Dynamics and Determinants of Energy Intensity: Evidence from Pakistan

Malik, Afia

Pakistan Institute of Development Economics

2019

DYNAMICS AND DETERMINANTS OF ENERGY INTENSITY: EVIDENCE FROM PAKISTAN

Afia Malik[1]

Senior Research Economist

Pakistan Institute of Development Economics (PIDE), Islamabad, Pakistan

***Abstract*:** The study has identified 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. For Pakistan being a country in transition, industrialization is expected to rise in future along with its adverse impact on energy intensity. However, economic policies that boost income would help in reducing energy intensity; provided income effect is large enough and sustainable to offset the negative impact of industrialization. Similarly, 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.

Key Words: Energy Intensity, Income per capita, Industry, Urbanization, Institutional Quality.

JEL: 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[2], while energy supply has failed to keep up with the rising demand. There is a threat to energy security given weaknesses in its conventional energy supplies owing to number of factors such as lack of sufficient energy, inconsistent supplies, inefficient tariff structures along with untargeted subsidies and significant import dependency. Pakistan is increasingly concerned with the issue of rising demand and energy security. Importing energy to meet its demand drains the local

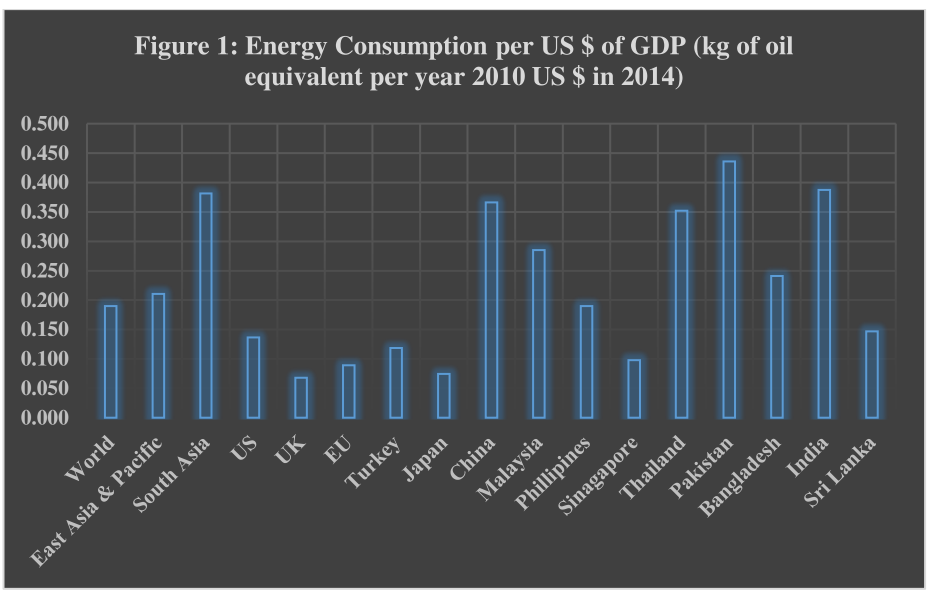
[1] The author alone is responsible for any error or omission in the paper.

[2] Since 1971 energy demand has grown 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).

economy and leaves the supply system extremely vulnerable, that most of the time is beyond the control of financial managers in the country.

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[3]. According to one estimate rural population is burning biofuels to realize 94 percent of its domestic energy needs[4] (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, efficiency in the use of energy can produce considerable improvements in supply in Pakistan, thus reducing the supply demand gap. Energy intensity (measured as ratio of energy consumption to GDP) in Pakistan is more than double to that of the world average and more than six times to that of UK, and more than five times to that of Japan[5] (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).



[3] Forests are vital for the environmental and economic sustainability of a country, but regrettably, in Pakistan are being exterminated at a rapid pace to meet energy requirements of people who are not connected to national gas networks and electricity grid.

[4] Almost 62 percent of population is still residing in rural areas (World Development Indicators).

[5] In addition to 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.

Source: World Development Indicators Database

The energy saving potential of Pakistan is estimated to be around 11.16 MTOE (Malik, 2012). For resource constrained economies like Pakistan it is more cost effective to increase its energy security and ease supply constraints through efficiency and conservation compared to exploiting/ building new sources of energy. So far it is the most neglected area in our energy strategies and plans. Energy efficiency should be an urgency that can be tackled by better capacity, legislation, management, and investment.

For mainstreaming the issue of energy efficiency into energy policy it is of utmost importance to identify the factors responsible for high energy intensity in Pakistan. Pakistan is on a high growth path with rising per capita income. Urbanization and industrialization are the most important features of economic development and both are expected to rise in future and would have an impact on the efficient use of energy resources. Besides, institutional quality, i.e., existence and implementation of environment and energy legislations have also an important role in enforcing energy conservation laws.

So far the empirical literature on Pakistan has focused on energy consumption, that is, to study energy consumption and growth causality; to study factors responsible for rising consumption or demand; and to forecast future 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); whereas Mahmood and Kanwal (2017) investigates the causal relationship between energy intensity and economic activity (GDP) in Pakistan. Lack of sufficient evidence for Pakistan qualifies the need for a detailed study on energy intensity.

To the best of my knowledge, this is the only comprehensive study that investigates the role of institutional quality, industrialization, urbanization, and economic development (measured by per capita income) behind high energy intensity for Pakistan and uses the longest available data from 1971-2017, making the estimation more reliable. The study will provide guidelines to policy makers in mitigating concerns regarding energy security issues through reducing energy intensity.

The paper is organized in a following way. Section 2 of the paper set out the contextual material while going through the relevant literature. Section 3 is the discussion with reference to Pakistan. In Section 4 data and methodology are explained. In Section 5 results are reported. In Section 6 results are assessed in the light of ground realities. Finally, section 7 concludes the discussion.

2. CONCEPTUAL FRAMEWORK

It is argued that energy intensity tends to correlate highly with ***income***. Higher income countries have lower energy intensity as compared to lower income countries. Evidence suggests energy intensity for high income countries to be falling over the past 30 years; as these countries are generally efficient at using energy as compared to low and middle income countries (Sadorsky, 2013).

In this context, Bernardini and Galli (1993) deliberate on the theory of dematerialization[6] while focusing on energy intensity. They identify three reasons[7] for the decline 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, industrialization is typified by large increases in energy consumption. As income rises in this stage, automobiles and household appliance ownership add up to the rising intensity stage. But ultimately ownership demand steeps, 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 combined effect of this transition is a reduction in energy intensity of GDP. This phenomenon is often referred to as dematerialization, the process which allows for reduction in material inputs per unit of output. Secondly, technological progress increases the efficiency with which energy is used. Third, technological progress leads to the use of substitute materials which are less energy intensive.

[6] Although Malenbaum (1978) showed empirically for the first time how resource intensity of minerals changed with increases in income per capita. But the concept was used for energy intensity by Bernardini and Galli (1993).
[7] Later on also cited in Galli (1998), Sadorsky (2013) and Elliot, *et al*. (2014).

Medlock III and Soligo (2001) also discuss the shifts in the structure of consumption and production in different stages of economic development that changes the demand for energy, while Galli (1998) examine the trends in energy intensity for ten emerging countries in Asia, and its findings validate the process of dematerialization.

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, China has developed remarkably with an annual economic growth rate of 9.9 percent (Zhao and Wang, 2015). The main driving force for the decline in energy intensity is the improvement in efficiency while the impact of structural changes in the economy is very limited. It is expected that China's energy intensity can be reduced further when structural changes become the main driver for dematerialization. China would then perform even better than its East Asian counterparts Japan and South Korea (Wu, 2012). However, Zhang (2009) reports increases in per capita income, time trend and capital-labor ratio playing an important role in the decline of China's energy intensity. Whereas, Elliot, *et al*. (2014) finds a minor role of urbanization in reducing energy intensity, and industrial activity to be the main contributor to energy intensity in China.

In general, empirical evidence has confirmed the convergence of energy efficiency over time across countries. Technological change is the most important factor easing the global increase in energy use and carbon emissions due to economic growth. Increasing total factor productivity is associated with rising energy efficiency, while higher fossil fuel reserves are responsible for lower energy efficiency (Stern, 2010).

Jacobs and Šlaus (2011) take the argument further, that is, only shift towards services with less emphasis on material resources does not guarantee sustainable energy supplies for development. Advances in technology, greater public awareness and commitment, changes in public policy and changes in culture are all important. The shift for services is more ostensible in high income countries as compared to those that are in an earlier stage of economic development. It has been assumed that full modern service economy in advanced nations would have little impact on rising 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 at least some of the unwarranted energy demands of industrialization.

In this transition, 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 sources more efficiently. So, as income per capita increases, not only technological progress leads to increases in energy efficiency, higher education and standard of living are also accompanied with it.

The impact of ***institutional strength*** is also important in this context. Existence of a strong correlation between the quality of institutions and policies on the one hand, and the per capita income level on the other hand has been proved in literature (Suslov, 2008). Suslov (2008) while examining factors responsible for higher energy intensity of production in the former socialist countries as compared to the market economies reports the importance of strong economic institutions and economic agents in implementing energy conservation measures. Fredriksson, *et al*. (2004) also provided a theoretical model of corruption's influence on energy efficiency. The study predicts that greater corruptibility of policy makers and their coordination with interest groups reduce the stringency of energy policy. The study reports a strong correlation between the corruption variable and energy intensity of production sectors.

Empirical evidence has also shown that 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 urbanized proportion of 75 percent, while the less developed countries have an average of 27 percent in the Asia-Pacific region (ESCAP, 2014).

Therefore, it is important to study the role of urbanization and industrialization with respect to energy intensity. Jones (1989 and later in 1991) was the first one to focus on the impact of urbanization and industrialization on the rising use of energy. According to him, urbanization and industrialization despite being a companion in the process of economic development differ in terms of their impact on energy use.

Urbanization leads to a significant concentration of human resources, economic activities, and resource consumption in cities[8]. There is substantial increase in energy demand and a change 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 this effect is induced by appliance purchase and operation and partly it reflects the increased ability to purchase more convenient and desirable 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 intensity[9].

The impact of urbanization mechanisms differs considerably between developed and developing countries as well as within the group of 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 a higher concentration of consumption and production; but 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).

Moreover, 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.

Many studies have investigated the impact 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) assess the implications of a plausible range of urbanization pathways for energy use and carbon emissions in India and China, while Ghosh and Kanjilal (2014) find unidirectional

---

[8] Even though covering only about 2% of the earth's surface, cities are responsible for about 75% of the world's consumption of resources (Madlener and Sunak, 2011).

[9] For details on various channels through which urbanisation can influence the use of energy see Sardosky, 2013, Madlener and Sunak, 2011, and Eliot, *et al.,* 2014.

causality running from energy consumption to economic activity and economic activity to urbanization.

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 hence, everything equal, an increase 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 having different energy intensities. Secondly, industrial aggregation can camouflage considerable product variation, with consequent variations in energy intensity. Third, maintenance and operational procedures vary greatly across countries. Finally, there is considerable learning by doing in industrial and commercial energy consumption (cited from Jones, 1991).

Thus it is important to study the impact of industrialization on energy intensity for each country separately. Rühl, *et al*. (2012) draws on evidence from the last two centuries of industrialization, and highlights the importance of specialization of the fuel mix, coupled with 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.

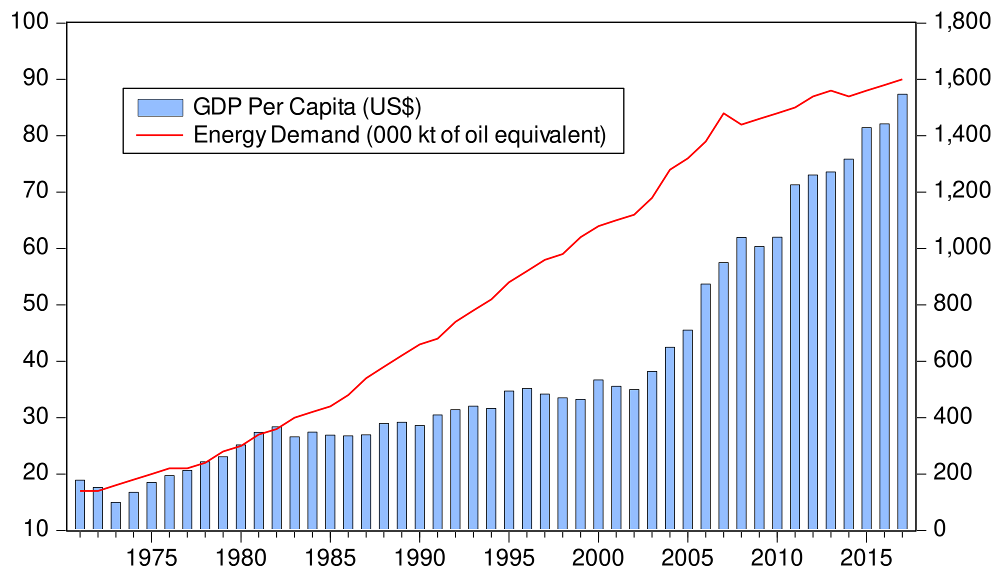
Sadorsky (2013) confirms the role of income in reducing energy intensity and industrialization in increasing energy intensity; while he finds a mixed impact of urbanization on energy intensity for an unbalanced panel of 76 developing countries. Xia and Hu (2012) find urban morphology, industrial structure and rising temperature causing electricity consumption intensity to rise while regulation pressure and enhancement of prices may largely be responsible for reducing electricity consumption intensity.

Few studies have also focused on energy prices (Fisher-Vanden, *et al.*, 2004; Metcalf, 2008; and Mirza and Fatima, 2014). 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) finds a limited role for energy prices in explaining variation in energy productivity, casting doubt on the effectiveness of price instruments to enhance energy efficiency in the service sector.

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: 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 dependence on fossil fuels as its primary energy source, it is not going to be sustainable[10]. 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

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

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 also 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).

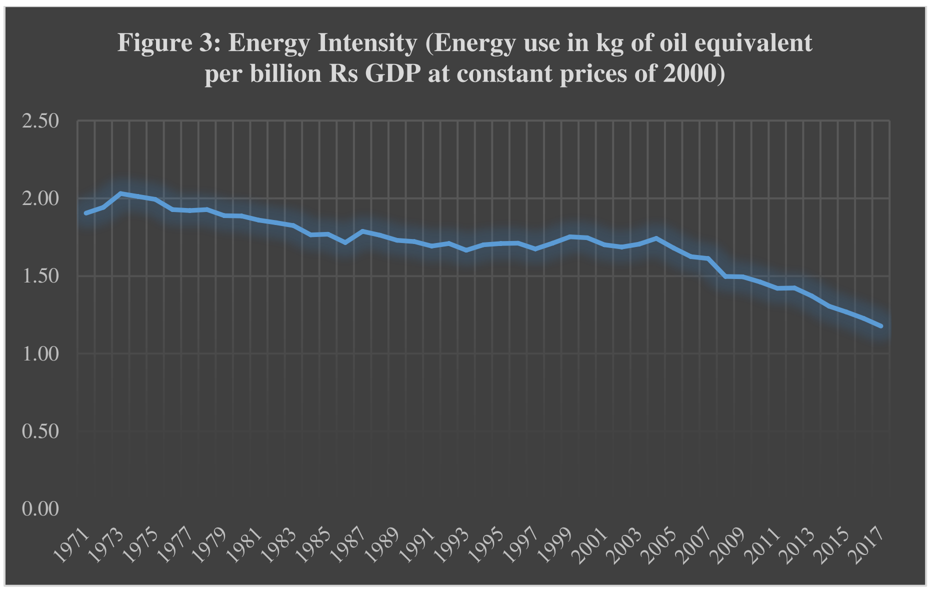


Figure 3: Energy Intensity (Energy use in kg of oil equivalent per billion Rs GDP at constant prices of 2000)

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 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 in the sample period (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 weak theoretical foundations, poor quality of data and inappropriate 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.

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 contextual framework developed in Section 2 and situation analysis of Pakistan in Section 3. Education is not included separately in the model because of data limitations[11], 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[12].

The econometric model is specified as follows:

$$EI_t = ß_0 + ß_1\ Y + ß_2\ Ur + ß_3\ Ind + ß_4\ Ins + \mathcal{E}_t \quad \ldots \ldots \ldots. \quad (1)$$

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.

It is argued that energy efficiency generally improves as economy develops. In accordance with this argument, the coefficient of the income variable is expected 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. Theoretically we

[11] Education Index data is available from 1981 onwards. Its inclusion would have made econometric problems.
[12] Fuel price index was tried as proxy for energy prices, but it was not only insignificant but has effected other variables. Therefore, ignored in the final reported equation.

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.

For estimation purpose we employ co-integration and vector error correction models (VECM) developed by Engle and Granger (1987).

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. All variables are used in log form to eliminate the effects of heteroscedasticity in the time series. The sample selected for the current analysis ranges from 1971 to 2017.

5. RESULTS

5.1. Results of 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 refer to 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 considered as equilibrium error and this error term can be used 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 co-integration test and then estimate a VECM to examine whether the long run relationship exists between the variables.

5.2.Co-integration Test

Johansen Maximum Likelihood method is used here to test for long run co-integration. 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. (1)) cannot be rejected at the 5 percent level, because the estimated statistic is greater than the critical value for the Trace test and Max-eigenvalue test. 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 co-integrated, there is a long-term equilibrium relationship between them so VECM is estimated to evaluate the short run adjustment of the co-integrated 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	**D(Intensity)**
Error Correction Term	-0.45 (-2.76)**
D(Intensity(-1))	-1.11 (-1.98)**

D(GDP per capita (-1))	-0.85 (-1.42)
D(Urban(-1))	-2.23 (-0.43)
D(Industry(-1))	-0.27 (-1.30)
D(Institutions(-1))	-0.51 (-1.23)

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

We are reporting equation important from the objective of this study where D (Intensity) is the dependent variable. 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 analysis, 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 temporarily after being affected by uncertainties, an equilibrium relationship will be evident in the long run.

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 among 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 clear and reliable negative relationship between energy intensity and level of economic development (income per capita) in Pakistan. With the 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 not only negative and highly significant, but greater than unity, indicating urbanization to accompany rising income per capita, high standard of living and high level of education attainment. Thus, this variable is having a decreasing impact on energy intensity. Further, poor quality of institutions in Pakistan for sure is 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 (1) using OLS (Newey-West method). The estimated equation displays reasonable adjusted R^2, and no sign of econometric problems as indicated 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.Income per Capita

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 an important role in reducing energy intensity. In Pakistan (unlike developing countries in East Asia where manufacturing played a significant role in different stages of development), we observe a shift from agriculture based economy to service based economy; while manufacturing has remained almost stagnant[13]. 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[14] (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.Urbanization

Cities are regarded as hubs of high standard of living, thus consuming material goods enormously. This may leads to excessive use of natural resources including energy resources. At the same time as an engine of economic growth cities provide opportunities for innovation, knowledge and technology. High population density and increased consumption levels create space for improved efficiency in the use of natural resources (Dhakal, 2004). So the impact of urbanization on energy intensity may 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). Empirical evidence has also proven that none of the country has grown to high income without vibrant cities.

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 development has encouraged rural inhabitants to migrate to urban areas to improve their economic opportunities and access to services. As a result, the impact of urbanization on energy intensity in Pakistan has

[13] India has experienced similar trends.
[14] In the last decade or so, fueled by remittances and a consumption boom, GDP grew at above 7 percent in 2002–06; it then fell to 4 percent in 2008 and 2 percent in 2009, in part because of the global economic crisis.

now changed[15]. In other words, 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.

6.3.Industrialization

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). Evidence for other countries have proved that to keep our income per capita on rising path we need to focus on production based growth. This eventually would have a negative impact on energy intensity in future (in the third phase of development). Undoubtedly, industrial sector of Pakistan has the potential to grow but its performance has been marred by a number of factors including poor policy initiatives, lack of innovation and diversification in products for meeting the needs of domestic and global consumers, high cost of production and low quality of products. In addition, ineffective macroeconomic policies, lack of infrastructure, poor quality of governance and human resources and inefficient use of energy are contributing towards industrial glitches.

Manufacturing activity in Pakistan is dominated by resource based and low technology activities[16]. Theses industrial activities besides being energy intensive; are susceptible to high rate of energy losses across various production processes resulting in higher energy bills and productivity losses[17]. Energy efficiency opportunities exist in almost the entire industrial sector of Pakistan, with an estimated energy saving potential of 22 percent without any loss in production[18].

---

[15] We have also estimated our model for different samples, impact of urbanization was insignificant prior to 2013.
[16] Besides textiles and food, chemicals and chemical products, cement, iron and steel, and pulp and paper are major industrial sub-sectors.
[17] http://www.smeda.org/index.php?option=com_content&view=article&id=18&Itemid=120
[18] www.pisd.com.pk

Energy efficiency in industry is strongly linked with competitiveness[19]. At the national level, competitiveness will be enhanced when industry consumes less energy. Energy use in the industrial sector depends primarily on the level of technology used, maturity of plants, sector concentration, capacity utilization and the structure 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.

Although large number of research and development (R&D) organizations have been established. With no real demand from industry, R&D in Pakistan is oriented towards the supply side. The state of science and technology in Pakistan has been far below many emerging economies[20]. China is a success case in terms of declining industry energy intensity. For China, R&D activities have played an important role 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 applying energy-efficient best practices in new industrial facilities. Improvement in energy efficiency is indispensable to promote the future growth of Pakistan's manufacturing sector.

6.4.Institutional Quality

Another noticeable result in this study is the positive and highly significant coefficient of institutional quality (EFW Index used as proxy). This result implies poor institutional quality leading to higher energy intensity. 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, limited government, regulatory efficiency and open markets are more successful not only in accelerating economic growth and innovation, but also in using energy more efficiently (Loris, 2015). In other words, strengthening the institutional capacity of energy and environmental agencies is important to address the environmental and energy efficiency issues.

[19] For details on Pakistan's industrial competitiveness see Sánchez-Triana, et.al. (2014).
[20] Pakistan is ranked at 120 and 111 for higher education & training and technological readiness respectively in Global Competitiveness Report, 2017-18.

For Pakistan its lower ratings in EFW Index[21] indicating a lower institutional quality is causing energy intensity to rise. 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[22]. 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[23].

Economically freer countries tend to consume energy more efficiently. Many of the problems associated with accessing, producing, and consuming energy in countries around the world are a direct result of government intervention and policies (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.

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 significant and consistent commitment in terms of public investment in relevant technical and general education, as well as strengthening 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.

---

[21] Pakistan is ranked at 132 in a group of 162 countries in Economic Freedom of World (EFW) Index.

[22] In Pakistan, environment and energy legislations do exist that have the capacity to force a shift to a more resource efficient and low carbon manufacturing sector. However, weak coordination among relevant institutions has hindered the implementation of existing laws (for details see UNIDO-Pakistan, 2014).

[23] 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 has not been able to commercialise energy efficiency activities effectively (cited from UNIDO-Pakistan, 2014).

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 increasing reliance on non-fossil fuels. As a result of these energy conservation programs, consumption of petroleum products in Philippines declined by 8 percent in almost two years (Bacon and Kojima, 2006).

The world is continuously becoming more energy efficient, while Pakistan is relatively inefficient. The state of affairs is not helped by a growing population (182 million in 2013), rising urbanization, low per capita energy consumption (489 kg of oil equivalent), low level of educational attainment and weak institutional capacity and a recent surge in cheap but energy hungry home appliances, and yet high energy intensity. Globally, energy demand in developed economies is expected to be lower by 2030 despite 50 percent projected growth in these economies. This would be possible due to significant advancements in energy efficiency in these countries (OICCI, 2012). Pakistan needs to build and strengthen its capacity to implement effective policies, market based mechanisms, business models and regulations with respect to energy use. If the country is expected to grow at 7-8 per cent, then the energy required to meet this target is immense. Without improving efficiency in the use of energy the country will not be able to achieve the desired target.

References:

1. Akbarullah, K. Khan and Akhtar, M. (2013). Energy Intensity: A Decomposition Exercise for Pakistan. Paper presented in the 29th Annual General Meeting and Conference of the Pakistan Society of Development Economist. http://www.pide.org.pk/psde/pdf/AGM29/papers/Akber%20Ullah.pdf (accessed September, 2015)
2. Alam, S. and Butt, M. S. (2001). Assessing Energy Consumption and Energy Intensity Changes in Pakistan: An Application of Complete Decomposition Model. *The Pakistan Development Review*, 40, 135-147.

3. Bacon, R. and Kojima, M. (2006). Coping with High Oil Prices. ESMAP Report 323/06, The World Bank.
4. Bairoch, P. and Goertz, G. (1986). Factors of Urbanization in the Nineteenth Century Developed Countries: A Descriptive and Econometric Analysis. *Urban Studies*, 23, 285-305.
5. Bernardini, O. and Galli, R. (1993). Dematerialization: Long Term Trends in the Intensity of Use of Materials and Energy. *Futures*, 25, 431–448.
6. Blanchard, O., (1992). Energy Consumption and Modes of Industrialization: Four Developing Countries. *Energy Policy*, 20 (12), 1174–1185.
7. Colbeck, I., Nasir, Z. A. and Ali, Z. (2010). Characteristics of Indoor/Outdoor Particulate Pollution in Urban and Rural Residential Environment of Pakistan. *International Journal of Environment and Health*, 20, 40-51.
8. Dhakal, S. (2004). Urban Energy Use and Greenhouse Gas Emissions in Asian Megacities: Polices for Sustainable Future. Institute for Global Environmental Strategies, Japan.
9. Elliot, Robert J. R., Sun, P. and Zhu, T. (2014). Urbanization and Energy Intensity: A Province-level Study for China. Department of Economics Discussion Paper 14-05, University of Birmingham.
10. Engle, Robert F. and Granger, C. W. J. (1987). Co-Integration and Error Correction: Representation, Estimation, and Testing. *Econometrica*, 55 (2), 251-276.
11. ESCAP (2014). Statistical Yearbook for Asia and the Pacific. Economic and Social Commission for Asia and the Pacific (ESCAP), United Nations.
12. Fisher-Vanden, K., Jefferson, G. H., Hongmei, L. and Quan, T. (2004). What is Driving China's Decline in Energy Intensity? *Resource and Energy Economics*, 26, 77-97.
13. Fredriksson, P. G., Vollebergh, H. R. J. and Dijkgraaf, E. (2004). Corruption and Energy Efficiency in OECD Countries: Theory and Evidence. *Journal of Environmental Economics and Management*, 47, 207-231.
14. Galli, R. (1998). The Relationship between Energy Intensity and Income Levels: Forecasting Long Term Energy Demand in Asian Emerging Countries. *The Energy Journal*, 19, 85-105.

15. Ghosh, S. and Kanjilal, K. (2014). Long-term Equilibrium Relationship between Urbanization, Energy Consumption and Economic Activity: Empirical Evidence from India. *Energy*, 66, 324-331.
16. Jacobs, G and Šlaus, I. (2011). Energy Efficiency and Human Economic Welfare. http://www.mssresearch.org/?q=node/624 (accessed August 28, 2015).
17. Jamil, F. and Ahmad, E. (2010). The Relationship between Electricity Consumption, Electricity Prices and GDP in Pakistan. *Energy Policy*, 38, 6016-6025.
18. Javid, M. and Qayyum, A. (2014). Electricity Consumption-GDP Nexus in Pakistan: A Structural Time Series Analysis. *Energy*, 64, 811-817.
19. Jones, D. W. (1989). Urbanization and Energy Use in Economic Development. *The Energy Journal*, 10, 29-44.
20. Jones, D. W. (1991). How Urbanization Affects Energy-use in Developing Countries. *Energy Policy*, 19, 621-630.
21. Khan, M. A. (2015). Modelling and Forecasting the Demand for Natural Gas in Pakistan. *Renewable and Sustainable Energy Reviews*, 49, 1146-1155.
22. Khan, M. A. and Abbas, F. (2016). The Dynamics of Electricity Demand in Pakistan: A Panel Cointegration Analysis. *Renewable and Sustainable Energy Reviews*, 65, 1159-1178.
23. Khan, M.A. and Qayyum, A. (2009). The Demand for Electricity in Pakistan. *OPEC Energy Review*, March, 70-96.
24. Li, B. and Yao, R. (2009). Urbanization and its Impact on Building Energy Consumption and Efficiency in China. *Renewable Energy*, 34, 1994–1998.
25. Loris, Nicolas D. (2015). Economic Freedom, Energy, and Development in *2015 Index of Economic Freedom: Promoting Economic Opportunity and Prosperity* by Terry Miller and Anthony B. Kim with James M. Roberts, Bryan Riley, and Ryan Olson. The Heritage Foundation in partnership with the Wall Street Journal, available at https://www.heritage.org/index/pdf/2015/book/index_2015.pdf.
26. Madlener, R. and Sunak, Y. (2011). Impacts of Urbanization on Urban Structures and Energy Demand: What Can We Learn for Urban Energy Planning and Urbanization Management? *Sustainable Cities and Society*, 1, 45–53.

27. Mahmood, R., Saleemi, S. and Amin, S. (2016). Impact of Climate Change on Electricity Demand: A Case Study of Pakistan. *The Pakistan Development Review*, 55, 29-47.
28. Mahmood, T. and Kanwal, F. (2017). Long Run Relationship between Energy Efficiency and Economic Growth in Pakistan: Time Series Data Analysis. *Forman Journal of Economic Studies*, 13, 105-120.
29. Malenbaum, W. (1978). World Demand for Raw Materials in 1985 and 2000. McGraw-Hill, New York.
30. Malik, A. (2012). Power Crisis in Pakistan: A Crisis of Governance? PIDE Monograph Series, Pakistan Institute of Development Economics, Islamabad.
31. Medlock III, K.B. and Soligo, R. (2001). Economic Development and End-Use Energy Demand. *The Energy Journal*, (22)2: 77- 105.
32. Metcalf, G. E. (2008). An Empirical Analysis of Energy Intensity and its Determinants at the State Level. *The Energy Journal*, 29, 1-26.
33. Mirza, F. M. and Fatima, N. (2014). Drivers of Energy Intensity in Pakistan: An Assessment using Index Decomposition Methods. Working Paper No. 03/2014, Institute of Public Policy, Beacon house National University.
34. Mulder, P., de Groot, H. L.F. and Pfeiffer, B. (2013). Dynamics and Determinants of Energy Intensity in the Service Sector: A Cross- Country Analysis, 1980-2005. Discussion Paper TI 2013-175/VIII, Tinbergen Institute.
35. Nawaz, S., Iqbal, N. and Anwar, S. (2014). Modelling Electricity Demand using the STAR (Smooth Transition Auto-Regressive) Model in Pakistan. *Energy*, 78 (C), 535-542.
36. OICCI (2012). A Roadmap for Energy Efficiency and Conservation in Pakistan. A position paper prepared by OICCI Energy Subcommittee. Available at http://www.oicci.org/wp-content/uploads/2012/07/Road-Map-for-Energy-Efficiency-Conservation.pdf
37. O'Neill, B. C., Ren, X., Jiang, L. and Dalton, M. (2012). The Effect of Urbanization on Energy Use in India and China in the iPETS model. *Energy Economics*, 34, S339–S345.
38. Parikh, J. and Shukla, V. (1995). Urbanization, Energy Use and Greenhouse Effects in Economic Development: Results from a Cross-national Study of Developing Countries. *Global Environmental Change*, 5 (2), 87-103.

39. Rühl, C., Appleby, P., Fennema, J., Naumov, A. and Schaffer, M. (2012). Economic Development and the Demand for Energy: A Historical Perspective on the Next 20 Years. *Energy Policy*, 50, 109-116.
40. Sadorsky, P. (2013). Do Urbanization and Industrialization Affect Energy Intensity in Developing Countries? *Energy Economics*, 37, 52-59.
41. Saeed, M. A., Irshad, A., Sattar, H., Andrews, G. E., Phylaktou, H. N. and Gibbs, B. M. (2015). Agricultural Waste Biomass Energy Potential in Pakistan. In: Proceedings of the International Conference held in Shanghai, P.R. China. International Bioenergy (Shanghai) Exhibition and Asian Bioenergy Conference, 21-23 Oct 2015, Shanghai, P.R. China. http://eprints.whiterose.ac.uk/98565/1/1%20CO%201%202%20.pdf
42. Sánchez-Triana, E., Biller, D., Nabi, I., Ortolano, L., Dezfuli, G., Afzal, J. and Enriquez, S. (2014). Revitalizing Industrial Growth in Pakistan: Trade, Infrastructure and Environmental Performance. The international Bank for Reconstruction and Development, The World Bank, Washington, DC.
43. Siddiqui, R. (1999). Demand for Energy and the Revenue Impact of Changes in Energy Prices. Research Report No 174. Pakistan Institute of Development Economics, Islamabad.
44. Stern, D. I. (2010). Modeling International Trends in Energy Efficiency and Carbon Emissions. Research Report No. 54, Environmental Economics Research Hub, Crawford School of Economics and Government, the Australian National University.
45. Sultan, R. (2012). An investigation of the Determinants of Energy Intensity for the Design of Environmental Strategies in Emerging Markets. Paper presented in the Workshop on Perspectives of Emerging Markets organized by the Faculty of Law and Management and the WTO Chair at the University of Mauritius (UoM) and HTW Berlin – University of Applied Sciences as part of the DAAD Partnership on Economic Development. http://daadpartnership.htw-berlin.de/fileadmin/Workshops/2012_Mauritius/Papers/Sultan_Energy_Intensity.pdf (accessed July 08, 2015).
46. Suslov, N. (2008). Explaining Factors Affecting Energy Demand Elasticity: Does the Quality of Institutions Matter? http://dspace-unipr.cineca.it/bitstream/1889/857/1/Suslov.pdf (accessed August 05, 2015).

47. UNIDO-Pakistan (2014). Resource Efficient Greening of Industry Initiative for Pakistan. UNIDO-Pakistan and Ministry of Industries and Climate Change Division Government of Pakistan, http://www.greenindustryplatform.org/wp-content/uploads/2015/03/Final-REGI-Initiative-for-Pakistan-28.-01.-14a.pdf (accessed September 01, 2015).
48. Wu, Y. (2012). Energy Intensity and its Determinants in China's Regional Economies. *Energy Policy*, 41, 703-71.
49. Xia, X. H. and Hu, Y. (2012). Determinants of Electricity Consumption Intensity in China: Analysis of Cities at Sub-province and Prefecture Levels in 2009. *The Scientific World Journal* 2012, www.hindawi.com/journals/tswj/2012/496341/ (accessed May 21, 2015).
50. Zhang, X. (2009). China's Energy Intensity and its Determinants at the Provincial Level. Department of Civil and Environmental Engineering and Department of Urban Studies and Planning, Massachusetts Institute of Technology http://hdl.handle.net/1721.1/53088 (accessed May 20, 2015).
51. Zhao, Y. and Wang, S. (2015). The Relationship between Urbanization, Economic Growth and Energy Consumption in China: An Econometric Perspective Analysis. *Sustainability*, 7, 5609-5627.