovation, but also in using energy more efficiently (Loris, 2015). In other words, boosting the institutional competence of energy and environmental agencies is important to address the environmental and energy efficiency issues.

For Pakistan its lower ratings in EFW Index indicating a lower institutional quality is causing energy intensity to rise (Table 4). Poor state of our institutional quality as well as weaknesses in the economic management in general and energy management in particular is also evident from the poor state of affairs (with reference to energy conservation) in the industrial sector. Generally speaking the legislative framework for energy conservation is weak in Pakistan[16]. There is need to redefine energy conservation laws (wherever weak) and ensure the timely implementation of these laws. To strictly implement legislative framework for energy conservation we need to strengthen our institutions designed especially for this purpose[17].

Countries with strong institutional set-up tend to consume energy more efficiently. In all the countries around the globe it is the government policies and interventions that are responsible for most of the glitches with respect to accessing, producing, and consuming energy (Loris, 2015). This argument calls for necessary market based mechanisms in Pakistan. Our energy strategy should focus on complete overhauling of the energy supply chain through improved governance practices, better regulation, and institutional and structural reforms.

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[16] In Pakistan, environment and energy legislations do exist that have the capacity to make our manufacturing sector more resource proficient and environment friendly. However, weak coordination among relevant institutions has hindered the implementation of existing laws (for details see UNIDO-Pakistan, 2014).

[17] National Energy Conservation Centre (ENERCON) has greatly suffered because of lack of funds and professional facilities and capabilities. Its functionality has remained dependent on donor assisted projects. Consequently, over the years, it is inept to commercialise energy saving activities effectually (cited from UNIDO-Pakistan, 2014).

7. CONCLUSION

In this paper we examine the impact of income per capita, urbanization, industrialization and institutional quality on energy intensity in Pakistan. Results indicate poor institutional quality and industrialization are positively related to energy intensity while income per capita and urbanization have a significant role in reducing energy intensity in Pakistan.

For Pakistan being a developing country, both urbanization and industrialization are expected to rise in future. A notable commitment in terms of investment in appropriate technical and general education, as well as boosting of research and development activities is a must to make Pakistan an innovation based economy and increase its productivity and eventually become an energy efficient economy.

Similarly, rationalization of energy prices along with good governance practices and better quality of institutions can play an effective role in increasing the efficiency in the use of energy thus reducing overall energy intensity. To make the energy system of Pakistan more sustainable, there is a need to adopt policies that will improve efficiency in energy production and use, besides encouraging dependence on non-fossil fuels.

The world has increasingly become more energy efficient, while Pakistan is relatively inefficient. Globally, energy demand in developed economies is expected to be lower by 2030 despite 50 percent projected growth in these economies. This would be achievable only due to extensive developments in the efficient use of energy in these countries (OICCI, 2012). Pakistan needs to develop and boost its capacity to apply effective policies, market based mechanisms and regulations with respect to the efficient usage of energye. The country is planning to achieve the growth rate of 7-8 per cent in the next few years. The energy required to meet this target is immense. Without improving efficiency in the use of energy the country would not be able to achieve the desired target.

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