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Dependence of Energy Intensity on Economic Growth: Panel Data Analysis of South Asian Economies

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ABSTRACT

The dependence of energy intensity (energy/GDP ratio) on the economic growth is studied in details for the panel of South Asian economies. Typically, it is assumed that for the technological advanced developed economies a negative relationship between energy intensity and economic growth is valid due to declining trends of energy intensity and in developing economies positive relationship between energy intensity and economic growth is valid. However, if the trend effects are removed, the growth effects may not be energy saving in under developed world. This is the main hypothesis of this study. In order to test this hypothesis, we use de-trend energy intensity (trend effect is removed). We found positive relationship between de-trended energy intensity and economic growth for the panel of underdeveloped south Asian economies. These results suggest that the energy saving options for south Asian countries are very small. Therefore, we find the cost of converting energy into GDP high in the developing economies of south Asia.

Keywords: Energy Intensity; Economic Growth; Energy Savings
JEL Classifications: O4, Q00, Q4

1. INTRODUCTION

Energy intensity is a measure of the energy efficiency of a national economy. It is calculated as units of energy per unit of GDP. Higher energy intensity indicates a high price or cost of converting energy into GDP. Low energy intensity indicates a low price or cost of converting energy into GDP. In addition, national energy intensities change over time. Countries with higher GDP tend to have energy intensities that improve, helping to insulate them from some of the erosive effects of declining energy supplies (Poveda and Martinez, 2011).

Countries at the bottom of the GDP scale tend to require more and more energy to produce the GDP, e.g. Huang et al. (2008) found that in poor countries, 1% increase in economic growth requires more than 1% increase in energy use. On other hand rich economies require less and less energy input in relative terms. In developing economies, as economies improve, pollution gradually increases, and as the industrial potential expands, the pollution problem becomes a major concern that requires immediate actions. Finally, as the income increases beyond some threshold, there is a tendency towards producing low pollution products (Huang et al., 2008; Grossman and Krueger 1995; Dinda, 2004 and Dinda et al., 2000).

The objective of this paper is to test the impact of economic growth on energy intensities where from the trend effects are filtered out. Thus we can also evoke the role of business cycles on the de-trended energy intensities. This study explores the determinants of energy intensity for the panel of undeveloped south Asian countries. A positive relationship existed for the panel of south Asian countries. These findings support the hypothesis that energy intensity falls as a country's economic growth takes place after a certain level of economic development. The high income group (i.e. rich countries) has low energy intensities because energy consumption in these countries grows more slowly than GDP because of the energy saving and conservation polices (Mahmood and Ahmad, 2018). Contrary to this, in poor countries growth requires intensive energy use, and the business cycles and the oil price shocks still affect de-trended energy use positively. Hence the cost of converting energy into GDP is high in poor countries.

The dependence of de-trended energy intensity on main contributing sectors of an economy (i.e. industry, services and agriculture) is also studied in details. The role of population growth is also noticed when the analysis is cast in GDP per capita format. The impacts of main economic indicators analyzed (i.e. GDP growth rate, growth in sector outputs, GDP per capita growth, and population growth) on de-trended energy intensity are large. Energy saving options for south Asian economies are small.

The study is organized as follows. Section 2 reviews the literature. Section 3 presents data and variables. Section 4 presents models and estimation procedures, and 5 gives the results and 6 present the conclusion.

2. LITERATURE REVIEW

Economic growth can be achieved either by quantity of inputs or by improving productivity of these inputs. Productivity growth implies when a greater output can be attained with a same amount of inputs. This type productivity growth is preferable to productivity growth which is attained due to increase inputs because marginal productivity input might be diminishing (Ray, 2012). The prosperity in developed nation has been attributed mainly to the sustained growth of their total factor productivity (Prescott, 1998). Energy is the main input for the economic growth. Sustainable development in economic growth underlines the importance of sustained growth of energy productivity. This is manifested by the declining energy intensity for industrial countries.

Countries at the bottom of the GDP scale tend to require more and more energy to produce the GDP, e.g. Huang et al. (2008) found that in poor countries, 1% increase in economic growth requires more than 1% increase in energy use. On other hand rich European economies require less and less energy input in relative terms. The European Environment Agency (EEA) found that over the period 1990-2002, European GDP grows at an annual average rate of 2.2% and total energy consumption at annual average rate of 0.5%. As a result, total energy intensity in the EU decreases at the average rate of 1.7% (EEA, 2008). Another study by Deichmann et al. (2018) concludes that reducing the energy intensity is a priority in efforts to slow climate change.

Southeast Asia is known due to its diversity and dynamic but energy insecurity is rising due to widening enrdy demand and supply gaps. According to the report published by southeast Asian energy outlook in 2019, overall energy demand has grown by more than 80% in 2019 and contribution of fossil fuel use is highest. Oil is the largest element in the regional energy mix and coal – largely for power generation – has been the fastest growing. This halts the development and growth in south east Asia, it has has also made air pollution a major risk to public health and driven up energy-related carbon dioxide (CO_2) emissions (SAE, 2019).

In general, the picture resembles closely to Environmental Kuznets Curve (EKC) phenomena. EKC is an “inverted U” relationship between the level of economic development and the pollution level. In poor countries, as economies improve, pollution gradually increases, and as the industrial potential expands, the pollution problem becomes a major concern that requires immediate actions. Finally, as the income increases beyond some threshold, there is a tendency towards producing low pollution products (Huang et al. 2008; Grossman and Krueger 1995; Dinda, 2004 and Dinda et al., 2000).

Energy intensity can be reduced by improving efficiency in the use of energy and by improving economic activities. Basically the economies with high GDP level manage to do this better than poor countries. This is due the (relative) less energy consuming service economy compared to agricultural or industry economy and efficiency of energy production and use. The level of economy’s technology, its energy base and conversion are key elements in the evolution of energy/GDP –ratio.

Some macroeconomists argue that the declining energy shares started in the late 1980’s are caused by the oil price shocks (Blanchard and Gali, 2008; Kilian, 2008a;b and 2009). Thus, energy intensity decline is due to these business cycle effects. However, we argue that declining trend is due to the technology and better energy conversion because if the business cycle view is valid there should be a positive correlation between de-trended energy intensity and GDP growth rate. In general oil price shocks may have indirect long run energy intensity effects but typically business cycle theories imply short run non-trend effects to be pro-cyclical. Our hypothesis is contrary to this as we argue that GDP growth effects are not energy saving, i.e. they have positive effects on the de-trended energy intensity.

3. DATA AND VARIABLES

The data on energy intensity is from the US Energy Information Administ-ration (EIA Independent Statistic and Analysis) from 1980 to 2018. Variable is calculated by dividing the data on total primary energy consumption in quadrillion British thermal units by the gross domestic product (GDP) using purchasing power parities in billions of U.S. dollars for each available country and year.

The data on Real GDP per Capita (GDPc), Real GDP and Population is from Centre for International Comparison at the University of Pennsylvania (Penn Tables). The definition of variables is following: GDPc is obtained from an aggregation using price parties and domestic currency expenditures for consumption, investment and government. GDP is calculated by multiplying GDPc for each country by Population. Where data on population is taken from World Bank Development Indicators and United Nation Development Centre sources.

We take sample of 10 South Asian developing countries (i.e. Afghanistan, Bangladesh, Bhutan, India, Indonesia, Maldives, Malaysia, Nepal, Pakistan, and Sri Lanka).

4. MODELS AND ESTIMATION PROCEDURE

4.1. Model

Many results confirm that the following energy-output relationship or linear regression is valid for industrial countries:

$$ln\ E_t = \alpha + \beta lnY_t + \varepsilon_t \quad (1)$$

where $0 < \beta < 1$.

Here, E_t is total primary energy consumption at time t, Y_t is gross domestic product at time t and is the natural log. Energy intensity is calculated as units of energy per unit of GDP. Therefore, by adding on both side $-lnY_t$ gives the energy intensity form

$$lnE_t - lnY_t = \alpha + \beta lnY_t - lnY_t + \varepsilon_t$$

$$\ln(E_t / Y_t) = \alpha + (\beta - 1)\ln Y_t + \varepsilon_t \quad (2)$$

Next we take a difference on both side of the equation 2 resulting in

$$Ln(E_t/Y_t) - ln(E_{t-1}/Y_{t-1}) = (\beta - 1)\Delta lnY_t + \mu_t \quad (3)$$

Now assume that past energy intensity can be approximated with an elementary trend function. We assume that there is one constant underlying trend in energy intensity.

$$(E_{t-1}/Y_{t-1}) = exp\ (c_1 + c_2 Tr_{t-1})$$

Thus we have model

$$Ln(E_{t-1}/Y_{t-1}) = c_1 + c_2 Tr_{t-1} + {}_{t-1} \quad (4A)$$

to data and use the fit $\ln(E_{t-1}/Y_{t-1})^F = \hat{c}_1 + \hat{c}_2 Tr_{t-1}$ to de-trend the current energy intensity. We modify Eq. 3 as following

$$\ln(E_t / Y_t) - (\hat{c}_1 + \hat{c}_2 Tr_t) = \ln(E_t / Y_t)^{DT} = (\beta - 1)\Delta \ln Y_t + \mu'_t \quad (4B)$$

In Eq. 4, we expect the sign of parameter $d = (\beta - 1)$ to be negative for developed countries and positive for underdeveloped economies in following regression model

$$\ln(E_t / Y_t)^{DT} = d\Delta \ln Y_t + \mu_t' \quad (5)$$

The parameter d measures the dependency of short-run energy-intensity on economic growth but it gives also an indirect estimate of long run energy output relationship, i.e. $\beta = d+1$. Thus the small negative value implies low energy intensity and large negative value of implies high energy intensity. Next we propose three steps to analyze the impact of economic growth on de-trended energy intensity.

4.2. Estimation Procedure

First we analyze energy intensity trends in the sample of south Asian countries, i.e. we estimate (Eq. 4A). The relationships of energy intensity with GDP, GDP per capita and population growth. The Table 1 shows positive and significant c_2 for all poor countries except for Afghanistan and Sri Lanka. Thus, we found positive trend in energy intensity $ln(E_t/Y_t)$ series for majority of sample countries.

In order to find proper relationship between de-trended energy intensity and economic growth, we need to know the order of integration of these series. Here, we apply unit root tests on de-trend energy intensity $ln(E_t/Y_t)^{DT}$ series and real GDP growth $\Delta(lnY_t)$ series. The analysis of non-stationary panels is similar to analysis of non-stationary time series of the 1980s. However non-stationary panels include some unique issue such as cross-sectional hetero-eneity and correlation. We use LLC test (Levin et al., 2002), Fisher-ADF, and Fisher –PP test (Maddala and Wu, 1999) to panel of series, i.e. energy intensity $ln(E_t/Y_t)^{DT}$ series and real GDP growth $\Delta(lnY_t)$ series, with 10 cross sections for 38 time periods.

Table 2 present the panel unit root test results. Table indicates that de-trended energy intensity series $ln(E_t/Y_t)^{DT}$ and real GDP growth $\Delta(lnGDP)$ series can be considered to behave like stationary time series based on the results from all the three tests. The de-ternd energy intensity is integrated of order zero I (0). If energy intesity is non stationary then we cannot remove the non-stationarity by deterministic de-trending.

Finally, we use model from equation 5 in panel setting in order to find the impact of economic growth on de-trended energy intensity.

$$\text{M1} \quad \ln(E\ /\ Y\ )^{DT}{}_{it} = \alpha_i + d\Delta \ln Y_{it-1} + \mu_{it}$$

$$\text{M2} \quad \ln(E\ /\ Y\ )^{DT}{}_{it} = \alpha_i + \gamma \ln(E / Y)^{DT}{}_{it-1} + d\Delta \ln Y_{it-1} + \mu_{it}$$

Table 1: Estimation of energy intensity trends results from the estimation of equation 4A

Countries	c_1	c_2
Afghanistan	8.34 (19.06)**	−0.04 (−1.87)*
Bangladesh	6.47 (255.88)***	0.02 (14.50)***
Bhutan	7.35 (12.23)***	0.01 (2.97)**
India	9.09 (250.09)***	0.001 (0.96)
Indonesia	8.71 (379.27)***	0.01 (4.03)***
Maldives	7.12 (7.80)***	0.03 (0.041)***
Malaysia	6.83 (34.22)***	0.08 (6.92)***
Nepal	6.29 (207.55)***	0.047 (5.48)***
Pakistan	8.88 (747.61)***	0.001 (2.50)*
Sri Lanka	7.75 (140.75)***	−0.002 (−1.00)
Panel Regression	7.80 (135.25)***	0.023 (6.14)***

0-3, ***,**, and *Denote rejection of null hypothesis at 1%, 5% and 10% level of significance, AC t-values in (parenthesis)

Table 2: Panel unit root test results

Test	De-trend Energy Intensity		Growth rate of GDP	
	Test value	P	Test value	P
LC	−2.06	0.001**	4.028	0.000***
FisherADF	27.80	0.058*	80.10	0.000***
PPtest	31.12	0.070*	119.89	0.000***

Automatic selection of lags based on minimum AIC: 0-3, ***,**, and *Denote rejection of null hypothesis at 1%, 5% and 10% level of significance, Deterministic components. LLC, PP, Breitung, and Fisher-ADF tests: Fixed cross section effects and individual trends. IPS: Fixed cross section effects, GDPc: Gross domestic product per capita, ADF: Augmented Dickey-Fuller

The OLS estimation of error component panel data model with lagged dependent variable in the set of repressors produces biased coefficient estimates. The basic problem of using OLS is that the lagged dependent variable is correlated with the error term as the dependent variable $\ln(E/Y)^{DT}_{it}$ is a function of μ'_{it}. and it immediately follows that $\ln(E/Y)^{DT}_{it-1}$ is also a function of μ'_{it}. Note that the fixed effect (FEM) estimators are also biased and inconsistent unless the number of time periods is large (Baltagi 2002, pp. 129-131). To cope with these problems estimators based on General Method of Moments (GMM) are employed which are consistent for fixed *T*. We exploit the GMM-DIFF procedure of Arellano and Bond (1991), which suggests first to difference the model and then to use lags of the dependent and explanatory variables as instruments for the lagged dependent variable.

5. RESULTS

5.1. Relationship between Energy Intensity and Economic Growth

In order to get the relationship between energy intensity and economic growth, we regressed de-trended energy intensity on the growth rate of real GDP in panel context. We used M1 (FEM) and M2 (GMM) regression models. The results in Table 3 show the positive estimate for *d*. The co-efficient describing the relationship between energy intensity and real GDP growth in poor countries is $\beta = d + 1 > 1$ (i.e. 0.09). Hence, the increasing energy intensity is a result of economic growth that does not induce energy saving.

Note that increasing energy intensities in under developing countries may also be the result of business cycles and oil price shocks. As a result, energy consumption has, in most of cases, grown more rapidly than GDP (for the case of India, Hannesson, 2002). Huang et al. (2008) found that in poor countries, 1% increase in economic growth requires more than 1% increase in energy use. The cost of converting energy into GDP is high in under developing economies of south Asia.

Table 3: De-trended energy intensity and economic growth

Dependent variable $\ln(E_t/Y_t)^{DT}$	M1 (FEM)	M2[(7)](GMM)
$\ln(E/Y)^{DT}_{it-1}: \gamma$		0.68 [43.40]***
$\Delta \ln Y_{it}: d_{SR}$	0.09[1.30]*	0.30 [14.34]***
$\beta_{SR} = d_{SR} + 1$	1.09	
$d_{LR} = d_{SR} / (1-\gamma)$		0.93
$\beta_{LR} = d_{LR} + 1$		1.93
R^2	0.15	
No of observation	378	364
DW-statistic	1.80	
Hansen test (p-Val)[(4)]		0.91
AR1 (p-Val)[(5)]		0.38
AR2 (p-Val)[(6)]		0.39

FEM is least squares dummy variable (fixed effect) model. (1) ***Significant at 1 % level of significance, (2) **Significant at 5 % level of significance. (3) *Significant at 10% level of significance. (4) Hansen test for over identifying restrictions, H_0: instruments do not correlate with residuals. (5) Arellano – Bond test of first-order autocorrelation, H_0: There is no first order-autocorrelation. (6) Arellano– Bond test of second-order autocorrelation H_0: There is no second order autocorrelation. (7) Instrument: Dependent variable lagged 2 periods. Explanatory variables in current period

5.2. Energy Intensity and the Main Sectors Contributing to Economic Growth

Typically, we can divide an economy into three main sectors. These are agricultural, industrial, and services sectors[1]. Theoretically there exist some views how these sectors are related with economic growth (Mahmood and Linden, 2017). The relation of industrial sector with economic growth has it roots in Kaldor's views of manufacturing sector. Kaldor (1966) argued that an industrial sector is the "engine of growth." It is widely believed that an expansion of the service sector relative to the rest of the economy leads to a reduction in the long run output per capita growth rate (Baumol et al., 1985; Bjork, 1999; Wolff, 1985b; Wilber, 2002).

We consider the following production function type relationship between GDP and its main sector outputs:

$$Y(t) = Ae^{\alpha t} AG(t)^{\beta} I(t)^{c} S(t)^{\delta} \quad | \ln(\ )$$
$$\ln Y(t) = A' + \alpha t + \beta \ln AG(t) + c \ln I(t) + \delta \ln S(t) \quad | \ dt$$
$$\frac{dY(t)/dt}{Y(t)} = \alpha + \beta \frac{dAG(t)/dt}{AG(t)} + c \frac{dI(t)/dt}{I(t)} + \delta \frac{dS(t)/dt}{S(t)}.$$

$$\Rightarrow$$

$$= \alpha_i + \beta \Delta \ln Agriculture_{it} + c \Delta \ln Industry_{it} + \delta \Delta \ln Services_{it} + \varepsilon_{it} \quad (4)$$

In order to find the impacts of sectors on de-trended energy intensity we recall that (M1).

$$\ln(E\ /Y\ )_{it}^{DT} = d \Delta \ln Y_{it} + \mu_{it}$$

By plugging the (Eq. 4) into model M1, we get the relationship between de-trended energy intensity and economy sector growths. We use following fixed effects and dynamic panel data models to estimate the extended form of M1.

5.2.1. Fixed effects model (FEM): M3

$$\ln(E_t / Y_{tt})^{DT} = \alpha_i + \beta_1 \Delta \ln Agriculture_{it} + \beta_2 \Delta \ln Industry_{it} + + \beta_3 \Delta \ln Services_{it} + \omega_{it}$$

5.2.2 Dynamic panel data model (GMM): M4

$$\ln(E\ /Y\ )_{it}^{DT} = \alpha_i + \gamma \ln(E\ /Y\ )^{DT}_{it-1} + \beta_1 \Delta \ln Agriculture_{it} + \beta_2 \Delta \ln Industry_{it} + \beta_3 \Delta \ln Services_{it} + \mu_{it}$$

In the earlier phases of economic development there is a shift away from agriculture towards heavy industry, while in the later stages of development there is a shift from the resource inten-sive and extractive industrial sectors towards services. It is argued that this will result in an increase in energy used per unit of output in the early stages of economic development and a reduction in energy used per unit output in the later stages of economic development (Panayotou, 1993).

However, service sector still need large energy and resource inputs (Stern, 2003). The energy consumption of the service sector

1 We have divided the economy in to these three main sectors since the separate data is available on these different sectors.

Table 4: Sector output growth and de-trended energy intensity

Dependent Variable is energy intensity $\ln(E_t/Y_t)^{DT}$		
Explanatory variable	**M3 (OLS)**	**M4 (7) (GMM)**
$\ln(E/Y)^{DT}_{it-1}$		−0.25 (−1.60)*
$\Delta \ln Agriculture_{it}$	−0.002 (−1.10)	−0.0001 (1.45)*
$\Delta \ln Industry_{it}$	−0.10 (1.30)	−0.01 (1.40)
$\Delta \ln Services_{it}$	Services0.19 (1.70)*	0.029 (6.34)**
R^2	0.30	
No of observation	376	362
DW-statistic	2.55*	
Hansen test (p-Val)(4)		0.90
AR1 (p-Val)(5)		0.69
AR2 (p-Val)(6)		0.61

(1) ***Significant at 1% level of significance, (2) **Significant at 5 % level of significance. (3) *Significant at 10% level of significance. (4) Hansen test for over identified restrictions, H_0:instruments do not correlate with residuals. (5) Arellano – Bond test of first-order autocorrelation,H_0: There is no first order-autocorrelation. (6) Arellano– Bond test of second-order autocorrelation H_0:There is no second order autocorrelation. (7) Instrument: Dependent variable lagged 2 periods. Explanatory variables in current period

comprises also the energy used in buildings of the public and private service sector. This sector is also often referred to as tertiary sector. The share of the sector in the final energy consumption has increased slightly in the EU-25 (13% in 2004 vs. 12% in 1990). The energy consumption of this sector is often calculated as a residual as the balance between the total final energy consumption and the energy consumption of industry and agriculture.

The results in Table 4 show the relationship between services sector and energy intensity is negative for rich countries and this relationship is positive for Asian countries. The factors impacting on services final energy intensity include the improvements in energy efficiency, use of information and communication technology in offices, the average office or floor space per unit of added value, climatic conditions, and insulation. These factors have much lower energy use than the capital intensive industrial processing has. the panel of south Asian economies, the relationship between services sector and energy intensity is positive. This is due to inefficiencies in services sector of these countries. Hence, Asian countries should learn from the successful energy conservation polices of Europe and America.

The sector energy intensities are also influenced by structural changes in the economy i.e. shifts in the GDP structure among economic or industrial branches). For instance, an increasing share of services in the GDP, all other things being equal, results in a decrease of the final energy intensity because it requires much less energy to create one unit of GDP in the services sector than in the manufacturing industry. For the same reason, a falling contribution of energy-intensive branches to the industry value added also results in a decrease of the final energy intensity (IEEA, 2009). This argument is true for rich countries but it may not be true for developing countries because our results show that in south Asian countries the relationship between services sector and de-trend energy intensity is positive.

5.3. Energy Intensity, GDP per capita and Population Growth

Two main indicators can be considered to characterize the level of service sector. These are the GDP per capita level, and the employment share of population. These have also direct effects on the nation's energy use. Therefore, we study also the role of population growth and GDP per capita growth on the de-trended energy intensity. Following models are specified.

Table 5: GDP per capita growth, population growth, and energy intensity

Dependent variable is de-trend energy intensity $\ln(E_t/Y_t)^{DT}$		
Explanatory variable	**M5 (FEM)**	**M6 (GMM)**
$\ln(E/Y)^{DT}_{it-1}$		0.12 (23.80)***
$\Delta \ln POP_{it}$	1.99 (1.30)	0.99 (7.54)***
$\Delta \ln GDPc_{it}$	0.10 (1.10)	0.24 (1.34)
No of observation	378	364
DW-statistic	1.15	
Hansen test (p-Val)(4)		0.82
M1(p-Val)(5)		0.31
M2(p-Val(6)		0.18

5.3.1. Fixed effects model: (M5)

$$\ln(E/Y)_{it}^{DT} = \alpha_i + \beta_1 \Delta \ln POP_{it} + \beta_2 \Delta \ln GDPc_{it} + \mu_{it}.$$

5.3.2. Dynamic panel data model: (M6)

$$\ln(E/Y)_{it}^{DT} = \alpha_i + \gamma \ln(E/Y)^{DT}{}_{it-1} + \beta_1 \Delta \ln POP_{it} + \beta_2 \Delta \ln GDPc_{it} + \mu_{it}.$$

Developed world has high and rising income levels. They have also stable or declining populations and constantly improving energy intensities. The result of all this is the high GDP per capita level. Their (active) population and energy intensity move in same directions that help insulate them from the worst effects of energy declines. Result in in Table 5 show positive relationship between population growth and energy intensity for south Asian economies.

Population growth in south Asia is high, and their energy intensities are also high. Therefore, these economies tend to show worsening energy intensities over time. The relationship between GDP per capita growth and de-trended energy intensities were also positive.

6. CONCLUSIONS

We found positive energy intensity trend for south Asian countries. Therefore, we de-trended the energy intensity series and analyzed the impact of economic growth, population, and GDP per capita growth on de-trended energy intensities. In under developed countries growth requires still intensive energy use. Energy intensity correlations in poor countries can be also a result of business cycles and oil prices shocks. The relationship between growth sector outputs (i.e. industry, services, and agriculture output) and de-trended energy intensity is positive for the south Asia.

The impact of GDP growth, GDP per capita, and population growth on de-trended energy intensity is large but it is not energy saving in the south Asia. Literature supports our results indicating that the energy intensities of most of industrialized countries are decreasing and energy intensities in developing countries are still increasing (Nielsson, 1993; Huang et al., 2008; and Hannesson, 2000).

Secondly, the cost of converting energy into GDP is high in south Asian countries because countries at the bottom of the GDP scale tend to require more and more energy to produce the GDP (Huang et al., 2008). On other hand rich European economies require less and less energy input in relative terms (EEA, 2008). Therefore, policy makers in both developed and south Asian countries should find methods and technologies to improve energy efficiency in the under developed countries. Poor developing countries can avoid the long lasting high energy intensity trap by improving their energy conversion and technology, with well managed family policy, and with sustained economic growth.

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