

# Relationship between energy consumption and economic development



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In the recent years China has rapidly developed into one of the largest economies in the World. China has shifted from the 108th to the 72nd rank on the World Development Index. The economic growth, industrialization and the urbanization have resulted to an annual average real GDP growth rate of 8 to 9 percent. The real income per capita has increased in this period, with the factor 10.

This impressive growth however also implies higher environmental pressures despite new technological improvements of resource utilization being applied. The enormous growth of China results in substantially higher energy consumption. This goes hand in hand with higher CO<sub>2</sub> emissions. The primary energy consumption in China has grown at an annual average rate of 6% between 1965 and 2008, with the first measurement of 183 oil equivalent million tonnes in 1965, and the latest measurement of 2003 MTN in 2008 (BP Statistical Review of World Energy June 2009).

The emission emitted by China in 2007 was 6. 466 MTN and 6. 897 MTN in 2008, indicating an increase of 6. 4%. The global CO<sub>2</sub> emission has increased from 31. 007 MTN in 2007, to 31. 578 MTN in 2008. This represents an increase of 1. 6 %. The share of China in the global emission in 2008 according to this information is a stunning 21, 8% (BP Statistical Review of World Energy June 2009). The projection of the IPCC (2007) is that the CO<sub>2</sub> emission from energy consumption between 2000 and 2030 are estimated to increase with 40 to even 110%.

The CO<sub>2</sub> emissions in China has exceeded the maximum amount stated in the Kyoto Protocol, which is a protocol to the United Nations Framework

Convention on Climate Change focusing on preventing global warming. China has not been able to meet 10 of the 13 critical points in the current five-year plan, with targets for air and water pollution control (The World Bank, State Environmental Protection Administration, P. R. China, 2007).

The overall environmental pollution costs in China are estimated to be about 5.8% of the GDP in China. For example it is estimated that in 2003 the acid rain which is mainly caused by fossil fuel emissions, has caused over 44 million dollars (30 billion Yuan[1]) damage to crops, and an estimated 10,3 million dollars (7 billion Yuan) in damage to building materials in China (The World Bank, State Environmental Protection Administration, P. R. China, 2007)

It is clear that economic growth contributes to a higher CO<sub>2</sub> emission and global warming. Is this economic growth sustainable in the long term due to the impacts on air pollution? Is it worth the growth of China given the limited amount of resources available and the need for environmental conservation? Countries will have to find a balance between their consumption and economic growth.

Various studies have analyzed the relationship between economic growth and the emission of CO<sub>2</sub>. For instance B. Friedl and M. Getzner (2003) found a significant relationship during the period of 1960 and 1999, with a structural break in the seventies due to the oil price shock. J. B. Ang (2007) found a dynamic relationship between pollutant emissions, energy consumption and economic development. They point out that the more energy is used in the economy, the more CO<sub>2</sub> emissions are released, which

in its turn has a quadratic relationship with the output in the long run. This indicates that output growth is a reactor for CO<sub>2</sub> emissions and energy consumption.

This relationship between output and the pollution level has been widely documented as the Environmental Kuznets Curve (EKC). The EKC hypothesis indicates that the relationship between economic development and the environment is shown as an inverted U-curve, whereas environmental damage first increases with income and over time will stabilize, and eventually declines.

China is one of the main driving forces of global warming, with the highest emission value and the highest economic growth rate. Since energy consumption has a direct impact on the level of environmental pollution, China is an interesting country to examine. Amidst the animated debate of global warming and sustainability, the energy consumption will be related as an input factor for economic activity along with the emission of CO<sub>2</sub> in China. Other influences which are included are price indices, total gross fixed capital, population and the technological developments.

I will make use of the measurements published by the following databases excluding the Chinese Statistical Yearbooks due to incoherent results with these databases; the BP Statistical Review of World Energy, the World Development Indicators database, The Conference Board Total Economy database and the World Intellectual Property Organization database.

The outcome of the research could contribute to the debate of the mitigation of global warming and should imply that China has to speed up the <https://assignbuster.com/relationship-between-energy-consumption-and-economic-development/>

technological developments to create or implement energy efficient technologies to reduce the CO<sub>2</sub> emissions in line with the targets of the Kyoto Protocol. This implies that policies should be reformulated to stimulate the use of alternative resources and technological developments.

The nexus of energy consumption - economic development - CO<sub>2</sub> emission, with price indices, total gross fixed capital, technological development and population.

Price indices and fluctuations

Investment in Pollution Treatment and R&D

Technological development

Air pollution:

CO<sub>2</sub> Emission

Economic Development:

GDP

TGFC

Consumption

Total Energy Consumption:

Oil / Gas Coal / Nuclear / Hydro-electricity

Households

Population

## **Literature review/Background**

There are two strands of literature relevant in the nexus of energy consumption and economic development and CO<sub>2</sub> emission. The first strand focuses upon the relation between energy consumption and economic development. More energy consumption leads to higher economic development through the enhancement of productivity.

The second strand focuses upon the relation between economic growth and CO<sub>2</sub> emission.

The latter strand represents the interrelation between energy consumption and the increase of CO<sub>2</sub>, which is well known and obvious. Various studies indicate that more energy use results in more CO<sub>2</sub> emission (J. Ang, 2007). Thus any movement of energy use will positively react to the emission level.

### 2. 1 Strand 1 - Energy consumption and economic development[2]

This first strand divides the causality between energy consumption and economic growth in three possibilities. Firstly the causality that runs from energy consumption to economic growth. Secondly the causality that runs from economic growth to energy consumption. Thirdly bidirectional causality which implies there is an effect, or no effect in either direction between energy consumption and economic growth.

#### 2. 1. 1 Unidirectional from energy consumption to economic growth

The traditional neo-classical model based upon economic growth uses the energy inputs as an intermediate. The factor inputs land, labor and capital are used as basic factors, in order to neutralize the function of energy in production. Energy is an intermediate function; however it is the consumption of energy that causes economic growth. Energy remains an important aspect in the determination of income. National economies therefore depend upon the use of energy and will be affected by changes in energy consumption. Therefore the elasticity is expected to be high between energy consumption and economic growth, since it is an important aspect.

Jia-Hai Yuan et al (2008) tests the causality between output growth and energy use in China at both aggregated total energy and disaggregated levels as coal, oil and electricity consumption and find that there exists Granger causality between the electricity and oil consumption to GDP. However they do not find Granger causality from coal and the total energy consumption of these three energy inputs to GDP. Soytas and Sari (2007) found the same Granger causality from electricity consumption to GDP in Turkey.

Previous research by Soytas and Sari (2003) examining the G-7 countries, indicated an unidirectional relationship running from energy consumption to GDP in Turkey, France, Germany and Japan covering the period 1950-1992.

Stern (1993) also found a Granger causality from total energy to GDP, employing a four-variable model with capital, labor, energy consumption and GDP.

A. E. Akinlo (2006) results indicate that energy consumption is co-integrated with economic growth within seven out of eleven African countries, using an autoregressive distributed lag bound test (ARDL). The study also implies that there exists a significant long run effect on economic growth in four African countries. Fatai et al. (2004) showed that energy consumption has a significant positive effect on economic growth in Indonesia and India.

C. Lee and C. Chang (2007) report a nonlinear relationship between energy consumption and an economic growth in Taiwan for the period 1955-2003, as inverse U-shape. They state from their previous research that in the long run energy unanimously acts as an engine of economic growth, and that energy conservation may harm economic growth. J. Ang (2007) found a unidirectional causality from the increase of energy and the output growth in the short run.

The existence of unidirectional causality has some policy implications; it could suggest that a country is dependent upon the inputs of energy to establish economic growth. The restriction of energy may directly lead to lower economic growth or even a restraint and could result in a fall in employment or equivalently an increase in unemployment rate (N. M. Odhiambo 2009, A. E. Akinlo, 2008).

It is difficult for governments to implement energy conservation policies as a part of a green future, and face the trade-off between energy consumption and growth. Environmental conservation will constantly be a part of every economic development process. Policies to conserve energy could be quotas,



taxes, subsidies or the promotion of efficient use of technology (C. Lee, C. Chang, 2007)

## 2. 1. 2 Unidirectional from economic growth to energy consumption

On the other hand I expect the increase in GDP will influence the energy consumption in various ways, firstly through an increased energy-intensity (energy consumption per unit of GDP) in households due to more spendable income. Also the private consumption of fuels in households and private car use seem to have a significant effect on the emission level (C. Lee and C. Chang, 2007). Population can thus be an indicator for the amount of energy consumption, whereas air pollution levels could be directly associated with population. The article of Lee and Chang (2007) discusses that the energy consumption in Taiwan has risen sharply due to rapid economic growth and higher living standards.

Secondly increases in income will increase activities as investment, which is an important input factor for production processes. If the economy grows, this will result to an increased demand for energy will increase. Pioneering in this strand is the article of Kraft and Kraft dated in 1978. It is one of the first articles to examine the phenomenon. They found a unidirectional causality running from output to energy consumption for the United States during the period 1947â€”1974. Jia-Hai Yuan et al (2008) is consistent with this result and found Granger causality in the short run from GDP to total energy consumption, coal and oil consumption. However there does exist causality from GDP to electricity consumption. Soytas and Sari (2003) found in their panel research a unidirectional relationship from economic growth to energy

consumption for Italy (1950-1992) and Korea (1953-1991). Total gross fixed capital can be an indicator for the amount of energy consumption.

This form of unidirectional causality from GDP to energy consumption can imply that a country is not solely dependent upon the energy consumption or energy input, leading to economic growth. Therefore policies can be implemented to conserve energy sources with no adverse or small effects on the economic growth (N. M., Odhiambo, 2009, A. E., Akinlo, 2008)

## 2. 1. 3 Bidirectional between energy consumption and economic growth

The third view implies that there exists a bidirectional relationship within the nexus of energy consumption and economic growth. N. M. Odhiambo (2009) and A. E. Akinlo (2008) found this bidirectional causality. Soytas and Sari (2003) found this relationship for Argentina (1950-1990) within the G-7 countries. A. E. Akinlo (2008) analyzed three African countries in the short and long run show that this relationship holds for developed countries, while developing countries endure economic growth through more energy consumption only in the short run.

C. Lee and C. Chang (2007) empirical findings suggest that energy consumption and economic growth are positively interrelated under a certain threshold. They stress the implications for future economic growth to the extent of resource scarcity.

The finding of causality in both directions implies that energy conservation policies will have an impact on economic growth. The other bidirectional causality is known as the neutrality hypothesis, which implies that energy

conservation policies do not affect economic growth. The insignificant impact in Taiwan beyond the mentioned threshold indicates that conservation policy is effective.

The conservation policy could be implemented through energy taxes, new subsidies, quantity restriction and promoting efficient usage of energy such as innovation. However such environmental protection policies will lead to high costs and avoidance of rules. Eventually this will result in control expenditures.

## 2. 2 Economic growth and CO2 emission

The more energy consumed the more CO2 emission will follow up to a level of total clean technology. The direct relationship between energy consumption and the amount of CO2 emission is logical and empirically proven in several articles.

The relationship between economic growth and CO2 emission is a more interesting one. Well known in the literature is the Environmental Kuznets Curve (EKC) hypothesis. Studies show that the EKC describes the relation between income and several local pollutants such as sulfur dioxide, nitrogen oxide and water pollutants. This relationship is an inverted U-curve, whereas environmental damage will first increase with income and over time will stabilize to its maximum. The curve will eventually decline, creating the inverted U-shape. It appears that economic growth can solely lead to environmental degradation (Soytasa & Saria 2007).

This implies that at low-income levels we might see a positive relation between national income and pollution, and at high levels of income we can trace a negative relation between the two variables (Liu, X. 2005). This non-linear relationship between environmental pollution and income levels can be explained by three factors: scale, composition, and technique effects.

The scale effect refers to the increase in pollution along with the size of the economy. The composition effect refers to the change in the production structure and reallocation of resources, from an agriculture based economy to an industry and service based economy. The technique effect refers to the used techniques of production which may reduce the amount of pollutant emissions.

### **(J. Ang, 2007)**

B. Friedl and M. Getzner (2003) analyzed the CO<sub>2</sub> emissions in a small open economy (Austria) and found a cubic relationship between GDP and CO<sub>2</sub> emissions in their research for the period of 1960 and 1999, meaning that the relationship has two inflection points, and change direction twice. They concluded that the Austrian emission and GDP are cointegrated and run parallel.

J. Ang 2007 shows that there is a quadratic relation between CO<sub>2</sub> emissions and output in the long run (parabola), in France for the period of 1960 to 2000. The results suggest that output growth causes CO<sub>2</sub> emissions and energy consumption in the long run.

A. Jalil, S. F. Mahmud 2009 analyzed the EKC hypothesis for China in the period 1971â€”2005 with an ADRL framework. From their analysis there  
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appears to be causality from economic growth to CO2 emissions, and a significant effect of energy consumption on the CO2 level.

## 2. 3 Other factors affecting energy consumption and economic growth

Another important factor is the research activity or investments in R&D to reduce the amount of emissions. The common belief is that improvement in productivity and research activity will lead to a reduced amount of emission. An example is the investment in technical upgrades and transformation in China in the electricity sector which increased sufficiently in 1990 and accelerated further since 1996. This should be one of the most important economic impulses driving energy efficiency improvements (L. Wu et al. 2006).

They also point out that the rising prices of energy since 1993 have provided strong economic incentives for the industry to decouple energy use from economic growth. This has driven the incentive to technically innovate. This refers to an economy that is able to sustain economic growth, without also experiencing a worsening of environmental conditions.

However, contrary to the case of Taiwan, which has substantial changes in the structure of production in the economic sectors and enormous increases in development. This has led to a rapid increase in energy consumption and carbon dioxide emissions.

Cole et al. (2008) show that productivity improvements and research activity will reduce the amount of emission. The article of J. Ang 2009 indicates that there exists a declining trend in CO2 emissions with the increase in research

activity in China. From the data covering 1953 to 1999, it becomes clear that more innovation and R&D activity will lead to beneficial influences in decreasing CO<sub>2</sub> emissions.

Policies created to decrease emission levels will lead to more research activity which will contribute directly through improved production techniques. This will decrease emissions and it will indirectly enable China to absorb green technology more efficiently from other countries. It is also likely that more efficient use of energy may require a higher level of economic development. That is, better economic performance may be a catalyst for energy efficiency, which makes energy consumption and economic development jointly determined (J. Ang 2007)

This is based on the premises that different countries are in different stages of development. There are different effects on the developing process and impacts on the energy and growth relation. Two countries with similar levels of technology and factor endowments may have significantly different industrial structures as a result of past investment decisions. Their aggregate capital levels may be similar, but differences in the composition of capital may lead to differences in the opportunity cost of reducing emissions. A regression of only emissions on income may lead to a misspecification and bias, without controlling for the industrial structure. Therefore the total gross capital formation is important to include (Liu, X. 2005)

Besides innovation and total gross capital formation, reforms of energy pricing systems in China since 1993 led to a dramatic rise in fuel prices and consequently to an economic decreased condition in the electricity

generation sector, petroleum refinery sector and coal mining sector. B. Friedl and M. Getzner (2003) directly relate this structural break in energy consumption as a result, to a lower CO<sub>2</sub> emission in Austria after the oil price shock.

The recent price hikes stresses the importance of energy policies for conservation (R. Mahadeva, 2006). Theoretically if the fuel price increases, it will stimulate energy conservation behavior if the demand is relatively elastic.

Practically the effect of rising prices can be seen by the oil price shock from 1973, which did not fail to leave its mark on CO<sub>2</sub> emissions. Economic growth in this period slowed down, and due to changes in energy policies, such as rationalizing private consumption of fuels by restricting private car use, CO<sub>2</sub> emissions dropped to about 57 million MTNE in 1975.