DRIVERS OF ENERGY INTENSITY IN PAKISTAN: AN ASSESSMENT USING INDEX DECOMPOSITION METHODS

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Abstract

We employ index decomposition techniques to decompose aggregate energy consumption into energy intensity, efficiency and structural change indices for Pakistan. Data suggests that energy inefficiencies play a prominent role in increasing energy intensity while structural changes cause small reduction in intensity index. Partial adjustment model was applied to investigate underlying forces of energy intensity and its components. Results illustrate that energy prices and capital-labor ratio have significant effect in reducing energy intensity through efficiency channel whereas; income predominantly increases energy intensity through inefficient energy use. Extensive policy intervention is required through implementing energy intensity reduction targets for efficient energy use.

Keywords: Index Decomposition, energy intensity, energy efficiency, structural change, Pakistan

JEL Classification: Z 000

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Introduction

Energy intensity is regarded as the amount of energy use per unit of economic activity. High energy intensity reflects high cost of converting energy into GDP. During the era of 1970s, economies around the globe experienced severe oil crises due to Arab oil embargo (Geller et al., 2006). High oil prices due to global energy shortages diverted the attention of economies to focus on the means to reduce energy intensity and bring energy savings. In this regard, a two pronged approach emerged as a policy decision among economists. First, policies were designed to improve energy efficiency in the economy and second; structural changes were introduced to move the economy from high energy intensive activities to less energy intensive activities.

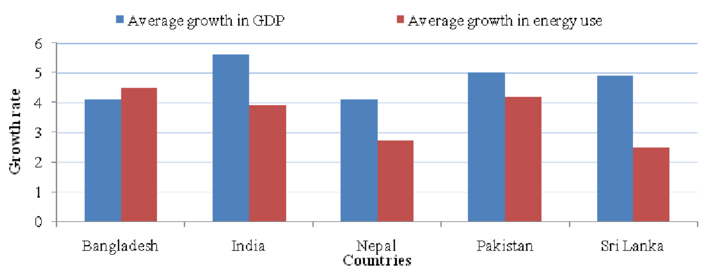
Energy efficiency is the demonstration of technological advancement, and can be defined as more units are produced with the same units of energy use (Xiu et al., 2007). It is not easy to compute energy efficiency. Therefore, energy efficiency is commonly measured by ratio of value added to energy use i.e. reciprocal of energy intensity (Nanduri, 1996). Structural changes in energy efficiency reflect the movement from or to sectors where the energy intensity differs from the rest of the economy (Na, 2006). For example, the industrial sector is high energy intensive. Hence, when economic activity moves from the industrial to the services sector, energy intensity tends to decrease.

In the global perspective, some countries have improved the level of energy intensity through the implementations of energy efficiency measures while others with structural changes. There is a strong evidence that Canada, the United Kingdom, France, Japan, Netherlands and Ireland reduced their energy intensity levels through structural changes from the 1974-2007,while in other countries like the US and China, energy efficiency measures were the major drivers in the reduction of energy intensity (Oseni, 2011; Xiu et al., 2007).

Problem Statement

Energy intensity in developing countries is 30 percent more than the developed countries (Akhter, 2010). Therefore, Pakistan being a developing economy possesses high energy saving potential. It is 15 percent more energy intensive than India and 25 percent more intensive than Philippines in the Asian region (ADB, 2009). Further, Pakistan claims double energy intensity as compared to the world average (FODP, 2010). On average, the growth rate in energy consumption stood at 5.5 percent and 4.0 percent per annum in 1980s and 1990s respectively, but it declined to 2.9 percent in 2000s. On the other hand, the average GDP growth rates were 6.6 percent, 4.0 percent and 4.5 percent per annum in 1980s, 1990s and 2000s respectively. Figure 1 shows that despite of reduction in growth of energy consumption; Pakistan has remained the second biggest consumer of energy among the South Asian countries during 1971-2010.

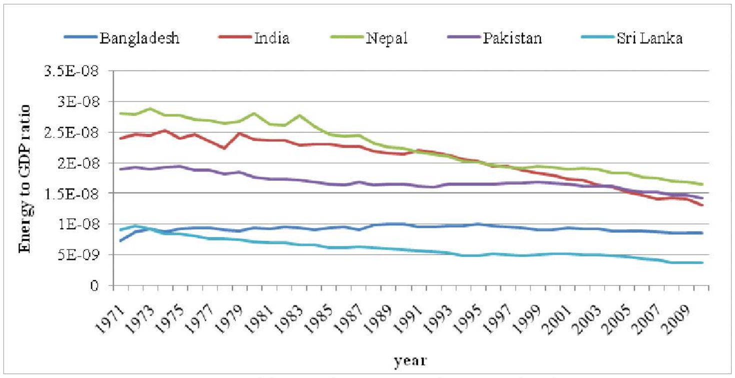
Figure 1:
Average growth rates of GDP and energy use in South Asian Countries



Source: World Development Indicators database

Figure 2 shows the trends in energy use per unit of GDP among South Asian countries. The energy intensity curve is almost flat and shows that that energy intensity remained stagnant during the last four decades in Pakistan. However, Pakistan stood at third position during 1971-2003 but from 2003 onward, it has become the second most energy intensive South Asian economy.

Figure 2:
Energy intensity of South Asian Countries



Source: World Development Indicators database

Industrial and residential sectors being the major energy consumers, contribute a key role in increasing energy intensity in Pakistan as petroleum, iron and steel, engineering and Electrical industries are relatively more energy intensive (Economic Survey of Pakistan, 2011-2012). Butto and Yasin (2010) conclude that the residential sector consumes approximately 42 percent of the electricity and most of the appliances used for lightning, cooling and heating are energy inefficient. With its high energy intensity, Pakistan also has the potential of 20-25 percent energy saving in all the sectors of the economy[3].

In this regard, the motivation to conduct this study is as follows. First, Pakistan is a high energy intensive economy but no empirical study has been carried out to identify the driving forces in its energy intensity. Second, since the oil price shock of the 1970s, most of the economies around the globe are trying to reduce energy intensity due to its adverse consequences including the depletion of energy resources and deterioration of environment through carbon

3- For details see http://www.enercon.gov.pk emission. Thus, there is a need to quantify energy intensity and its driving forces so that it can be maintained at the desired level.To fill this gap in the empirical research, we use time series data to carry out the decomposition analysis of energy intensity and its determinants for the case of Pakistan.

Concurrently, objectives of this study are as under;

First, we decompose energy intensity into different factors that underlie the energy intensity namely; energy efficiency and structural change.

Second, we also carry out the decomposition analysis at sectoral level to assess its components at the disaggregated level.

Third, we estimate the impact of underlying factors that affect the decomposed components of energy intensity to come up with the relevant policy recommendations.

Fourth, we further estimate energy savings associated with the changes in energy intensity and its components in the economy.

The rest of the paper is organized as follows. Section 2 of the paper encompasses the review of literature on the issue. Section 3 presents data, theoretical framework and methodology employed to carry out the analysis. Results from the analysis have been discussed in section 4 whereas section 5 concludes the paper with relevant policy implications.

Review of Literature

The world oil crises of 1970s diverted the attention of researchers to empirically estimate the impact of oil prices on the change in industrial production and their demand for energy use. Simple techniques were employed to decompose energy intensity into structural change and aggregate energy intensity for industries.

Effects of structural change on aggregate energy intensity were measured as the difference between observed aggregate energy intensity in the base year (t_0) and hypothetical aggregate energy intensity (t_T) in current year by holding sectoral energy intensity constant. The effect of sectoral energy intensity on aggregate energy intensity was measured as the difference between observed aggregate energy intensity and hypothetical aggregate energy intensity. This approach to estimate the effect of energy efficiency and structural change on energy intensity was adopted following Myers and Nakamura (1978). Since then, this area of research has developed significantly, and energy decomposition methods have become more sophisticated. Survey studies of Ang (1995) and Ang and Zhang (2000) incorporate 51 and 124 studies respectively from a variety of countries to cover the developments in decomposition technique since late 1970s.

Metcalf (2008) used the Fisher Ideal index decomposition technique to decompose energy intensity into energy efficiency and economic activity for the period of 1970-2003 in the U.S economy at the national and state level, applying a partial adjustment model to estimate the effect of economic (prices, income, K/L, and I/K) and other climatic variables on energy intensity. He concluded that a declining trend can be observed in energy intensity for the U.S economy during 1970-2007. Energy efficiency contributes more to energy savings than changes in economic activity. His study concludes that along with other variables, price and income affect energy intensity through the energy efficiency channel.

Shahiduzzaman and Alam (2012) used the logarithmic mean Divisia index (LMDI) technique to decompose energy intensity into energy efficiency, fuel mix and structural changes in Australia for the period 1978-2009. Their decomposition analysis showed that energy efficiency played a major role in reducing energy intensity as compared to structural composition. They found that fuel mix has a very little effect in reducing energy intensity. Similar work using LMDI was carried out by Ang and Zhang (2000), Chung et al. (2013) and Lotz and Blignaut (2011) for decomposition of energy consumption in Chinese transport sector and South Africa's sectoral energy consumption respectively.

Song and Zheng (2012) used province level panel data for 1995-2009 and apply Fisher Ideal index in decomposing the determinants of energy intensity in china. By decomposing energy intensity into energy efficiency and structural changes, their results demonstrate that almost 90 percent of decline in energy intensity is due to improvements in the energy efficiency. Their econometric analysis showed that price effect in reducing energy intensity is very small while income has a U-shaped relationship with energy intensity. Moreover, their results suggest that policy interventions and the finding that energy and capital are substitutes; helped deceasing energy intensity in Chinese provinces. High investment and rapid urbanization experienced in china were also responsible for the increase in energy intensity.

Wu (2011) applied regional data of 1997-2007 to identify the determinants of energy intensity in China. By using index decomposition analysis, he decomposed energy intensity into energy efficiency and structural changes. His Empirical findings suggest that energy efficiency played major role in the reduction of energy intensity but share of structural adjustment was very small. The results of his partial adjustment model demonstrate that high energy prices and high income contribute to the decline in energy intensity.

Elliott et al. (2011) investigated the relationship among income per capita, energy intensity and FDI by employing fixed and random effect models on panel data of 206 cities of china for the period of 2005-2008. Their study provides theoretical foundation towards the inverted U-shaped relationship between income per capita and energy intensity. FDI is positively related to energy intensity in two ways. First, foreign firms introduce energy saving technologies and second, foreign firms spread out energy saving technologies to domestic firms which not only increase their productivity but also decrease energy intensity.

Hubler and Keller (2009) used macro level panel data of 60 developing countries for the time period of 1975-2004 to empirically investigate the effect of FDI inflows on energy intensity by employing OLS regression analysis. They conclude that FDI reduces energy intensity in developing countries only with the diffusion of energy saving technologies. Otherwise FDI may cause shift of the economy towards more energy intensive sector.

Wachsmann et al., (2009) decomposed the Brazilian industrial and residential energy use into eight components using the structural decomposition analysis for the period of 1970-1996. The findings demonstrate that out of the eight factors, population, economic affluence and inter-sectoral dependencies are the most influential factors in energy use. However, energy intensity and per capita household energy reduce the overall energy use in Brazil.

Data and Methodology

We employ secondary time series data for residential, industrial, agricultural and services sectors from 1980-2009 to decompose energy intensity and model its determinants for the case of Pakistan. Fisher's Ideal Index number methodology has been applied for decomposing energy intensity into structural change and energy efficiency, whereas a partial adjustment model is employed to estimate the impact of different economic and climatic variables on disaggregated components of energy intensity.

Index decomposition analysis (IDA)

We follow Xiu et al. (2007), Metcalf (2008), Shahiduzzaman and Alam (2012) and Song and Zheng (2012) for decomposing energy intensity into its components. For this purpose, the Index decomposition method is the best disaggregation tool as one can separate and quantify the effects of each factor that affects energy intensity at aggregated and disaggregated level.Recently, the most commonly used approach in decomposition is the index number theory. Boyd et al. (1987) and Howarth et al. (1991) were the first to apply index number theory in decomposing energy intensity by adopting Divisia and Laspeyres index methodologies respectively. But like earlier studies, these methodologies contained two problems. First, these methods always generate a residual term after decomposition which can neither be associated with energy efficiency nor to the structural change. Second, the inclusion of zero value in the dataset makes the logarithmic form of Divisia index difficult to compute. To overcome these problems, refined methods of Laspeyres and Divisia index were proposed by Ang and Choi (1997) and Sun (1998) respectively that we employ in this paper.

Following Diewert (2001), changes in value aggregate in terms of price and quantity can be expressed as;

$$\frac{V_T}{V_0}=\frac{\sum_i P_{it}Q_{it}}{\sum_i P_{0t}Q_{0t}}$$

Where the change in value aggregate (consumption) is the function of price and quantity which can be expressed as;

$$\frac{V_T}{V_0}=\text{P}\ (P_0, P_t, Q_0 Q_t)\ \text{Q}\ (P_0, P_t, Q_0 Q_t)$$

Moreover, also following Diewert (2001),total energy intensity(e_t) is the function of energy efficiency for different sectors (e_{it}) and the share of each sector in total value added (s_{it}).

$$e_t=\frac{E_t}{Y_t}=\sum_i \frac{E_{it}}{Y_{it}}\frac{Y_{it}}{Y_t}=\sum_i e_{it}\ s_{it} \quad (1)$$

In equation(1) (E_t), (E_{it}), (Y_t) and (Y_{it}) are aggregate energy consumption, sectoral energy consumption, GDP and sectoral economic activity respectively at time (t).The important point to note is that the sectoral energy consumption is the sum of aggregate energy use but the activity of each sector need not to sum to GDP as it can be in differentunits for each sector e.g; residential sector activity is measured in household'sfinal consumption expenditures.

By focusing on price and quantity relationship in Diewert (2001) and equation (1), changes in aggregate intensity between the two time periods in terms of efficiency and structural change can be expressed as;

$$\frac{e_t}{e_0}=\frac{\sum_i e_{it} s_{it}}{\sum_i e_{i0} s_{io}} \quad (2)$$

and change in aggregate energy intensity can be shown as;

$$\frac{e_t}{e_0} \equiv I_t = F_t^{str} F_t^{eff} \quad (3)$$

In IDA we decompose aggregate intensity into efficiency and structural change. Changes in energy intensity index are quantified by changes in structural adjustment index () and efficiency index () separately. Our index formulation is based on Fisher Ideal index that is the geometric mean of Laspeyres and Paasche indices. The Fisher Ideal index provides the exact decomposition with no residual term, and fulfills the factor reversal property of index number theory (Boyd and Roop, 2004). This method is also desirable in the presence of zero or negative values in the data set.

Laspeyres and Paasche indices for structural effects and efficiency can be computed as;

$$L_t^{str}=\frac{\sum_i e_{io} s_{it}}{\sum_i e_{i0} s_{io}} \quad (4)$$

$$L_t^{eff}=\frac{\sum_i e_{it} s_{io}}{\sum_i e_{io} s_{io}} \quad (5)$$

$$P_t^{str}=\frac{\sum_i e_{it} s_{it}}{\sum_i e_{it} s_{io}} \quad (6)$$

$$P_t^{eff}=\frac{\sum_i e_{it} s_{it}}{\sum_i e_{io} s_{it}} \quad (7)$$

The Laspeyres index takes base year values as weights, while the Paasche index take the current year values as weights.

More precisely the equation (3) can be represented as;

$$F_t^{str}=\sqrt{L_t^{str} P_t^{str}} \quad (8)$$

$$F_t^{eff}=\sqrt{L_t^{eff} P_t^{eff}} \quad (9)$$

The decomposition in equation (3) will be helpful in measuring energy saving into the economy. Energy saving can be expressed as

$$\Delta E_t = E_t - \widehat{E_t} \qquad (10)$$

is actual energy consumption and is energy consumption that is assumed to be fixed at its 1980 level. Change in energy saving can be attributed to the improvements in efficiency and sectoral change and expressed as follows:

$$\Delta E_t = \Delta E_t \left(\frac{\ln (F_t^{str})}{\ln (I_t)}\right) + \Delta E_t \left(\frac{\ln (F_t^{eff})}{\ln (I_t)}\right) \equiv \Delta E_t^{str}\ \Delta E_t^{eff} \quad (11)$$

Partial adjustment model

Decomposition analysis just provides the trend of changes in energy intensity over time but does not shed light on the determinants of energy intensity, energy efficiency and sectoral changes. We apply a partial adjustment model to analyze the effect of different climatic and economic variables on energy intensity and its decomposed components. The partial adjustment model can be applied in this situation irrespective of the fact that variables are stationary or non-stationary (Frey and Manera, 2007; Breitkreuz, 2011; Mirza and Bergland, 2012). Our partial adjustment model can be represented as;

$$e_t^* = \beta_1 + \beta_2 x_t + \mu_t \qquad (12)$$

Desired level of energy intensity (e_t^*) is the function of independent variables (x_t). Desired energy intensity is not observable so we proxy it by the actual value of energy intensity (e_t) that is observable. To achieve some level of desired energy intensity there are some partial adjustments in the economy that can be represented as;

$$e_t - e_{t-1} = \lambda(e_t^* - e_{t-1}) \qquad (13)$$

where (0<λ<1) and (λ=speed of adjustment). Higher the value of λ, higher will be the speed of adjustment process. Now By merging equation (12) into (13) we get;

$$e_t = \gamma_0 + \gamma_1 x_t + \gamma_2 e_{t-1} + v_t \quad (14)$$

where, $\gamma_0 = \lambda\beta_1$, $\gamma_1 = \beta_2\lambda$, $\gamma_2 = (1-\lambda)$ and $v_t = \lambda\mu$. This shows that energy intensity not only depends upon exogenous variables but also on its own lagged values. Short run effects of independent variables on the dependent variable are represented by the coefficient on x_t, whereas long run effect is represented by λ i.e., β_2/λ.

Specification of our Partial Adjustment Model

Prices

High prices lead to adoption of energy saving technologies or move the economy from high energy intensive to less energy intensive activities. We have taken data on nominal electricity prices as proxy to energy prices for estimating its effect on energy intensity and its components.

Income

Income is an important determinant of energy intensity. In the regression analysis we include per capita income as explanatory variable to estimate its impact on energy intensity.

Capital-labor ratio

The relationship between capital to labor ratio and energy intensity is based on whether capital and energy are substitutes or compliments. When energy and capital are compliments, energy intensity increases while it decreases when they are substitutes. We include capital to labor ratio as an explanatory variable.

Temperature

We take temperature as climatic variable to estimate its effect on energy intensity. It is an important natural variable because it cannot be changed by human activities in the short run and thus has significant effect on aggregate energy intensity.

Data sources and summary statistics

Our study utilizes time series data on Pakistan from 1980 to 2009. The analysis comprises of all the sectors of the economy except transportation sector due to data limitations. Data for GDP, capital (gross fixed capital formation), sectoral economic activity and aggregate private consumption is in constant local currency unit and has been obtained from world development indicators database. Data on energy consumption (in tons of oil equivalent) has been taken from various issues of Pakistan energy year book published by hydrocarbon development institute of Pakistan (www. http:// hdip.com.pk/). As data for Pakistan's overall energy prices is not available; we used nominal electricity prices (Paisa/kWh) as proxy for energy prices. Electricity prices data was obtained from the annual reports of National Transmission and Dispatch Company Limited (www.ntdc.com.pk).

Discussion of Results

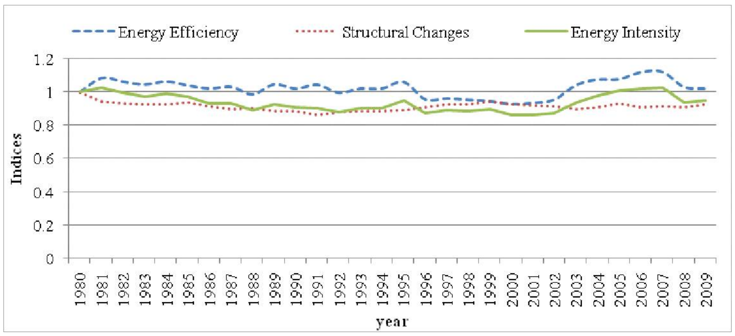
Discussion on Decomposed Energy Indices

By applying the Fisher's Ideal index on time series data from 1980-2009, we construct efficiency index, structural change index and intensity index. In the construction of these indices we take 1980 as the base period where all the indices are assumed to be fixed and comparison is made from the base period.

Figure 3 reflects the aggregate Energy intensity index in 1990 stood at 90 percent of its intensity level in 1980, decreased to 85 percent in 2000 and increased again to 94 percent of its 1980 level in 2009.This implies that there is no considerable decline in energy intensity since 1980 mainly due to prevalence of inefficiencies in the economy.

Figure 3:

Pakistan energy indices relative to 1980 level



(Source: Author's own calculations)

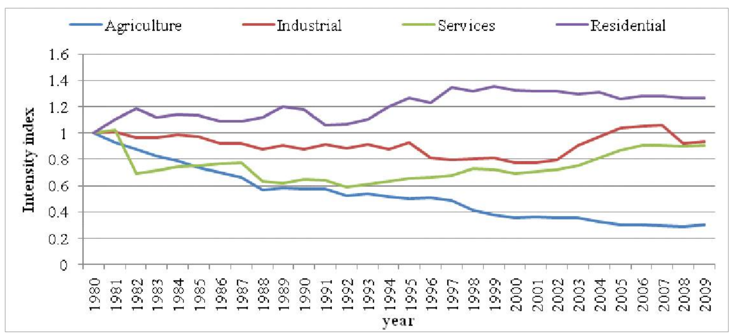
Change in aggregate energy intensity requires some understanding of contributions from energy efficiency and structural change index. The Fisher Ideal index clearly demonstrates the contribution of efficiency and structural change index in changing energy intensity. Efficiency index in 1990 stood at 1.02 percent of its efficiency level in 1980. It decreased to 92 percent (showing efficiency improvements) in 2000 but again reached at 1.02 percent of its 1980 level in 2009. This demonstrates that 2 percent inefficiency into the economy contributed to increase the energy intensity by 2 percent over the period. In most of the periods, there was inefficiency into the economy except between the period 1996-2002 where efficiency improved.

Our structural change index estimates were 88 percent and 92 percent of its 1980 level in 1990 and 2009 respectively; which led to 8 percent decline in energy intensity since 1980's. It has a small contribution in declining energy intensity as its curve is almost flat. Therefore, we conclude that there is no efficient utilization of energy and there is no considerable change in sectoral adjustments in the economy. However, changes in the mix of economic activities are relatively more important variable in declining aggregate energy intensity in the case of Pakistan.

Our sectoral decomposition suggests that residential sector is the highest energy intensive sector while the second more energy intensive sector is the industrial sector (Figure 4).

Figure 4:

Trends of intensity indices in different sectors of Pakistan



(Source: Author's own calculations)

Structural changes are the main contributor to high energy intensity in industrial and services sectors while inefficiencies play a key role in increasing energy intensity in the residential sector. In 2009 the agricultural sector was at 32 percent of its energy intensity level in1980 level. This shows that there is remarkable decline in energy intensity on amount of efficiency improvements.

We calculate aggregate energy saving by making use of equation (11) and table 1 represents average share of each component of energy intensity in aggregate energy saving to its level in 1980. Only the structural changes in the economy contribute to the energy savings whereas energy inefficiencies reduce the extent of savings that could have been achieved if the efficiency had remained at its 1980 level. Energy savings are positive, but there is no considerable change in energy use. Furthermore, there are considerable variations in energy savings among different sectors of the economy.

Table 1:
Contribution of energy indices in aggregate energy saving in Pakistan

Years	Energy Saving (TOE)	Share Due to Structural Change (%)	Share Due to Efficiency (%)
1984	1215357	418	-318
1989	3122481	154	-54
1994	5620196	120	-20
1999	8193567	91	9
2004	1.11E+07	148	-48
2009	1.88E+07	-379	479
Average		92	8

Discussion on Findings from Partial Adjustment Model

Table 2 presents our regression analysis of energy indices with respect to economic and climatic variables. In column 1, energy price is negatively associated with energy intensity. One percent increase in energy prices drops energy intensity by 0.247 percent and is significant at l percent level. Income per capita shows positive relationship with energy intensity. One percent increase in per capita income increases energy intensity by 0.289 percent. The negative coefficient of capital-labor ratio shows that capital and energy are substitutes. Increase in capital-labor ratio decreases energy intensity by 0.315 percent. This coefficient is statistically significant at one percent level. Further, intensity index is not responsive to temperature change in static model results.

Column 3 and 5 demonstrate that all the variables in efficiency index model are significant while insignificant (except capital-labor ratio) in structural change index. Our income coefficient estimates increases energy inefficiencies by 0.31 percent, which his significant at one percent level. However, our efficiency index estimates declineby 0.26 percent and 0.21 percent with 1 percent increase in energy prices and capital-labor ratio respectively. Too small and insignificant coefficient estimates of energy prices in structural change model reveal that energy prices solely operate through efficiency channel.

Table 2:
Regression Results for Short Run

Variable	Intensity index		Efficiency index		Structural Change index	
	(1)	(2)	(3)	(4)	(5)	(6)
Log (Price)	-0.247*	-0.108***	-0.26*	-0.136***	-0.006	0.0006
	(0.051)	(0.059)	(0.059)	(0.08)	(0.031)	(0.021)
Log (Income per capita)	0.289*	0.196**	0.312*	0.185***	0.0009	0.042
	(0.076)	(0.076)	(0.087)	(0.102)	(0.046)	(0.032)
Log (Capital-labor ratio)	-0.315*	-0.222*	-0.212**	-0.183**	-0.116**	-0.05
	(0.084)	(0.076)	(0.096)	(0.092)	(0.051)	(0.039)
Log (Temperature)	-0.695	-0.544	-1.024***	-0.6	0.251	-0.056
	(0.455)	(0.398)	(0.52)	(0.538)	(0.277)	(0.189)
Constant	6.967*	4.598**	6.283*	4.523***	2.028	1.018
	(2.078)	(1.903)	(2.374)	(2.389)	(1.263)	(0.914)
Adjustment Parameter	-	0.503*	-	0.436*	-	0.537*
		(0.152)		(0.1)		(0.141)

Note: We also included other variables like population growth, square of capital-labor ratio, square of income per capita, time trend and square of time trend but these variables appeared statistically insignificant in all the models across all specifications. Standard errors are presented in parenthesis. Columns 1, 3, and 5 represent static model coefficients while 2, 4 and 6 are dynamic model results.
* indicate 1% level of significance
** indicate 5% level of significance
*** indicate 10% level of significance

Point estimates in column 2, 4 and 6 are reported from Partial Adjustment model. These results are more realistic than static model results, and their point estimates are relatively small because energy indices are not likely to respond immediately to change in economic and climatic variables. More precisely, because of inclusion of lagged dependent variable, partial adjustments are involved in achieving full impact of independent variables on energy indices.

Column 2 shows that one percent increase in energy prices reduces energy intensity by 0.108 percentage point, while increase in income increases energy intensity by 0.196 percentage point. Positive income effect on energy intensity indicates that the economy is moving towards materialization as it is at its developing stage. Similar to our static model, our capital-labor ratio estimate indicates that energy and capital are substitutes and reduce energy intensity by

0.22 percentage points. Temperature is an important variable in affecting energy intensity. But in case of Pakistan, no energy indices are responsive to change in temperature even at 10 percent level. All the point estimates of structural changes are insignificant which indicate no contribution of changes in mix of economic activity in affecting energy intensity. This implies that point estimates of economic variables in energy intensity model create an impact through the efficiency channel.

Table 3 reports price and income elasticities for the short run and long run which are computed form partial adjustment regression. Short run and long run price elasticities of energy intensity are -0.108 percent and -0.215 percent respectively. The short run and long run price elasticity of energy efficiency is -0.136 and -0.312 respectively. This means continuous increase in energy prices leads the economy towards more efficient use of energy. Price elasticity of structural changes is too small (near to zero) to change energy intensity. This implies that increase in prices reduce intensity level more in long run through efficient use of energy rather than moving from high energy intensive to less energy intensive activities.

Table 3:
Price and Income Elasticity Estimates of Decomposed Energy Intensity Indices

	Intensity index	Efficiency index	Structural Change index
Price Elasticity			
SR	-0.108	-0.136	-0.0006
LR	-0.215	-0.312	0.001
Income Elasticity			
SR	0.196	0.185	0.042
LR	0.90	0.424	0.078

One percent increase in income causes an increase of 0.2 percent and 0.9 percent in energy intensity in short run and long run respectively. The estimated response of energy intensity with respect to income is relatively more in long run. Estimates in table 4 demonstrate that income elasticity of efficiency and structural changes tends to increase energy intensity while impact of energy efficiency is more prominent than structural changes.

The price and income elasticity estimates for all the energy intensity indices except structural change index are in accordance to the existing evidence [Oseni, 2011;Metcalf, 2008; Song and Zheng, 2012]. Our regression results for structural change index reflect that it remains unaffected by changes in energy price and the income. Since structural change index is only significantly affected by the changes in capital to labor ratio, this could be because the structure of the economy has change independently along its development path, rather due to the economic policies pursued to move the economy from traditional sectors to the industrial sector.

Conclusion

The prime objective of the present study was to investigate the major components of energy intensity in Pakistan from 1980 to 2009. This study adds value to the empirical literature on the issue in Pakistan by employing index decomposition methodology to decompose energy intensity into energy efficiency and structural change. We further employed a partial adjustment model with the objective to quantify the effect of economic and climatic variables on energy indices namely; energy intensity index, energy efficiency index and structural change indices.

Energy indices in decomposition model clearly demonstrated that Pakistan is facing high energy intensity. The main reason for this high energy intensity is the prevalence of energy inefficiency. Structural changes have least contribution in affecting energy intensity which demonstrates that there are no structural adjustments as far as the energy consumption is concerned. Energy inefficiencies have played prominent role in increasing energy intensity while structural changes cause a minor decline in the indices. However, change in the mix of economic activity appeared as relatively more important variable in declining aggregate energy intensity in case of Pakistan. At sectoral level energy intensity appeared relatively high in residential and industrial sectors.

With the help of energy indices we calculated aggregate energy saving as well as sectoral energy savings for Pakistan. Our results suggest that Pakistan is experiencing positive but insignificant energy saving. However, the percentage share of structural changes in total energy saving is more than the share of energy efficiency. Our sectoral savings estimates demonstrate that residential and industrial sectors claim relatively more energy savings.

Our regression analysis showed that energy indices are not responsive to structural changes. As all the coefficients of structural changes are insignificant and have no remarkable effect in changing all energy indices. Energy prices and capital-labor ratio are important variables for declining energy intensity through efficiency channel. Income coefficient had positive and significant impact on increasing energy intensity.

Pakistan had experienced high energy intensity since its inception. However no, target was ever set for significant reduction in energy intensity and no steps were taken to reduce it. As Pakistan has the potential of energy savings, relevant polices should be implemented to reduce energy demand pressures prevailing in the economy. Government should also start awareness campaigns for the people about energy efficient appliances through the publicity. Reduction in energy intensity will not only increase the energy savings but will also contribute to increase the economic and social welfare in the economy.

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Appendix 1

Table 1: Energy Indices for Pakistan

Year	Efficiency Index	Structural Change Index	Intensity Index
1980	1	1	1
1981	1.085453	0.943148	1.023743
1982	1.063123	0.934847	0.993857
1983	1.046053	0.927975	0.970711
1984	1.064269	0.92743	0.987035
1985	1.040253	0.936942	0.974656
1986	1.020461	0.913315	0.932002
1987	1.031675	0.899213	0.927696
1988	0.985602	0.902697	0.8897
1989	1.046772	0.885658	0.927082
1990	1.020222	0.886268	0.90419
1991	1.044779	0.860403	0.898931
1992	0.99505	0.880333	0.875976
1993	1.020867	0.883322	0.901754
1994	1.020752	0.885339	0.903711
1995	1.061308	0.893656	0.948444
1996	0.956376	0.910789	0.871056
1997	0.961517	0.92716	0.89148
1998	0.953251	0.927392	0.884037
1999	0.945132	0.94527	0.893405
2000	0.926684	0.92767	0.859658
2001	0.933351	0.921745	0.860311
2002	0.954226	0.913959	0.872124
2003	1.042168	0.896381	0.934179
2004	1.076581	0.906861	0.97631
2005	1.078431	0.932111	1.005218
2006	1.121414	0.910234	1.020749
2007	1.123892	0.912153	1.025161
2008	1.030451	0.909766	0.937469
2009	1.020055	0.92793	0.94654