The Impacts of Energy Efficiency and Consumption on GDP in the Euro Area

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Abstract:

This paper analyzes the aggregate data of the Euro Area to determine how GDP per unit of energy is affected by the use of common energy sources. Time series data from 1980 to 2005 is used to show the change in how energy is used compared to the growth of GDP. It is revealed in this paper that the consumption of efficient forms of energy is highly correlated to GDP growth and the use of inefficient energy sources leads to less growth.

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Keywords: Energy; Energy Efficiency; Energy Consumption; Euro; GDP

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1.0 INTRODUCTION

The energy crises in the 1970s, including but not limited to the 1973 oil crisis raised the prices of energy and oil. This had a negative effect on economic growth and called for a look into energy conservation. It was not known at the time whether energy conservation would help or hurt the economy. Some thought it would help the economy because people would spend less on energy and have more left to invest. Others thought that energy conservation would hurt the economy because tasks that need energy might need to be done slower or be given up altogether.

Since the energy crises, there has been quite a bit of research interest on the Granger Causality between energy consumption and economic growth. Many have found causality to exist and some have even come up with policy implications on their findings. The main question these papers looked to answer was whether or not energy consumption or energy efficiency can stimulate economic growth. What these papers did not look at was if the use or conservation of certain energy types affected economic growth more than others.

This paper will assume the causality found in previous works and look at the GDP per unit of energy use ratio in the Euro area and relate that to usage of specific types of energy in the same area. By studying different types of energy, policy decisions can be made as to where, if any, government funding in energy should be placed. It would make sense that the funding be placed in the most efficient and cost effective forms of energy. The goal of this paper is to recommend certain energy types and discourage others as to best affect the economic growth per unit of energy usage ratio.

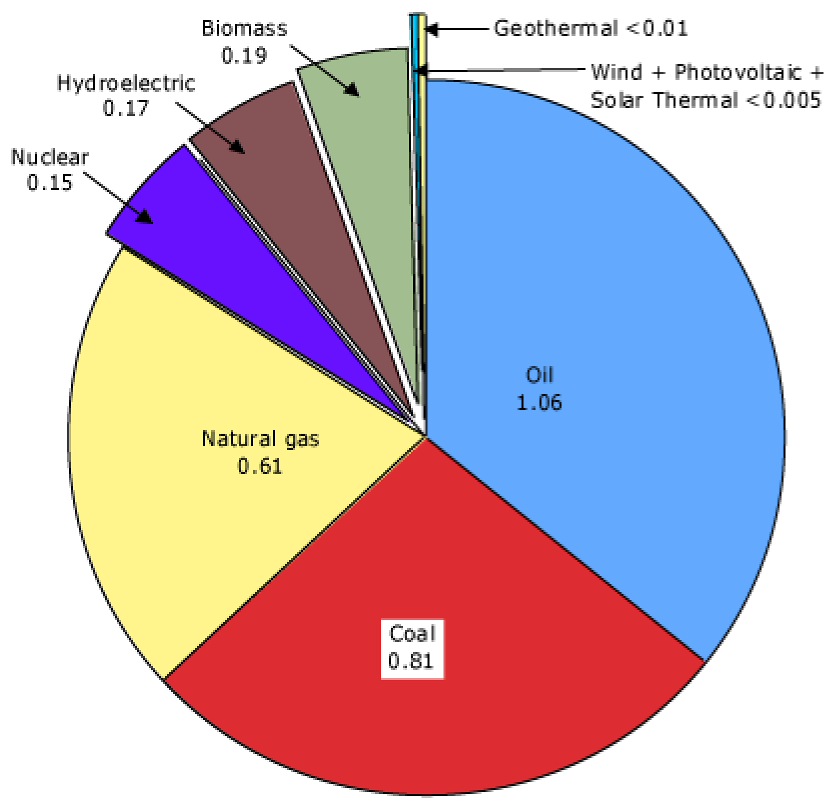
This paper proceeds as follows. Section 2 briefly reviews previous studies on the topic and looks into current policies the EU implements regarding energy. Section 3 deals with the data used in the empirical analysis while Section 4 presents the results found. In Section 5, conclusions are drawn about the topic and possible policy implications are presented.

2.0 TRENDS IN ENERGY AND THE EURO AREA

Identifying what types of energy should be used is a topic worth investigating. The main sources of energy in the world include petroleum, coal, and natural gas. All of these sources are non-renewable meaning there is a limited supply of these sources. The development of other energy sources will be necessary once the supply of the three main energy sources run out. Some alternative sources of energy that are renewable include nuclear, hydroelectric, biomass, geothermal, wind, and solar power. The usage of these renewable sources has been increasing over the years but is still much less than the three main sources of energy.

The chart below shows the amount of each source of energy used in the world. We can see that the consumption of oil, coal, and natural gas account for about 80 percent of the total energy consumption in 2006.

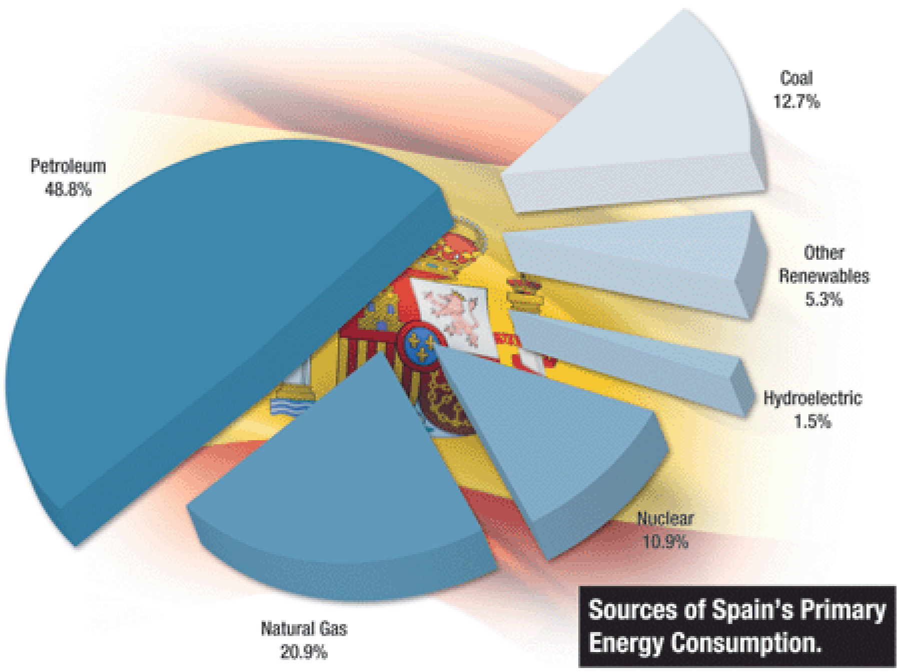
Global Sources of Energy in 2006



<http://news.cnet.com/i/bto/20080424/Energy_sources.gif>

Because this paper is concentrated on the Euro area, it is shown in the next graph the energy consumption by source in Spain which is part of the Euro zone. Spain has split up its energy consumption similar to that of the rest of the world with one exception. Spain uses less coal and more petroleum in providing its energy. The amounts of renewable energy sources are similar to the rest of the world in that they represent less than twenty percent of the total energy consumption.

Sources of Energy in Spain

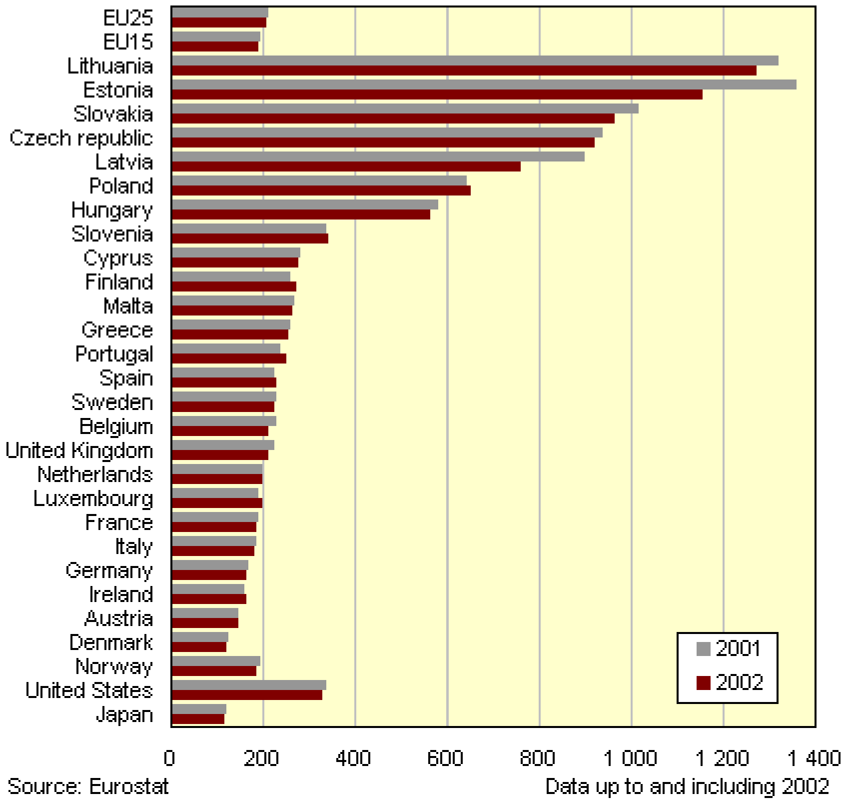


<http://www.energytribune.com/live_images/euro_pie_feb_08.gif>

This next graph shows the energy consumption in relation to GDP. As you can see, most countries shown have decreased their energy consumption in relation to GDP from 2001 to 2002. This also means that their GDP per unit of energy ratio has increased as well. The countries with the most energy consumption in relation to GDP such as Lithuania and Estonia are the least efficient energy users. The countries with a lower ratio like Denmark and Austria have a much higher energy efficiency.

Energy intensity of the economy

Energy consumption in relation to GDP (tons of oil equivalents per 1,000,000 euro)



<http://www.scb.se/Statistik/OV/OV0011/2003M00/OV0011_2003M00_DI_54_EN_Energy_EU.gif>

Even though most countries here are increasing their energy efficiency, some countries like Poland, Finland, and Portugal are doing just the opposite. These countries may need to look into some reforms in their energy policies to keep up with the changing energy trends.

3.0 LITERATURE REVIEW

Energy Consumption and Economic Growth: Assessing the Evidence from Greece by Hondroyiannis et al. looks at the empirical relationship between economic growth and energy consumption for Greece from 1960 to 1996. The results from this analysis do not show any short term correlation but does suggest a long term relationship between energy consumption and economic growth. Improvements in economic efficiency would promote economic growth and, in turn, improve energy consumption. Also, improvements in economic efficiency would help improve energy efficiency. Therefore, improved energy efficiency would not hamper economic growth and should be a good focus point for Greece to improve. It is assumed that the same policies would work for any middle size country.

Economic growth, trade and energy: implications for the environmental Kuznets curve by Suri and Chapman shows that pollution follows an inverted-U path in relation to economic growth. The turning point of pollutant emissions to economic growth is either at $55,000 or at $224,000 depending on if international trade is configured into the analysis. This would imply that even the most developed countries have a long way to go to reach the turning point where more energy consumption does not yield a higher economic growth. Even though countries do not need to worry about reaching the peak of the Kuznets curve, many developing countries already have flattening returns to energy consumption.

The article by Cutler J. Cleveland et al. *Aggregation and the role of energy in the economy* includes three related studies in their one article. The first study is to determine how much energy is actually taken out of fossil fuels in the United States. The second study looks to figure out if there is a causal relationship between energy consumption and GDP. The third, energy quality is looked at to determine if changes can be predicted in the energy/GDP ratio. The main point of this article is to show that countries are improving their energy efficiency by replacing low quality energy with high quality energy. Some low quality energies cannot be replaced, however, because it would not make sense to use certain energy sources for specific tasks.

Energy consumption and GDP: causality relationship in G-7 countries and emerging markets by Soytas and Sari looks at the causal relationship between energy consumption and GDP in G-7 countries. It is found that causality runs from energy consumption to GDP in these countries. They state their case that energy conservation in countries like Argentina could negatively impact economic growth in the same country.

Causal relationship between energy consumption and GDP revisited: the case of Korea 1970–1999 by Oh and Lee examines the causal relationship between energy consumption and GDP for Korea. The results of this article suggest there is a long run causal relationship between energy consumption and GDP in Korea. The methods used were a Granger Causality test with a VECM model.

Energy efficiency in China: accomplishments and challenges by Sinton, Levine, and Qingy shows how China is an example for other countries to follow in energy efficiency policies. China's energy consumption has not grown as fast as their GDP meaning their energy efficiency has been getting better every year. This also shows that economic growth is possible with energy conservation acts in place. The paper also looks at the various energy conservation policies put in place by China and attempts to show why each one worked. Each policy is determined whether or not it will help other countries like it did for China.

4.0 DATA AND EMPIRICAL METHODOLOGY

4.1 Definition of Variables

$$GDPPE_t = \beta_0 + \beta_1 COAL_t + \beta_2 DNG_t + \beta_3 GEO\_S\_WE_t + \beta_4 NUCELEC_t + \beta_5 HYDRO_t + \beta_6 PETRO_t + \beta_7 N\_ELEC\_IMP_t + \varepsilon_t$$

$GDPPE_t$ is the GDP per unit of energy use in constant 2005 purchasing power parity dollars per kilogram of oil equivalent at time t. Time t runs from the starting year 1980 to the ending year 2006. The sample from which data is taken from is the Euro area, or also known as the Euro zone. This area includes these 16 countries: Austria, Belgium, Cyprus, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Malta, Netherlands, Portugal, Slovakia, Slovenia, and Spain. These 16 countries make up the aggregate data known as the Euro zone. The importance of the GDP per unit of energy has been downplayed by authorities in the recent past. It is, however, important for this study because it is one of the few variables that capture both GDP and energy consumption. Another name for the relationship between energy consumption and GDP is energy efficiency.

Independent variables consist of seven variables all from the Energy Information Administration. Appendix A and B provide data source, acronyms, descriptions, expected signs, and justifications for using the variables. First, $COAL_t$ is the consumption of coal from 1980 to 2006 in Quadrillion Btus. Coal is an inefficient form of energy that was used much more in the past as it is now. Second, DNG_t is the consumption of natural gases from 1980 to 2006 in the Euro zone. Many homes are heated with natural gas and claims are that it is cleaner than heating oil. Third, $GEO\_S\_WE_t$ is the consumption of Geothermal, Solar, Wood, Wind, and Waste Electric power from 1980 to 2006. These sources of electricity are not used very often but many say are cheaper sources for the future. Fourth, $NUCELEC_t$ is the consumption of nuclear electric power from 1980 to 2006 and is a main source of electricity. Fifth, $HYDRO_t$ is the consumption of electricity from a hydroelectric source. The amount of hydroelectric power consumed over the last 25 years has been quite constant. Sixth, $PETRO_t$ is the consumption of oil used in heating homes and operating vehicles. It the most used energy source in the Euro area. Lastly, $N\_ELEC\_IMP_t$ is the amount of electricity brought in from other regions minus the exports of electricity from 1980 to 2006. This is important because not every country supplies enough their energy to its citizens and need to buy it from elsewhere.

4.2 Data

This study takes data from the World Bank and the Energy Information Administration for the Euro area. Summary statistics of the data are provided in Table 1.

<Insert Table 1 about here>

5.0 EMPIRICAL RESULTS

5.1 Non-renewable Energy Sources

The results for the regression between GDP/energy unit and the non-renewable energy sources like petroleum, natural gas, and coal came out as expected. It was expected that natural gas and petroleum come out as either a positive variable or slightly negative because they are known to be more efficient energy sources than coal. The coefficient of coal was expected to be negative because coal is an inefficient energy source. All three variables came out to be significant at the 1% level showing that all three variables made an impact on the regression fit.

5.2 Electricity Added

The results for the regression between GDP/energy unit and all energy sources both renewable and non-renewable appeared to be a better fit. The results still came out as expected with coal having a negative coefficient and new sources of electricity like geothermal and solar energy having a positive coefficient. One problem with this set of data, however, is that many variables are related and have a similar impact on the regression. Therefore, the variables DNG and HYDRO turned out to be insignificant. The use of these sources of energy has been relatively constant over the last 25 years in the Euro area.

5.3 Electricity Imports

This regression has added the variable N_ELEC_IMP to the independent variables to see if the amount of energy taken in from other areas affects the GDP/energy ratio. It has been found on a 1% significant level that imports positively affect the GDP/energy ratio. It is not known whether imports of electricity cause for a higher GDP or whether a higher GDP allows for countries to import more electricity. It makes more sense to be the latter.

<Insert Table 2 about here>

6.0 CONCLUSION AND POLICY IMPLICATIONS

6.1 Conclusion

This study looked at energy sources in the Euro Area and attempted to determine the effect of energy consumption on GDP. The hypothesis of this paper was that the consumption of the most efficient sources of energy would lead to a higher GDP per unit of energy consumed. Likewise, the consumption of the least efficient sources of energy would lead to a lower GDP per unit of energy consumed. The results of this paper show that coal, which is often considered an outdated energy source, is an inefficient form of energy. Other sources of energy such as petroleum and natural gas are much more efficient than coal and can be considered direct substitutes. The newest forms of energy such as geothermal, solar, and nuclear energy are shown to be very efficient energy sources. Even though these sources of energy are not direct substitutes of oil and natural gas, they still can be used to satisfy many types of energy needs.

6.2 Policy Implications

For the better of the Euro Area, policy implications can be made in regards to energy consumption and economic growth. It has been shown in this paper that the use of efficient energy sources lead to a higher GDP per unit of energy use. Therefore, it is suggested that government funding towards the development of energy sources like geothermal, nuclear, and solar energy be increased. Also, to discourage the use of inefficient energy sources, it is suggested that a tax be placed on the production and consumption of coal in the Euro Area. The implementation of these two government tweaks will stimulate economic growth and show the way to higher energy efficiency.

Appendix A: Variable Description and Data Source

Acronym	Description	Data Source
GDPPE	GDP per unit of energy use (constant 2005 PPP $ per kg of oil equivalent) Euro area	World Bank
COAL	Consumption of Coal in EU (Quadrillion (10^15) Btu), 1980-2006	Energy Information Administration
DNG	Consumption of Natural Gas in EU (Quadrillion (10^15) Btu), 1980-2006	Energy Information Administration
GEO_S_WE	Consumption of Geothermal, Solar, Wood, Wind, and Waste Electric Power in EU (Quadrillion (10^15) Btu), 1980-2006	Energy Information Administration
NUCELEC	Consumption of Nuclear Electric Power in EU (Quadrillion (10^15) Btu), 1980-2006	Energy Information Administration
HYDRO	Consumption of Hydroelectric Power in EU (Quadrillion (10^15) Btu), 1980-2006	Energy Information Administration
PETRO	Consumption of PETRO in EU (Quadrillion (10^15) Btu), 1980-2006	Energy Information Administration
N_ELEC_IMP	Consumption of Electricity Imports in EU (Quadrillion (10^15) Btu), 1980-2006	Energy Information Administration

Appendix B: Variables and Expected Signs

Acronym	Variable Description	What it captures	Expected sign
COAL	Coal consumption	An inefficient and outdated source of energy	-
DNG	Natural gas consumption	Used in home heating	+/-
GEO_S_WE	Geothermal, solar, wind, wood, and waste electricity consumption	New, cheaper sources of electricity	+
NUCELEC	Nuclear electricity consumption	Source of electricity	+
HYDRO	Hydroelectricity consumption	Source of electricity	+/-
PETRO	Petroleum consumption	Energy used in home heating and cars	+/-
N_ELEC_IMP	Net electricity imports	Electricity consumed but not produced	+/-

Table 1: Summary Statistics

	Observations	Mean	Std. Dev.	Minimum	Maximum
GDPPE	26	6.669231	0.530554	5.7	7.46
COAL	26	15.99388	2.745098	12.73165	19.72517
DNG	26	14.07221	2.998925	10.25982	19.60231
N_ELEC_IMP	26	0.079186	0.062515	-0.02502	0.188499
GEO_S_WE	26	0.49593	0.418403	0.157742	1.614721
HYDRO	26	3.20004	0.22195	2.811622	3.812505
NUCELEC	26	7.662409	2.301608	2.434414	9.966801
PETRO	26	29.03564	1.635547	26.20626	31.45939

Table 2: Regression Results for the Euro Area

	GDPPE		
	I.	II.	III.
CONSTANT	9.943757*** (1.017234)	9.804803*** (1.235277)	9.709387*** (0.896563)
COAL	-0.126417*** (0.022447)	-0.126383*** (0.024040)	-0.161054*** (0.019254)
DNG	0.100471*** (0.018353)	-0.044580 (0.054113)	-0.001285 (0.040561)
N_ELEC_IMP			2.182604*** (0.513156)
GEO_S_WE		0.530590** (0.223606)	0.391956** (0.165484)
HYDRO		0.002212 (0.124024)	-0.006636 (0.090012)
NUCELEC		0.088324*** (0.030604)	0.056750** (0.023413)
PETRO	-0.091834*** (0.024272)	-0.049383* (0.027740)	-0.042259* (0.020197)
R^2	0.958923	0.972574	0.986322
F-Statistics	171.1938	112.2976	185.4210
Number of Observations	26	26	26

Note: *** , **, and * denotes significance at the 1%, 5%, and 10% respectively. Standard errors in parentheses

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