Oil Producers, Refiners and Renewable Energy Consumers: Correlation to the Wealth, Competitiveness, Peace and Happiness of Populations

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Abstract
A popular perception suggests that nations with abundant natural resources will ultimately demonstrate stronger economic performance. Studies investigating this perception, however, showed conflicting results.
Fossil energy resources abundance (oil), processing capacity of energy resources (oil refining) and use of renewable energy technology from forty five countries, were correlated with four socio-economic indicators. The indicators included the gross national income (GNI) per capita, the global competitiveness index (GCI), the happiness index and the peace index.
We demonstrated weak correlations between the crude oil production per capita and GNI per capita ($r=0.392$, $p=0.01$) but no correlations were observed between crude oil production and the other indicators. A strong positive correlation was detected between the amount of refined products per capita and GNI per capita ($r=+0.875$, $p<.0001$), GCI ($r=0.602$, $p<0.0001$) and happiness index ($r=0.612$, $p<0.0001$). Strong positive correlations existed between the renewable energy consumption per capita and each of the GNI per capita ($r=0.681$, $p<0.0001$), happiness index ($r=0.611$, $p<0.0001$) and peace index ($r=0.709$, $p<0.001$).
The abundance of oil reserves does not make nations wealthier or happier. Processing of fossil fuels correlate strongly to the wealth and happiness of nations. The utilization of renewable energy technologies is associated with improved economic and social performance.

Keywords: Crude oil production; oil refining; renewable energy; socio-economic indicators

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Introduction

The relation between the abundance of natural resources in a particular nation and its economic growth is an interesting concept in global economy. Popular perceptions suggest that nations with abundant natural resources will ultimately demonstrate stronger economic performance. However, this assumption needed to be scientifically tested. Therefore, several studies have been conducted to test the credibility of this hypothesis. Different studies yielded conflicting results.

Auty (1980) studied the rates of economic development in eight resource rich developing countries and analyzed the factors affecting the economic performance in these countries. Interestingly, he demonstrated that resource rich countries showed slow economic growth. In a larger study, Sachs and Warner (1995) investigated the relation between the economic growth rate and the ratio of natural resources (agricultural, mineral and hydrocarbons) exports to Gross Domestic Product (GDP) in 92 countries from 1970 through 1989. This study also showed a negative correlation between the abundance of natural resources and economic growth (Sachs and Warner, 1995). Using Bayesian Averaging of Classical Estimates (BACE), Doppelhofer et al (2000) analyzed the factors influencing economic growth and found that the amount of exports from mining activities inversely correlated with a nation's economic growth supporting the findings of Sala I Martin (1997). Based on these findings, the term "The curse of natural resources" was coined by Sachs and Warner (2001) who argued that the "curse" cannot be explained by geography or climate.

Advocates of the curse of natural resources have tried to offer reasons behind that strange phenomenon. Sachs and Warner, 2001 showed that several casual and empirical correlations prove the inverse correlation between abundance of natural resources and economic performance. Gylfason (2001) and Stijns (2006) attributed that curse to four factors, namely the Dutch disease; rent seeking, over confidence and neglect of education. The "Dutch disease" is a term used to describe the negative implications of the sudden and dramatic increase in a nation's wealth, a phenomenon that usually occurs after the discovery of vast natural resource reserves or a large increase in the price of a given resource. This results in decline in non-resource exports and an increase in imports. In some natural resource rich countries, rent seeking occurs when the government utilizes all its resources to achieve economic gains (such as aid or grants) from other countries or organizations without creating benefits for its population. Some resource rich nations develop a false sense of economic security, thanks to the abundance of their natural resources. As a result, these governments may fail to adopt good sound economic policies. This overconfidence may also result in less spending on education. The people in resource rich countries tend to engage in low skill intensive occupations related to the exploitation of natural resources.

However, the validity of the" curse" was questioned by Brunnschweiler (2007) who considers that the "curse" might be a misinterpretation resulting from the use of the ratio of primary exports to GDP as resource abundance measures which might yield misleading results. Thus, Brunnschweiler (2007) used the per capita mineral and total

natural resource wealth which he considers a more accurate and representative measure. He correlated it with economic growth during the period 1970-2000 and observed that a statistically significant positive correlation exists between the two parameters. The correlation became highly significant with mineral resources. Lederman and Maloney (2003), using the Leamer's net natural resource exports per worker as a measure of resource abundance, observed a positive effect of natural resources abundance on economic growth. Davis (1995) who used the share of mineral exports in total merchandise exports found a positive correlation between resource abundance and economic growth.

Due to the depletion of fossil fuel resources and the large increase in demand and prices, many countries have focused on the gradual shift towards renewable energy resources to ensure energy independence. The causal relationship between renewable energy consumption and economic growth is intriguing and has been investigated in some studies which yielded different conclusions that can be grouped into four categories. The first category is sometimes referred to as the "feedback hypothesis", whereby renewable energy consumption and economic growth are interdependent and interrelated. The second category is termed the "growth hypothesis", whereby renewable energy consumption is among the factors that result in economic growth. The third category, the "conservation hypothesis", suggests that economic growth causes an increase in renewable energy consumption. The "neutrality hypothesis", however, denies the existence of any causal relationship between renewable energy consumption and economic growth (Omari et al, 2015).

To date, the relation between abundance of natural resources or renewable energy and the nation's economical performance and social status has not been fully understood due to the diversity of economic measures and indicators used in previous studies and the non-homogenous methods of analysis. Therefore, we designed the current study to investigate the relations between three economic enablers, namely crude oil production, refining technology and renewable energy consumption to specific socioeconomic indicators.

Study Methodology:

Data source

In the current study, we derived the economic enablers' data from different sources. The data for crude oil production was derived from the Organization of Petroleum Exporting Countries (OPEC) report: "World Crude Oil Production by Country". The amount of refined products data was obtained from the OPEC's "World Output of Refined Petroleum Products by Country". The renewable energy consumption data was generated from British Petroleum (BP) report: "Statistical Review of World Energy". The population data for various countries presented in the study were obtained from the World Bank and national sources.

Socio-economic indicators

In the current study, we aimed to specifically measure the countries' economic performance, institutional development, population satisfaction and political stability. Although there is no single best indicator to reliably estimate the socio-economic status of a given country, we selected four indicators that we believe will help our specific research question. .

The four indicators are:

I. **Gross national income per capita (GNI per capita) Purchasing Power Parity (PPP):** GNI is defined as the summation of the value of goods produced in that nation, as well as the product taxes collected by the government and the incomes or salaries received by residents from abroad. The GNI per capita is calculated by dividing the gross national income (GNI) of a particular country by its population. We used the World Bank GNI per capita, PPP data for 2013.

II. **Global competitiveness index (GCI)**: GCI is a measure of a country's productivity level determined by analyzing a set of factors related to that country's institutions and policies. Specifically, the GCI is a weighted average of the 12 pillars of competitiveness which include infrastructure, macroeconomic environment, health and education and technological readiness, among others. The results of this analysis are reported as a number ranging between 1 and 7, with 7 being the highest and 1 the lowest. The GCI is estimated for most countries and published as part of the Global Competitiveness Report semiannually by the World Economic Forum (WEF).

III. **World Happiness index:** The world happiness index is a survey that studies a certain population's satisfaction with the prevailing conditions in the country. Specifically, the respondents are asked whether they are "happy with their lives" and not the related concept of emotional happiness. We obtained the happiness index data for the included countries from the "World Happiness Report" by the United Nations Sustainable Development Solutions Network.

IV. **Global Peace index:** The global peace index is an indicator of a country's peace, security and stability. The peace index is determined by three factors, namely the security enjoyed by the population, the country's involvement in internal, regional or international conflicts, and the level of the country's militarization. As the peace index increases, the country becomes less "peaceful". In the current study, we derived the global peace index from the 2014 annual report by the Institute for Economics and Peace. To maintain consistency, we used the inverse of the global peace index. The inverse of the global peace index increases as the country becomes more "peaceful".

Countries selection

Based on OPEC's "World Crude Oil Production by Country", we identified the largest 45 crude oil producers and included them in our study. Similarly, the largest 45 oil refiners were identified and selected based on OPEC's "World Output of Refined Petroleum Products by Country". Using BP's "Statistical Review of World Energy", we identified the largest 45 consumers of renewable energy resources namely wind, geothermal, solar, biomass and waste in 2013 and included them in the analysis.

Data processing and correlations

To achieve accurate measures of the economic enablers, the crude oil production, amount of refined products and renewable energy consumption for each country were divided by the population to express them as per capita values.

The crude oil production per capita for the 45 producers was then correlated with the GNI per capita, the GCI, the happiness index and peace indicator. The amount of refined products per capita for 45 refiners was also correlated with the four socio-economic indicators. We also correlated the renewable energy consumption per capita for the largest 45 consumers with the four socio-economic indicators. Countries for which socio-economic indicators were not available were excluded from the analysis.

Statistical analysis

All of the correlations were performed using Spearman analysis technique with SPSS statistics software (IBM SPSS statistics version 20). For each correlation, the correlation coefficient (r) as well as the p-value was calculated. The criteria for determining the strength of the correlations are based on the guidelines of (Evans 1996), summarized in **Table 1.**

Table 1 Criteria for identifying the strength of the correlation (Evans 1996)

Correlation coefficient	Correlation strength
±0.00-±0.19	Very Weak
±0.20-±0.39	Weak
±0.40-±0.59	Moderate
±0.60-±0.79	Strong
±0.80-±1.0	Very Strong

Results

Oil Production

The crude oil production per capita of the largest 45 producers was first correlated with the four socio-economic indicators, namely GNI per capita, GCI, happiness index and peace index (**Fig. 1).** A significant positive correlation (r=0.392, p=0.01) was observed between oil production per capita and GNI per capita. The correlation

between oil production per capita and GCI was insignificant (r=-0.022; p=0.888). In addition, the correlation between oil production per capita and happiness index was positive though very weak (r=0.144) and insignificant (p=0.364). No correlation could be observed between crude oil production per capita and the peace indicator (**Fig. 1).**

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Oil Refining

The volume of refined products of the largest 45 oil refiners was next correlated with the three socio-economic indicators (**Fig. 2).** A very strong positive correlation was observed between the amount of refined products per capita and GNI per capita (r=+0.875) that is also statistically significant (p<.0001). In addition, strong positive correlations were observed between the amount of refined products per capita and each of the GCI (r=0.602) and happiness index (r=0.612). Both correlations were also statistically significant (p<0.0001).

A moderate positive direct correlation (r=0.520) which was statistically significant (p<0.001) was observed between the amount of refined products per capita and the peace indicator.

Renewable energy

The results of the correlations between renewable energy consumption per capita and the three socio-economic indicators are summarized in **Fig. 3**. Strong positive correlations existed between the renewable energy consumption per capita and each of the GNI per capita (r=0.681) and happiness index (r=0.611). These two correlations are also statistically significant (p<0.0001). The correlation between renewable energy consumption per capita and GCI, however, was moderate (r=0.538) but statistically significant (p<0.0001). A strong positive (r=0.709) statistically significant (p<0.001) correlation was observed between renewable energy consumption per capita and peace indicator.

All correlations are summarized in **Table 2.**

Table 2 Summary of correlations with the socio-economic indicators

	Wealth	Competitiveness	Happiness	Peace
Oil production per capita	Weak Positive	Very weak Negative	Very weak Positive	None
Volume of refined products per capita	Very strong Positive	Strong Positive	Strong Positive	Moderate Positive
Renewable energy consumption per capita	Strong Positive	Moderate Positive	Strong Positive	Strong Positive

The crude oil production per capita of the largest 45 producers was then correlated with both the volume of refined products per capita as well as the renewable energy

consumption per capita **Fig. 4.** The correlation between crude oil production per capita and volume of refined products per capita was positive but weak (r=0.386) and statistically insignificant (p=0.062). A moderate negative correlation was observed between crude oil production per capita and renewable energy consumption per capita (r=-0.549). This correlation was statistically significant (p=0.005).

Discussion:

In the current study, we investigated the relationship between three economic enablers (crude oil production, amount of refined products and renewable energy consumption) and four socio-economic indicators (GNI per capita, GCI, happiness and peace index). We demonstrated weak positive correlations between crude oil production per capita and the socio-economic indicators GNI per capita and happiness for the largest crude oil producers. Thus, our findings do not support the "curse of natural resources" hypothesis which assumes that the abundance of mineral and oil resources has a negative impact on economic development. If such "curse" is valid, it would have been expected to get negative correlations between crude oil production per capita and the economic indicator, GNI per capita, which is not the case in this analysis. Although we found a negative correlation between crude oil production and GCI, such correlation was very weak and not statistically significant suggesting that the abundance of fossil energy resources did not make nations more economically competitive. Our findings do not support the findings of Sachs and Warner (1995), Auty (1980) and Doppelhofer et al (2000) in favor of the "curse of natural resources" assumption.

The lack of strong correlations between crude oil production per capita and the tested socio-economic indicators, however, is an interesting intriguing point. According to popular perceptions, crude oil is an expensive and vital commodity that should bring a large influx of money into the producing nations resulting in economic growth. However, the current study does not provide any evidence that crude oil production may be associated with or stimulate economic growth. The lack of strong correlations between these parameters may be attributed to several factors. First, some oil producing nations do not possess adequate refining capabilities. As a result, these nations are forced to sell their crude oil production to other countries with efficient refining capabilities and then purchase the refined products at a higher price. As has been previously suggested by Gylfason (2001) and Stijns (2006), the abundance of crude oil reserves may provide the governments of resource rich nations with over confidence and a false sense of economic security which prevent these governments from adopting sound economic policies or invest in the countries' infrastructure and projects for people welfare .

In contrast, our study showed strong positive correlations between the quantities of refined products per capita and the socio-economic indicators (GNI per capita, GCI and happiness) implying that nations that posses and invest in refining technology tend to be wealthy and economically competitive with stronger institutions and happier populations. Thus, the possession of knowledge and technology to process hydrocarbons seems more important for economic development than the abundance of

the resource itself. Petroleum refining nations buy crude oil resources at relatively low prices from oil producing nations and then sell the refined products to these nations at a higher price resulting in actual profits. We also detected a statistically significant positive correlation between the amount of refined products per capita and the peace index. Constructing and operating oil refineries requires large investments and research which are more likely available in politically stable nations.

In contrast to the absence of significant correlations between crude oil production and the tested socio-economic indicators, we demonstrated statistically significant strong positive correlations between renewable energy consumption per capita and each of GNI per capita, happiness and GCI. This is an interesting finding although it is not clear whether the country's wealth encourages exploitation of renewable resources or if utilization of renewable energy has a positive economic impact and increases country's wealth. Both speculations seem plausible. The adoption of renewable energy technology requires large investments that can only be provided by a wealthy country capable of meeting its population energy needs through renewable recourses resulting in an ultimate increase in renewable energy consumption. The increased use of renewable energy resources would decrease the demand on expensive imported fossil fuels resulting in cost savings that may be directed to income generating projects.

Apergis and Payne (2010 a) studied the economic growth and renewable energy consumption for thirteen countries in Eurasia by analyzing the economic performance data for these countries over a period of 15 years (1992 to 2007) using GDP, labor force and real gross capital formation as determinants of economic growth. Their results support the "feedback hypothesis" which suggests that renewable energy consumption and economic growth are both interdependent and interrelated. In another study, Apergis and Payne (2010 b) analyzed the economic development and renewable energy consumption in 20 OECD countries during the period 1985 to 2005. They also showed that the "feedback theory" may better explain the causal relationship between the two parameters. Sadorsky (2009) supports the "conservation theory" in his analysis of renewable energy consumption in emerging economies. In this study, Sadorsky concludes that an increase in the income per capita causes a significant increase in renewable energy consumption

However, Menegaki (2011) suggested the "neutrality hypothesis" as he could not detect a relation between renewable energy consumption and economic growth (GDP) when he analyzed the renewable energy consumption in 27 countries in Europe during the period from 1997 to 2007.

We demonstrated a positive, strong and statistically significant correlation between the peace index and renewable energy consumption per capita. To our knowledge, the relation between the two parameters has not been previously studied. Nevertheless, one may speculate that peace and political stability encourage development of extensive industries resulting in higher energy demands. Consequently, non-traditional, cost effective, clean renewable sources of energy are critical. It is also possible to claim that renewable energy consumption fosters political stability and

peace. Renewable energy resources provide a secure energy resource to nations and reduce their economic dependence on fossil fuels that are imported from unstable nations. In other words, this “energy independence” ensures the political stability of a nation and protects it from engaging in international conflicts aimed at securing its energy resource.

Interestingly, correlating crude oil production per capita with renewable energy consumption per capita in the largest crude oil producers, showed a statistically significant negative correlation. It seems that in major oil producers, crude oil still represents a secure and cheap source of energy. Thus, such countries have little incentive to invest in renewable energy resources that require large capital expenditure and new technologies. Furthermore, rich oil producers do not adopt contingency plans for future decline in oil resources.

The current study not only analyzed economic performance but incorporated social indicators that have not been previously analyzed such as the GCI, happiness index and peace index. Thus, our findings provided more insight on the relation of socio-economic status and different economic enablers. Also, we did not restrict our analysis to the crude oil production but we extended it to refining products and renewable energy. However, our study could not ascertain the causal direction between some tested parameters which need future research on more countries.

Conclusions:

The abundance of fossil fuels is not necessarily associated with economic growth, institutional development, happiness and political stability. In fact, other factors are better predictors of social and economic performance. Possession of refining infrastructure and consumption of renewable energy resources are directly correlated with the indices GNI per capita, GCI, happiness and peace index. In oil rich countries, the abundance of fossil fuels hampers the development of renewable energy.

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Figures

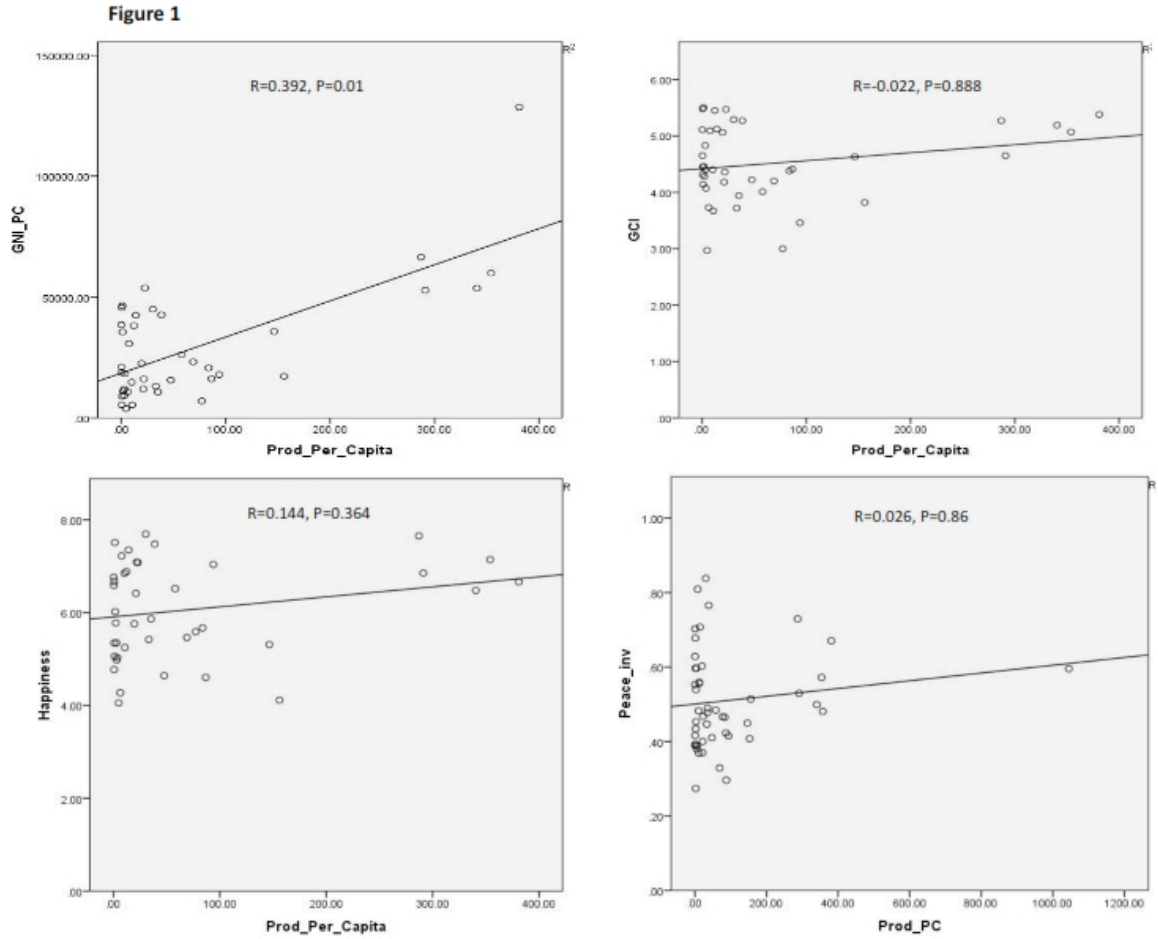

Figure 1: Correlation between crude oil production per capita and the four socio-economic indicators (GNI per capita, GCI, happiness index and peace index). A weak correlation was observed between the crude oil production per capita and GNI per capita (r=0.392, p=0.01) but no correlations were observed between crude oil production and GCI (r=-0.022, p=0.888), happiness index (r=0.144, p=0.364) and peace index (r=0.026, p=0.86).

Figure 2

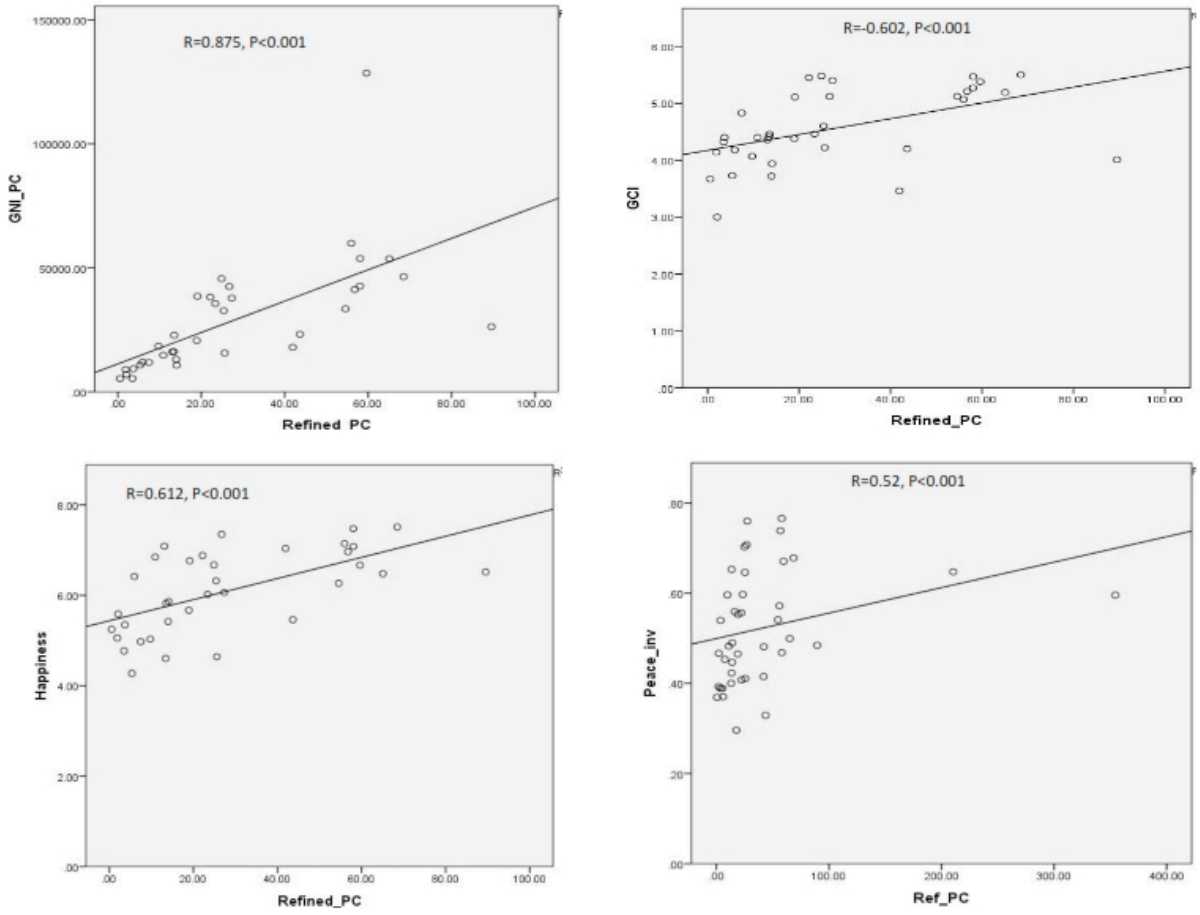

Figure 2: Correlation between amount of refined products per capita and the four socio-economic indicators (GNI per capita, GCI, happiness index and peace index). A strong positive correlation was detected between the amount of refined products per capita and GNI per capita (r=+0.875, p<.0001), GCI (r=0.602, p<0.0001) and happiness index (r=0.612, p<0.0001). A positive direct correlation was observed between the amount of refined products per capita and the peace indicator r=0.520, p<0.001).

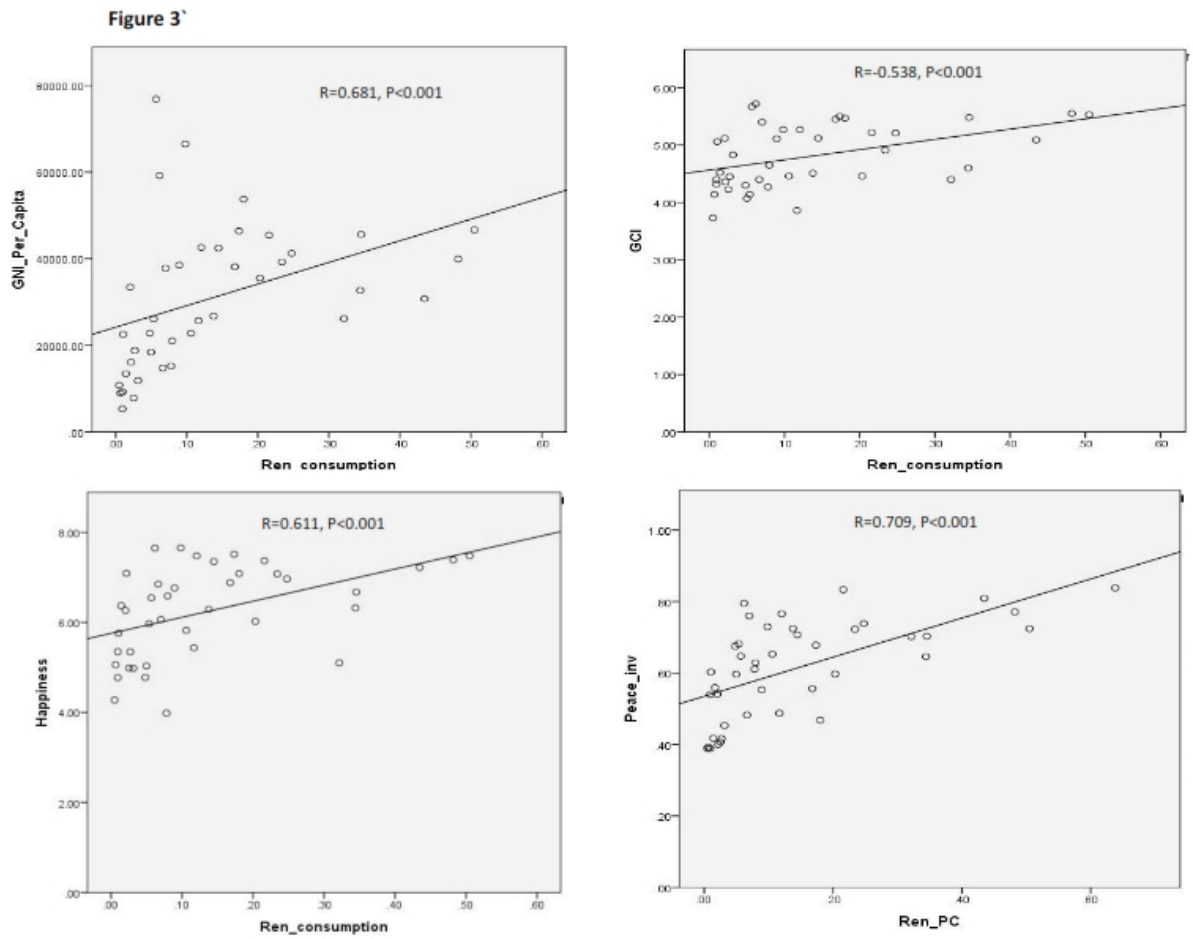

Figure 3: Correlation between renewable energy consumption per capita and the four socio-economic indicators (GNI per capita, GCI, happiness index and peace index). Strong positive correlations existed between the renewable energy consumption per capita and each of the GNI per capita ($r=0.681$, $p<0.0001$), happiness index ($r=0.611$, $p<0.0001$) and peace index ($r=0.709$, $p<0.001$). The correlation between renewable energy consumption per capita and GCI, however, was moderate ($r=0.538$, $p<0.0001$).

Figure 4

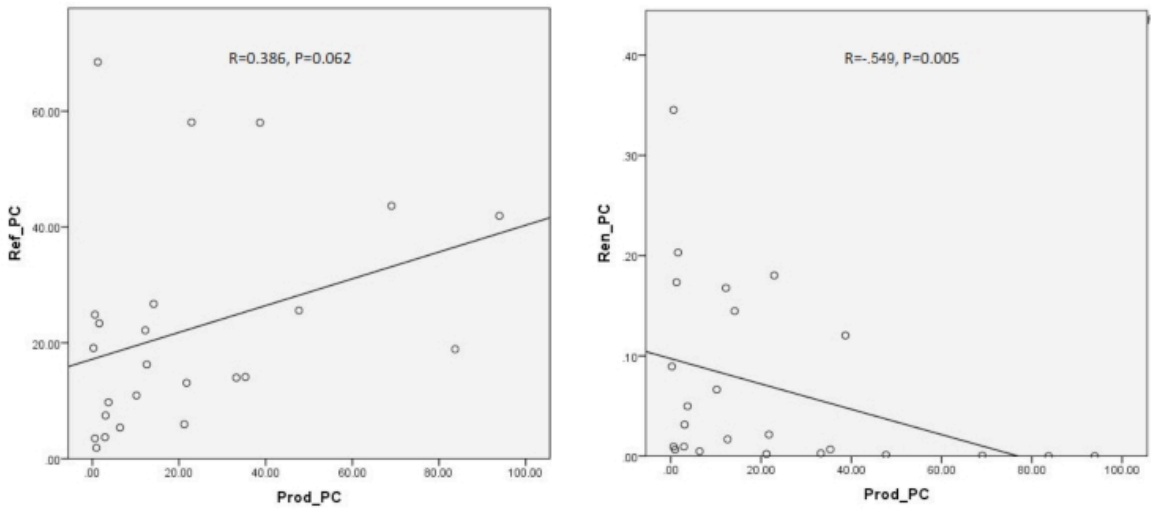

Figure 4: Correlation between the crude oil production per capita of the largest 45 producers and both the volume of refined products per capita as well as the renewable energy consumption per capita A moderate negative correlation was observed between crude oil production per capita and renewable energy consumption per capita (r=-0.549, p=0.005). The correlation between crude oil production per capita and volume of refined products per capita was positive but weak (r=0.386, p=0.062).