# Emissions and Growth: Who is to blame and how to improve?*

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Abstract

Reducing energy intensity is key to reducing greenhouse gas emissions, we study energy intensity, measured by energy use per real value added, across countries and sectors between 1970-2010. Using energy use data from IEA and sectoral value added data from GGDC, we document three facts on energy intensity across countries, time and sectors. First, we find that energy intensity has a hump shape across income levels and that both sectoral composition and sectoral energy intensity are important to explain this hump shape. In addition, we find that for middle income countries most of the difference in energy intensity is explained by differences in energy intensity in the industrial sector. We then decompose energy intensity in this sector into differences in sectoral composition and in energy intensity across industrial sectors. We find that within the industrial sector most of the difference in industrial energy intensity across countries is due to differences in energy intensity across industries. We then use the development accounting framework to quantify the importance of productivity, energy prices and energy-saving technologies in industrial energy intensity. We find that differences in energy-saving technologies explain most of the differences in industrial energy intensity across countries.

Keywords: Energy Intensity, Economic Development, Structural Transformation
JEL codes: O1, O4, Q4, Q5

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# 1 Introduction

In this paper, we study energy intensity, measured by energy use per unit of real output, across countries and sectors between 1970-2010. Reducing energy intensity is key to reducing greenhouse gas emissions, which is in turn key to reducing the risks from future climate change. The importance of energy intensity for greenhouse gas emissions can be illustrated using the following accounting identity

$$\text{Total Emissions} = \text{Total Output} \times \frac{\text{Energy Use}}{\text{Total Output}} \times \frac{\text{Total Emissions}}{\text{Energy Use}}$$

According to the equation, we can decompose total emissions into three components: total output, energy use per output, or energy intensity, and greenhouse gas emissions per energy use which is mainly determined by the share of renewable energy resources, such as wind, solar, and hydroelectricity in total energy use. As world output is expected to continue to grow, total greenhouse gas emissions will be reduced only if we increase the share of renewable energy resources in total energy use, or reduce energy intensity.

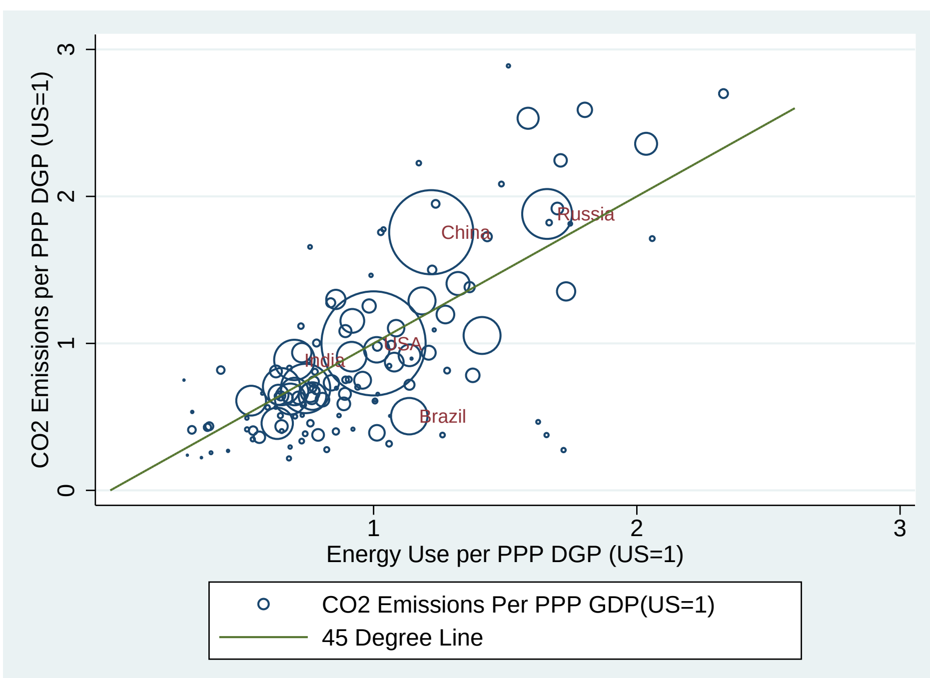


Figure ?? shows the relationship between CO2 emissions per PPP GDP (emission intensity) and energy use PPP GDP (energy intensity) for a large set of countries. As we can see, there are large variations in both energy intensity and emission intensity, and most countries lie close to the 45 degree line. This suggests that for the most important greenhouse gas, CO2, variations in energy intensity is key to the variations in emission intensity across countries.

To understand the variations of energy intensity across countries, we combine different data sources and construct sectoral real value added, capital and labor, and energy use and prices for a large set of countries. Specifically, we extend the development accounting framework to including energy use, and use the data and accounting framework to answer the following questions:

1. How does energy intensity differ across countries of different development levels?
2. Which factors account for differences in energy intensity across countries?
3. What are the policy implications?

We find that energy intensity has an hump shape across income levels. That is, middle-income countries have much higher energy intensity than other countries. We also find that both sectoral composition and sectoral energy intensity are important to explain this hump shape, but the high energy intensity of the middle-income countries is mostly explained by their high energy intensity in the industrial sector, in which high-income countries have lower energy intensity than both low and middle-income countries.

Given the importance of the industry energy intensity, we carry out a more detailed analysis on the industry sector. Contrary to what many people believe, the composition of the industrial sector, measured by the shares of real value added of each industry in the sector, plays a minor role in the cross-country differences in energy intensity of the industrial sector, while energy intensity of each industry plays a key role.

We then use the development accounting framework to quantify the importance of total factor productivity, energy prices and energy technologies in industrial energy intensity. We find that cross-country differences in energy-saving technologies explain most of the differences in industrial energy intensity, while differences in energy prices only plays a minor role at least in the short run. In sum, our results point to the importance of improving energy technologies in reducing energy intensity in low and middle-income countries.

Our paper is related to a large literature that studies trends in energy intensity among OECD countries. See Atkeson and Kehoe (1999), Mulder and de Groot (2012), Hassler et al. (2012), Levinson (2015) among others. These papers mainly focus on the changes in energy intensity for OECD countries, and their results in general suggest the importance of energy technologies. For example, using 473 six-digit NAICS industries for the US industry sector between 1982 and 2007, Levinson (2015) finds that changes in energy intensity of each individual industry appear to be the most important source of changes in the US industry energy intensity, while changes in industry composition over time plays a very small role. Our paper complements this literature by studying energy intensity differences across a large set of countries, covering low, middle and high-income countries. Besides, we combine our data and development accounting framework to quantify the relative roles of composition of economic activities, energy prices and energy technologies.

# 2 Empirical Facts

Improving energy intensity is key to reduce emissions and reduce climate change In this section, we document how energy intensity evolves development and what are sources of differences in energy intensity across countries.

## 2.1 Data

We measure energy intensity as total energy consumption divided by PPP GDP. We measures total energy consumption as a fuel (heat, power, and electricity generation) used in production. That is, we exclude non-energy use residential energy consumption from total energy consumption.[1] On average our measure of energy consumption accounts for more than 70 percent of total energy consumption in the countries where data is available.[2]

We use the energy consumption data from International Energy Agency (IEA henceforth), GDP and relative prices data from Penn World Table 8.0 (PWT 8.0 henceforth), and sectoral value added data from World Input-Output Tables (WIOD henceforth), to construct stylized facts on variations in energy efficiency across countries, across time and across sectors. IEA reports energy consumption by end-use sectors: residential, agricultural, industrial, commercial (services), and transportation. We use the data to construct measures of energy efficiency at both the country and sector level.[3] In total we have 40 countries that account for more than 80 percent of total energy consumption in the world.

[1]Non-energy use covers those energy commodities that are not consumed as a fuel or transformed into another fuel, for example, natural gas and petroleum products used as feedstocks for the production of plastics and fertilizer.

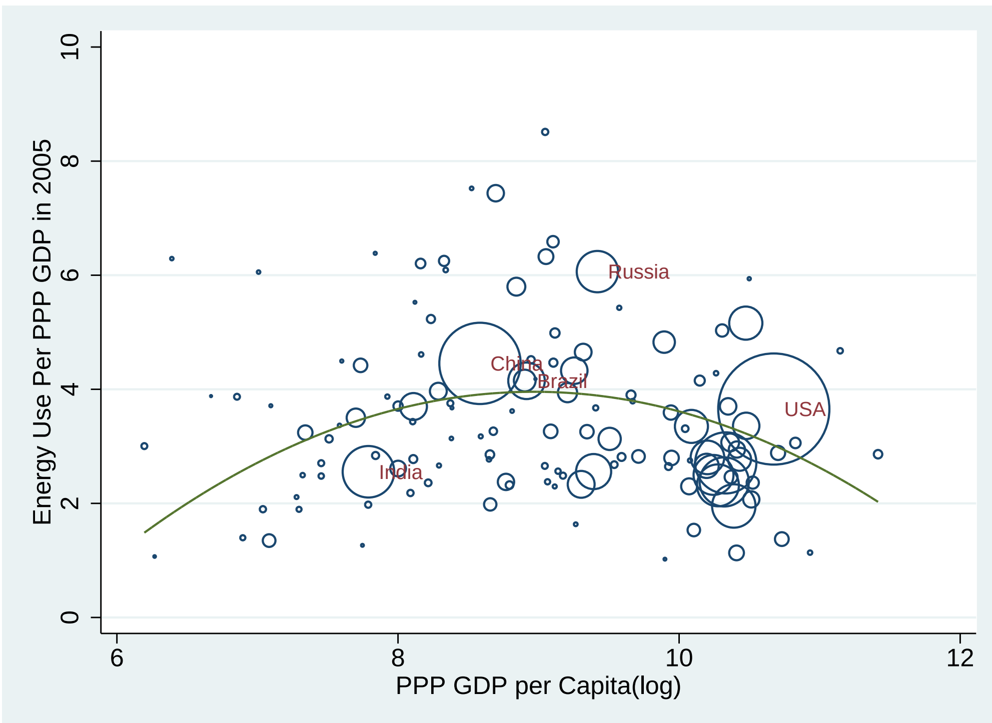
[2]In the Appendix we present the results for a more broad measure of energy efficiency and we show that the main difference between these two measures is caused by residential energy consumption in low-income countries, which consists mostly of biomass energy.

[3] Energy consumption in the transportation sector includes both owned-supplied and purchased transport services, which may cause troubles because the value added of the transport sector includes only purchased transport services.

## 2.2 Energy Intensity across Income Levels

Energy intensity varies substantially across countries that have a different level of development and within countries that have the same level of development. In Figure 1 we plot energy intensity against log PPP GDP per capita in 2005. The size of the balls indicates each country share on world PPP GDP.

Figure 1: Energy Intensity against PPP GDP per Capita in 2005




Data from International Energy Agency and Penn World Table 8.0.

From Figure 1 we find a hump shape, countries that have a lower PPP GDP have low energy intensity, as countries start developing energy intensity grows and pick around 10 thousand dollar PPP GDP and then start decreasing. This hump shape has been found previously in the literature in studies that analyze energy intensity over time in developed countries and has the implication that many large developing countries like China and India have not reach the pick of energy intensity. This relation is robust and significant as our empirical estimation indicates:

Table 1: Energy Intensity Estimation

| **Variable** | Coefficient | (Std. Err.) |
|---|---|---|
| log_gdppc | $4.628**$ | (1.977) |
| sq_log_gdppc | $-0.261**$ | (0.106) |
| Intercept | $-16.569*$ | (9.137) |

In addition, we perform some robustness check by cutting from our sample the top five and bottom five energy intensity countries and we still find the same result. In the next section, we analyze the source of this hump shape.

### 2.3 Sources of Energy Intensity Across Countries

There are large differences in sectoral composition across countries with different level of development. Developed countries on average have a larger service sector, which has very low energy intensity, while developing countries, in particular, middle-income countries have a large industrial sector, which has high energy intensity. In order to study the importance of sectoral composition in differences in energy intensity across countries we construct agricultural, industrial, and services value-added shares and energy intensity for 50 countries in our sample. Then we divide our sample in four quartiles. Table 2 summarizes the sectoral composition of each quartile and energy intensity across sectors in our sample.

Table 2: Energy Intensity and Sectoral Composition

| | Agriculture | Industrial | Services |
|---|---|---|---|
| Energy Intensity | 2.90 | 6.10 | 0.69 |
| Top Quartile | 0.02 | 0.28 | 0.71 |
| Middle High | 0.06 | 0.33 | 0.60 |
| Middle Low | 0.11 | 0.41 | 0.48 |
| Bottom Quartile | 0.17 | 0.24 | 0.59 |

In our sample the service sector's energy intensity is almost ten times less energy intense than the industrial sector, while the agricultural sector is three times less energy intense.

Regarding sectoral composition our sample is consistent with the structural transformation literature[4] the bottom quartile of our sample have the largest agricultural sector while the top quartile have largest service sectors. We can decompose differences in energy intensity into differences in sectoral composition and differences in sectoral energy intensity. All comparisons are with respect to the United States. In Table 3 the main results are presented, in the first column we divide each quartile energy intensity against the United States, in the next two columns we decompose how much of the differences in energy intensity is due to differences in energy intensity across sectors and due to differences in sectoral composition. In the last column. we quantify how much of the difference in energy intensity is due to only differences in energy intensity in the industrial sector.

Table 3: Energy Intensity Decomposition Relative to the United States

| Quartile | Percentage | Due to Energy Intensity | Due to Sectoral Composition | Only Industrial Energy Intensity |
|---|---|---|---|---|
| Top Quartile | 0.92 | -0.01 | -0.08 | -0.01 |
| Middle High | 1.26 | 0.24 | 0.02 | 0.22 |
| Middle Low | 1.32 | 0.37 | -0.05 | 0.47 |
| Bottom Quartile | 0.85 | -0.04 | -0.11 | 0.17 |

We find that middle high and middle low quartile are more energy intensive than the United States, while the top quartile and bottom quartile are more efficient. When we decompose these differences we find that differences in energy intensity are more important than sectoral decomposition in Middle High and Middle Low income countries. In addition, we find that most of this differences is due to only difference in energy intensity in the industrial sector. Regarding the bottom and top quintile we find that most of the difference is due to sectoral composition.

[4] See **??**

# 3 Accounting for Energy Intensity of Industry Sector

In Section 2, we show the importance of the industrial sector to explain differences in enrgy intensity in middle-high and middle-low economies. In this section, we decompose differences in enrgy intesity in the industrial sector into differences in the industrial composition and differences in the in the industrial energy intensity.

## 3.1 Industry Composition and Industry Energy Intensity

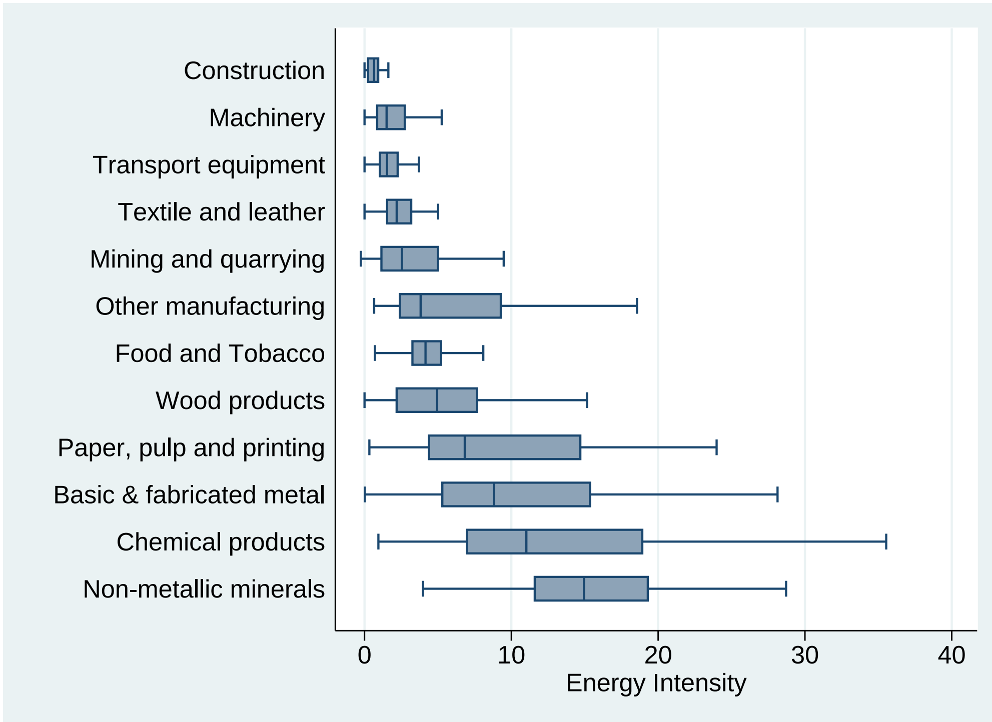
In this subsection, we examine the role of the composition of the industrial sector in the energy intensity of that sector across countries. To implement the exercises, we construct the real value added data for individual industries in the the indursty sector for 40 major economies in 2005, using the nominal value added from WIOD(Timmer et al. (2015)) and international price data from GGDC(Inklaar and Timmer (2014)). Then we combine the real value added data with the IEA data on energy consumption of individual industries.[5] In the top panel we plot the median energy intensity for the 13 countries in our sample and their standard deviation and in the bottom panel we plot the sectoral value added.

Specifically, we implement the following two counterfactual exercises that illuminate the role of industrial composition. Our preferred measure of industry composition is the shares of real value added from each individual industry. In the first exercise, we change the industry composition in each country to that in the US, while keeping the energy intensity of each individual industry as the same. In the second, we change the energy intensity of each individual industry in each country to that in the US, while keeping the composition of the industry sector as the same.[6] We conclude from the results of these exerceises that

[5] The data allows us to study 13 industries within the industry sector: Food and tobacco, Mining and quarrying, Construction, Iron and steel, Non-ferrous metals, Non-metallic minerals, Transport equipment, Machinery, Chemical and petrochemical, Paper, pulp and printing, Wood and wood products, Textile and leather, and Other manufacturing

[6] For robustness check, we also choose other countries such as Japan, China and Germany as the benchmark

Figure 2: Industry Composition and Industry Energy Intensity




Data Source: IEA, WIOD and GGDC, 2005

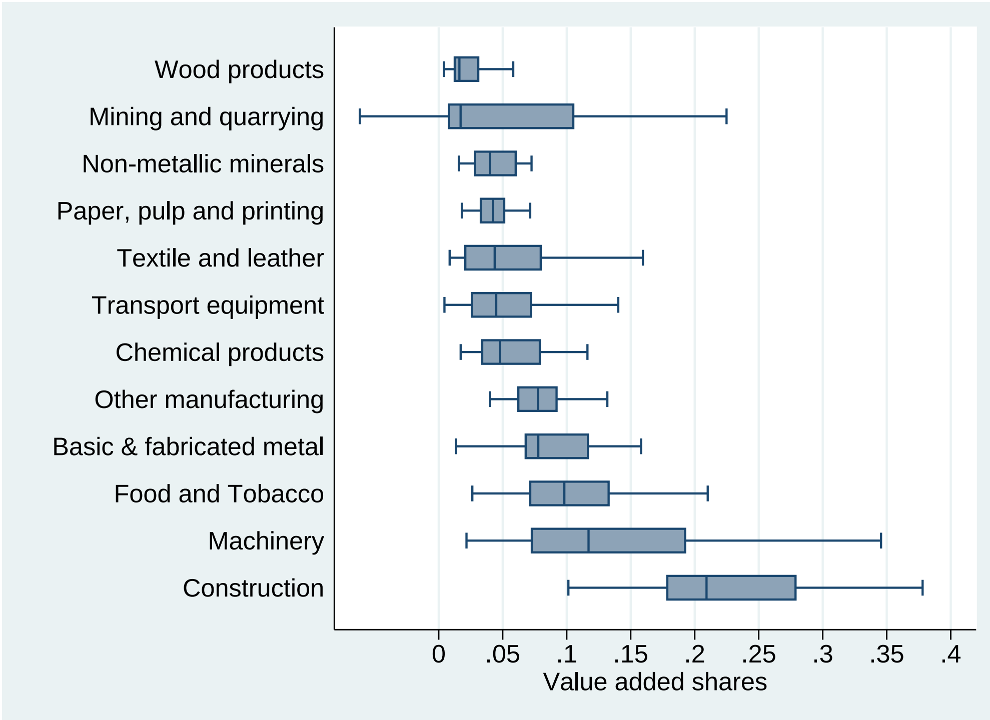
cross-countries differences in energy intensity of the indursty sector are not explained by differences in the industry composition.

Figure 4 summarizes the results of these exercises. The left panel shows the actual and counterfactual energy intensity of the indursty sector across countries, if all the countries had the same composition of the industry sector as the US, and the right panel shows the actual and counterfactual energy intensity of the indursty sector if all the countries had the same energy intensity of each individual industry as the US.

It's clear from Figure 4 that cross-country differences in the industry composition can't account for the cross-country differences in industry energy intensity. In fact, had all countries had the same industry composition as the US, the variations in the industry energy intensity across countries would become even larger, and the negative correlation between industry

countries, and our basic conclusion on the limited role of the composition of the industry sector is not affected.

Figure 3: Industry Composition and Industry Energy Intensity

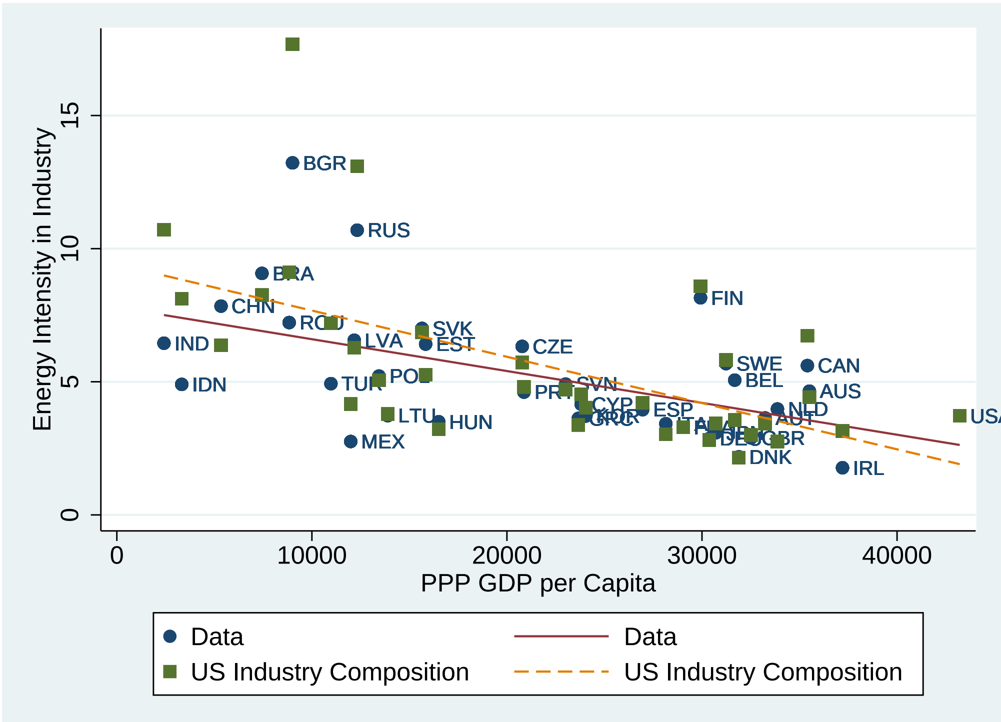



Data Source: IEA, WIOD and GGDC, 2005

energy intensity and PPP GDP per capita would become even stronger, as low and middle income countries such as India, Indonesia and Russia would have much higher industry energy intensity. On the other hand, had all countries had the same energy intensity in each industry as the US, the variations in the industry energy intensity across countries would become much smaller, and the negative correlation between industry energy intensity and PPP GDP per capita would disappear. In this case, low and middle income countries would see a large decrease in industry energy intensity, while most high income countries would see an increase in industry energy intensity.

In sum, our results imply that while cross-country differences in the industry composition can't explain the cross-country differences in industry energy intensity, differences in energy intensity of each individual industry seem to play a vital role. Levinson (2015) carries out a similar set of exercises at a more disaggregated level (473 six-digit NAICS industries) for the

Figure 4: Industry Composition and Industry Energy Intensity




Data Source: IEA, WIOD and GGDC, 2005

US industry sector between 1982 and 2007. Consistent with our findings, he also finds that changes in industry composition over time do not account for the changes in US industry energy intensity, while changes in energy intensity of each individual industry (which he calls technique effect) appear to be the most important source of changes in industry energy intensity.

## 3.2 The Roles of Technology and Energy Prices

In this section, we bulid a simple model based on aggregate production analysis, and use it to quantify the roles of overall productivity, energy-saving technology and energy prices in industry energy intensity. As we see above, the industry composition can't explain the cross-country differences in industry energy intensity, and therefore will be ignored in the analysis below.

### 3.2.1 The Model

A representative industry firm uses capital $K$, labor $L$ and energy $E$ to produce the final good $Y$, using the following production function

$$Y = F(K, L, E) = [\gamma(A_K K)^\rho + (1-\gamma)(A_E E)^\rho]^{\frac{\alpha}{\rho}} L^{1-\alpha} \tag{1}$$

where $A_K$ is capital/labor-augmenting technology, $A_E$ is energy-augmenting technology, $E$ is the amount of energy used in production, and $1/(1-\rho)$ is the elasticity of substitution between capital and energy. [7] The interest rate $r$ and energy price $p$ are determined exogenously, and there is a fixed supply of labor $L_s$.

The firm maximizes its profit by choosing $\{K, L, E\}$, given interest rate $r$, wage $w$ and energy price $p$

$$\max_{K,L,E} [\gamma(A_K K)^\rho + (1-\gamma)(A_E E)^\rho]^{\frac{\alpha}{\rho}} L^{1-\alpha} - rK - wL - pE \tag{3}$$

[7] An alternative specification, used by Hassler et al. (2012), is as follows

$$Y = F(K, L, E) = [\gamma(A_K K^\alpha L^{1-\alpha})^\rho + (1-\gamma)(A_E E)^\rho]^{\frac{1}{\rho}} \tag{2}$$

Using the US annual data, they find a large negative value for $\rho$, implying that energy is highly complementary to the capital-labor composite in the short run. Atkeson and Kehoe (1999) use a nested CES function, and estimate the elasticity of substitution between capital and energy to be about 1/3, which is very close to the value we use in our quantitative part.

The first-order conditions are

$$\alpha[\gamma(A_K K)^\rho + (1-\gamma)(A_E E)^\rho]^{\frac{\alpha}{\rho}-1}\gamma(AK)^\rho L^{1-\alpha} = rK \tag{4}$$

$$\alpha[\gamma(A_K K)^\rho + (1-\gamma)(A_E E)^\rho]^{\frac{\alpha}{\rho}-1}(1-\gamma)(A_E E)^\rho L^{1-\alpha} = pE \tag{5}$$

$$(1-\alpha)[\gamma(A_K K)^\rho + (1-\gamma)(A_E E)^\rho]^{\frac{\alpha}{\rho}} L^{1-\alpha} = wL \tag{6}$$

From these conditions we can solve for $(A_K, A_E)$,

$$A_K = (\alpha\gamma)^{-\frac{1}{\rho}}(\frac{Y}{L})^{\frac{1-\alpha}{\alpha}}(\frac{Y}{K})(\frac{rK}{Y})^{\frac{1}{\rho}} \tag{7}$$

$$A_E = (\alpha(1-\gamma))^{-\frac{1}{\rho}}(\frac{Y}{L})^{\frac{1-\alpha}{\alpha}}(\frac{Y}{E})(\frac{pE}{Y})^{\frac{1}{\rho}} \tag{8}$$

These equations have some important implications:

- We can back out $(A_K, A_E)$ if we know $(Y, L, K, E, r, p)$ and $(\alpha, \rho)$
- $A_E$ is increasing in $\frac{Y}{L}$ and $\frac{Y}{E}$, while the relationship between $A_E$ and energy's share of income $\frac{pE}{Y}$ depends on $\rho$

  1. $\rho > 0$: elasticity of substitution between capital and energy is greater than 1. Capital is good substitute for energy relative to the Cobb-Douglass case. Then $A_E$ is increasing in $\frac{pE}{Y}$. Countries with particularly low $A_E$ use more capital to substitute for energy.
  2. $\rho < 0$: elasticity of substitution between capital and energy is less than 1. Capital is good complement for energy relative to the Cobb-Douglass case. Then $A_E$ is decreasing in $\frac{pE}{Y}$. Countries with particularly low $A_E$ use more energy.

From the first-order conditions, we also get the formula for capital-to-energy ratio:

$$\frac{K}{E} = (\frac{\gamma}{1-\gamma}\frac{p}{r})^{\frac{1}{1-\rho}}(\frac{A_K}{A_E})^{\frac{\rho}{1-\rho}} \tag{9}$$

This equation also has important implications:

- $\frac{K}{E}$ is increasing in $p$, and the impact of $p$ is increasing in $\rho$
- The relationship between $\frac{K}{E}$ and $A_E$ depends on $\rho$

1. $\rho > 0$: Capital is good substitute for energy relative to Cobb-Douglass. Then $\frac{K}{E}$ is increasing in $A_E$. Countries with particularly low $A_E$ use more capital to substitute for energy.
2. $\rho < 0$: Capital is good complement for energy relative to Cobb-Douglass. Then $\frac{K}{E}$ is decreasing in $A_E$. Countries with particularly low $A_E$ use more energy.

Finally, the equilirium quantity of energy use $E$ is

$$E = (\frac{\alpha}{rB + p}[\gamma(BA_K)^\rho + (1-\gamma)A_E^\rho]^{\frac{\alpha}{\rho}})^{\frac{1}{1-\alpha}}L \tag{10}$$

where

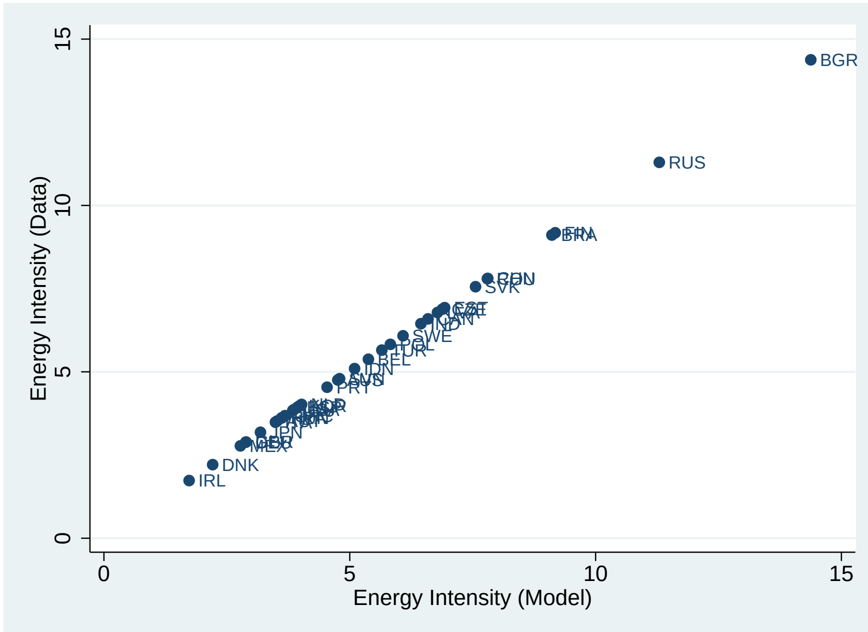
$$B = (\frac{\gamma}{1-\gamma}\frac{p}{r})^{\frac{1}{1-\rho}}(\frac{A_K}{A_E})^{\frac{\rho}{1-\rho}} \tag{11}$$

### 3.2.2 Estimation

We estimate the model for a large group of countries that account for the majority of both world output and world energy consumption in 2004. Our sample includes low-income countries such as China, Brazil India and Indonesia, middle-income countries such as Russia, Mexico and Turkey, and high-income OECD countries.

First, we need to pick values for the model parameters $(\alpha, \rho)$. $\alpha$ is chosen to match the income share of labor in each country. $\rho$ is another key parameter. We start with the case $\rho = -2$, which implies a mild complementary between capital and energy in the production. Later we will compare the results with other values of $\rho$. Then $(A_K, A_E)$ are estimated using

Figure 5: Industry Energy Intensity: Model vs. Data




equilibrium conditions and quantities and input prices data. Specifically, we take industry energy consumption data from IEA, and energy prices (in current USD at market exchange rates) data from the IMF. Value added, capital stock, capital income, all in current USD at market exchange rates, and employment data for the industry sector are from WIOD. Our measure of energy intensity is based on real value added, therefore we also use international prices from GGDC.[8]

Figure 5 shows that the model does a perfect job in matching the energy intensity in the data. Figure 6 shows that when $\rho = -2$, there's a positive correlation between the ratio of $A_E$ to $A_K$ and PPP GDP per capita, implying that high-income countries in general have better energy-saving technologies.

We use the estimated model to isolate the impact of different factors on energy intensity. We carry out the following experiments

[8]The representative firm in the model make decisions based on domestic prices, or current USD at market exchange rates. After solving the model, we multiply the value added by PPP and construct energy intensity based on real value added. In this way, our measure of energy intensity is not affected by differences in relative prices across countries.

Figure 6: Ratio of $A_E$ to $A_K$ across Countries

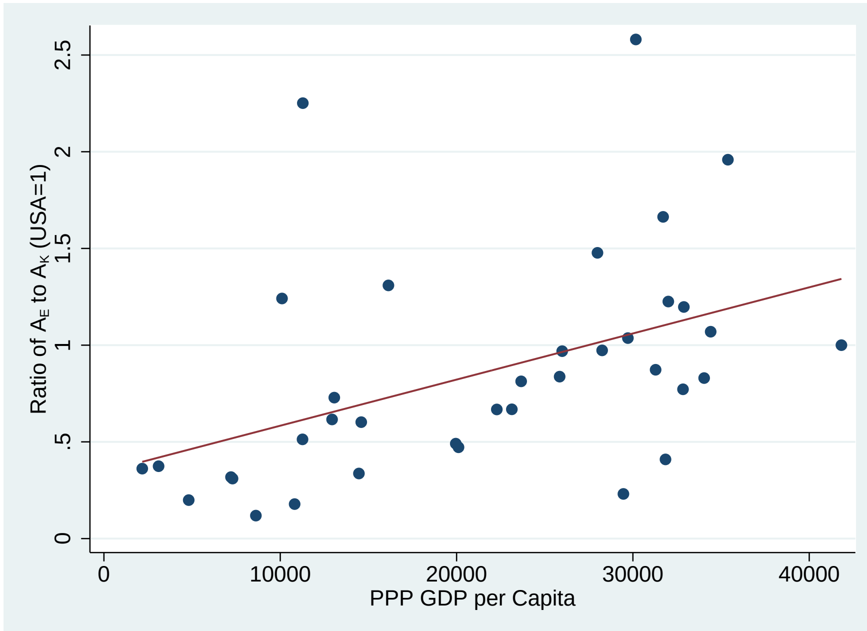



Figure 7: All Countries Had the US Energy-Saving Technology

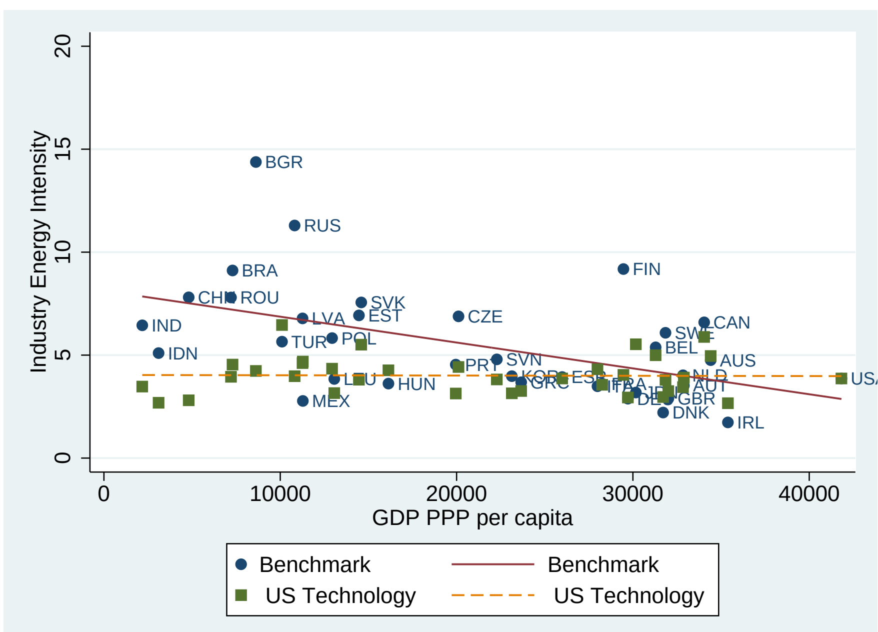
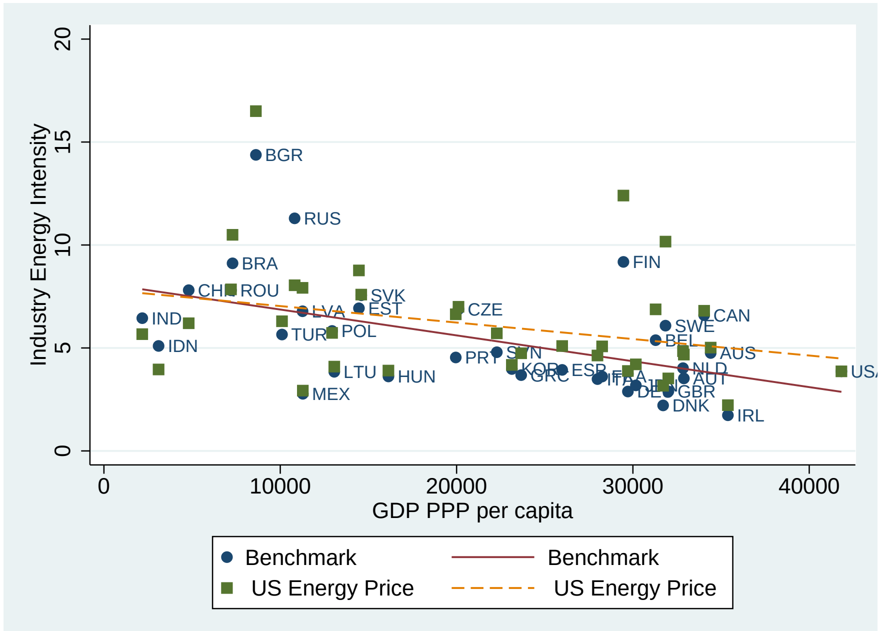


Figure 8: All Countries Had the US Energy Prices




- Change the ratio of $A_E$ to $A_K$ in each country to that of the US. This isolates the impact of energy-saving technologies.

- Change the energy price $p$ (in current USD at market exchange rates) in each country to that in the US. [9] This isolates the impact of changes in $p$.

Notice that we assume changes in $A_E$ are independent of and not induced by changes in $p$, which is not an innocuous assumption.

Figure 7 and 8 summarize the results of these counterfactural experiments. Figure 7 shows that had all countries had the same ratio of $A_E$ to $A_K$ as the US, had all countries had the same energy-saving technology as the US, the variations in the industry energy intensity across countries would become much smaller, and the negative correlation between industry energy intensity and PPP GDP per capita would disappear. In this case, low and middle

[9] A well-known fact in development economics is that price levels increase with development level. Therefore the differences between energy prices in USD at market exchange rates and in PPP USD can be large in low-income countries. Low-income countries such as India and Indonesia have lower energy prices in USD at market exchange rates than the US, but may have higher domestic relative price of energy to output.

income countries would see a large decrease in industry energy intensity, while most high income countries would see an increase in industry energy intensity. the variations in the industry energy intensity across countries would become even larger, and the negative correlation between industry energy intensity and PPP GDP per capita would become even stronger, as low and middle income countries such as India, Indonesia and Russia would have much higher industry energy intensity. On the other hand, had all countries had the same energy price as the US, the variations in the industry energy intensity across countries would become somewhat smaller, as low and middle income countries such as India, China and Indonesia have lower energy prices than the US, while most high-income countries have higher energy prices than the US. However, the negative correlation between industry energy intensity and PPP GDP per capita would persist.

Table 4: Quantifying Differences in Energy Efficiency in BRICS

| | Industry Energy Intensity (US=1) | | |
|---|---|---|---|
| | Benchmark | US Technology | US Energy Price |
| Brazil | 2.36 | 1.18 | 2.72 |
| China | 2.02 | 0.72 | 1.61 |
| India | 1.67 | 0.90 | 1.47 |
| Russia | 2.93 | 1.03 | 2.08 |

In particular, Table 4 shows the results of the counterfactural experiments for the BRIC countries, which makes the same point clearer. In the benchmark case (data), industry energy intensities in the BRIC countries are 1.7-2.9 times of the US level. Had these countries had the same energy-saving techology as the US, industry energy intensities in these countries would fall to 0.7-1.2 times of the US level. On ther other hand, had all BRIC countries had the same energy price as the US, industry energy intensities in these countries would still be 1.5-2.7 times of the US level.

In sum, energy-saving technology seems to play a much more important role than energy prices in energy intensity, if energy and capital are complements. A better understanding of energy-saving technology is needed.

# 4 Conclusions

We study energy intensity, measured by energy use per real value added, across countries and sectors. We find that energy intensity has a hump shape across income levels and that both sectoral composition and sectoral energy intensity are important to explain this hump shape. We find that for middle income countries energy intensity in the industrial sector is key to explain differences in energy intensity. We then decompose energy intensity in this sector into differences in sectoral composition and in energy intensity across industrial sectors. We find that within the industrial sector most of the difference in industrial energy intensity across countries is due to differences in energy intensity across industries.

Last, We use the development accounting framework to quantify the importance of productivity, energy prices and energy-saving technologies in industrial energy intensity. We find that differences in energy-saving technologies explain most of the differences in industrial energy intensity across countries. As a result, we find that in order for low and middle income countries to reach the energy intensity level of advanced economies is key that these countries leapfrog and adopt technologies that are already available and the consume less energy per value-added.

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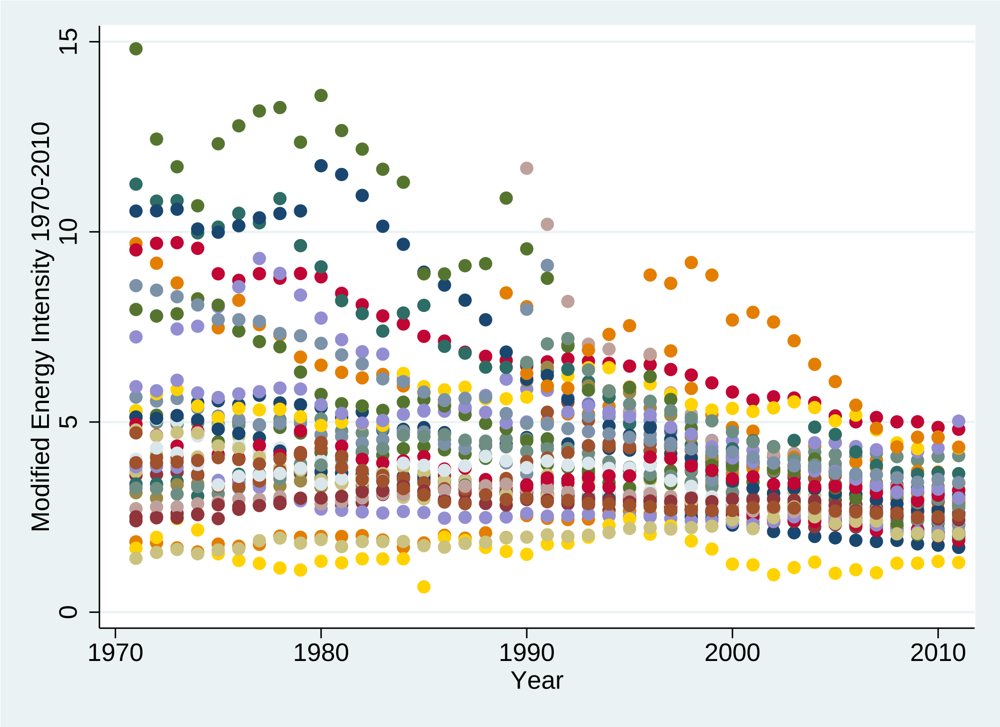
Figure 9: Convergence in Modified Energy Intensity across Countries from 1970-2010




Source: International Energy Agency and Penn World Table 8.0.

# A Appendix

Table 5: Sectoral Shares of Real Value Added

| *Country* | *Agriculture* | *Industry* | *Service* | *Transport* |
|---|---|---|---|---|
| Australia | 0.05 | 0.28 | 0.63 | 0.04 |
| Austria | 0.02 | 0.29 | 0.65 | 0.04 |
| Belgium | 0.01 | 0.26 | 0.67 | 0.05 |
| Brazil | 0.09 | 0.25 | 0.62 | 0.04 |
| Bulgaria | 0.09 | 0.19 | 0.61 | 0.11 |
| Canada | 0.03 | 0.33 | 0.61 | 0.03 |
| China | 0.10 | 0.42 | 0.42 | 0.06 |
| Cyprus | 0.03 | 0.18 | 0.75 | 0.04 |
| Czech Republic | 0.03 | 0.31 | 0.55 | 0.10 |
| Denmark | 0.03 | 0.30 | 0.62 | 0.05 |
| Estonia | 0.04 | 0.24 | 0.63 | 0.10 |
| Finland | 0.04 | 0.36 | 0.54 | 0.05 |
| France | 0.03 | 0.22 | 0.71 | 0.04 |
| Germany | 0.01 | 0.31 | 0.64 | 0.04 |
| Greece | 0.05 | 0.18 | 0.66 | 0.11 |
| Hungary | 0.06 | 0.24 | 0.66 | 0.04 |
| India | 0.17 | 0.22 | 0.56 | 0.06 |
| Indonesia | 0.15 | 0.40 | 0.40 | 0.05 |
| Ireland | 0.03 | 0.37 | 0.57 | 0.03 |
| Italy | 0.03 | 0.28 | 0.62 | 0.06 |
| Japan | 0.01 | 0.31 | 0.65 | 0.03 |
| Korea, Republic of | 0.02 | 0.43 | 0.50 | 0.06 |
| Latvia | 0.03 | 0.17 | 0.66 | 0.13 |
| Lithuania | 0.06 | 0.25 | 0.58 | 0.12 |
| Mexico | 0.05 | 0.33 | 0.51 | 0.11 |
| Netherlands | 0.03 | 0.25 | 0.68 | 0.04 |
| Poland | 0.06 | 0.26 | 0.64 | 0.04 |
| Portugal | 0.03 | 0.28 | 0.65 | 0.05 |
| Romania | 0.07 | 0.30 | 0.50 | 0.13 |
| Russia | 0.04 | 0.32 | 0.52 | 0.12 |
| Slovak Republic | 0.04 | 0.27 | 0.62 | 0.08 |
| Slovenia | 0.04 | 0.34 | 0.58 | 0.05 |
| Spain | 0.05 | 0.28 | 0.63 | 0.05 |
| Sweden | 0.02 | 0.29 | 0.64 | 0.05 |
| Turkey | 0.08 | 0.26 | 0.52 | 0.14 |
| United Kingdom | 0.02 | 0.23 | 0.72 | 0.04 |
| United States | 0.02 | 0.23 | 0.72 | 0.03 |

Table 6: Sectoral Shares of Energy Use

| *Country* | *Agriculture* | *Industry* | *Service* | *Transport* |
|---|---|---|---|---|
| Australia | 0.04 | 0.39 | 0.11 | 0.47 |
| Austria | 0.03 | 0.38 | 0.15 | 0.44 |
| Belgium | 0.03 | 0.44 | 0.17 | 0.36 |
| Brazil | 0.06 | 0.49 | 0.06 | 0.38 |
| Bulgaria | 0.04 | 0.49 | 0.11 | 0.36 |
| Canada | 0.04 | 0.37 | 0.20 | 0.39 |
| China | 0.04 | 0.73 | 0.05 | 0.19 |
| Cyprus | 0.03 | 0.27 | 0.14 | 0.57 |
| Czech Republic | 0.03 | 0.48 | 0.17 | 0.32 |
| Denmark | 0.08 | 0.28 | 0.19 | 0.44 |
| Estonia | 0.05 | 0.37 | 0.20 | 0.37 |
| Finland | 0.04 | 0.60 | 0.14 | 0.23 |
| France | 0.05 | 0.31 | 0.20 | 0.44 |
| Germany | 0.00 | 0.38 | 0.23 | 0.39 |
| Greece | 0.08 | 0.29 | 0.13 | 0.50 |
| Hungary | 0.05 | 0.28 | 0.31 | 0.36 |
| India | 0.09 | 0.60 | 0.08 | 0.23 |
| Indonesia | 0.04 | 0.53 | 0.05 | 0.38 |
| Ireland | 0.04 | 0.29 | 0.19 | 0.48 |
| Italy | 0.03 | 0.39 | 0.15 | 0.42 |
| Japan | 0.02 | 0.37 | 0.27 | 0.34 |
| Korea, Republic of | 0.03 | 0.43 | 0.21 | 0.32 |
| Latvia | 0.06 | 0.29 | 0.24 | 0.41 |
| Lithuania | 0.03 | 0.33 | 0.19 | 0.46 |
| Mexico | 0.04 | 0.35 | 0.04 | 0.57 |
| Netherlands | 0.09 | 0.37 | 0.22 | 0.31 |
| Poland | 0.12 | 0.40 | 0.17 | 0.32 |
| Portugal | 0.04 | 0.38 | 0.15 | 0.43 |
| Romania | 0.01 | 0.60 | 0.11 | 0.28 |
| Russia | 0.04 | 0.48 | 0.14 | 0.35 |
| Slovak Republic | 0.02 | 0.46 | 0.22 | 0.30 |
| Slovenia | 0.02 | 0.45 | 0.13 | 0.40 |
| Spain | 0.04 | 0.39 | 0.11 | 0.47 |
| Sweden | 0.03 | 0.48 | 0.17 | 0.32 |
| Turkey | 0.08 | 0.51 | 0.11 | 0.30 |
| United Kingdom | 0.01 | 0.34 | 0.18 | 0.47 |
| United States | 0.02 | 0.24 | 0.18 | 0.56 |

Table 7: Decomposition of Aggregate Energy Intensity

| *GDP per Capita* | *Agg Energy Intensity* | *Agriculture* | *Industry* | *Service* | *Transport* |
|---|---|---|---|---|---|
| 2,272.19 | 2.47 | 0.20 | 1.41 | 0.20 | 0.66 |
| 5,235.18 | 4.51 | 0.20 | 3.02 | 0.24 | 1.06 |
| 12,663.01 | 4.18 | 0.19 | 1.85 | 0.60 | 1.54 |
| 35,908.23 | 3.06 | 0.08 | 0.94 | 0.58 | 1.46 |

Table 8: Estimation results : regress

| **Variable** | **Coefficient** | **(Std. Err.)** |
|---|---|---|
| log_gdppc | 4.628$^{*}$ | (1.977) |
| sq_log_gdppc | -0.261$^{*}$ | (0.106) |
| Intercept | -16.569$^{\dagger}$ | (9.137) |
| | | |
| N | 128 | |
| $R^2$ | 0.095 | |

Significance levels : $\dagger$ : 10% $*$ : 5% $**$ : 1%