Macroeconomic Indicators Used to Study the Efficiency of Investments in Renewable Energy Field

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ABSTRACT
This paper aims to analyze the main indicators used to express the efficiency of renewable energy investments at macroeconomic level. Based on three econometric models, we present the calculation method of these indicators, along with interpretation. In the study are included countries with very high and high human development, member states of the European Union. Results indicate that all countries have a good economic efficiency of investments in renewable energy, but low social efficiency. As for the environmental efficiency of renewable investments, the findings reveal that only six European countries manage to direct their efforts to mitigate carbon dioxide emissions and in this way to have a high environmental efficiency of investments.

KEYWORDS: *renewable energy investments, economic efficiency, ecological efficiency, social efficiency.*

JEL CLASSIFICATION: *C50, C82, E22, O13, O52, Q40, Q43*

INTRODUCTION

Seen as important statistics about different fields of an economy, the macroeconomic indicators are able to provide an overview for those fields. In the same time they are used for conducting economic analysis and for providing reliable forecasts of studied issues.

Generally, economic indicators are classified, if taking into consideration time, into leading, lagging and coincident indicators (IBS Center for Management Research, 2012).

In this study, we use coincident and lagging indicators for calculating some variables used in three macroeconomic models that describe efficiency of investments in the area of renewable energy. The models are subject of a previous work, where they were theoretically presented; the present paper explains the dependent variables of the models, trying to identify generally tendency for countries in European Union. Further investigation will reveal the estimation of the models.

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1. LITERATURE REVIEW

As Fernandez (2010) defines it, an indicator consists of "an information or a group of information contributing to evaluate a situation by a decision maker".

The coincident indicators are the ones that reflect the intensity of an economic activity, as shown in a recent work (Dagnino, 2003). As examples, one can mention: Employment, production, housing activity, retail sales, car sales. Another feature of coincident indicators expresses their correlation with the current level of economic activity (Mongardini & Saadi-Sedik, 2003), as they "occur at approximately the same time as the conditions they signify" (Investopedia, 2007).

The leading indicators, unlike coincident indicators, are described by a correlation with future economic activity. If designing a time axis, changes in leading indicators can be positioned before changes in the economic activities (Sullivan & Sheffrin, 2003). As an example, The growth in monetary aggregates anticipates changes in the financial markets and in the economy (Dagnino, 2003).

The lagging indicators are those indicators that cannot predict a change, but which can confirm the change by confirming the long term trend (Investopedia, 2012). If positioning their changes on the same axis with leading indicators, they occur after the changes in economy as a whole does. For instance one can think of Unemployment, interest rates, labour cost per unit of output and so on.

In this paper, we use for our analysis the following indicators: CO_2 emissions from electricity and heat production (World Bank, 2012a), GDP per capita (World Bank, 2012b), Investments in renewable energy and Human Development Index. Only Investments in renewable energy represent an indicator calculated after the idea mentioned by Scandurra (n.d.), as a ratio between electricity production from renewable sources (kWh) (World Bank, 2012c) and electricity production (kWh) (World Bank, 2012d). The other ones are taken as they are calculated after certain methodology by the World Bank.

Investments in renewable energy represent a lagging indicator, as it monitors the changes in electricity production (this is valid for our case, in which we use a certain method for obtaining investments in renewable energy). GDP per capita and CO_2 emissions from electricity and heat production are coincident indicators. Human Development Index, as a composite indicator, needs the results from other indicators in order to be calculated, so it can be included in the category of lagging indicators. These last three indicators were considered in many studies regarding the energy field (Sheinbaum, Ruíz & Ozawa, 2011; Narayan and Popp, 2012; Hatzigeorgiou, Polatidis & Haralambopoulos, 2011; Tsilingiridis, Sidiropoulos & Pentaliotis, 2011). The interest in relating them to energy, consists in the important role of energy to the other domains. Energy is connected with poverty alleviation, climate changes, development (economic, social, environmental or sustainable) and many other human well being aspects. Among the latest studies that put together this indicators, analyzing them and revealing important aspects to field and decision makers, are the ones of: Openshaw (2010), Ogola, Davidsdottir and Fridleifsson (2012), Oyedepo (2012).

2. FINDINGS

Those three econometric models for describing efficiency of renewable energy investments treated in a previous work are:

$$EfEc_{it} = a_i + b_i \times RC_{it} + c_i \times CG_{it} + d_i \times EG_{it} + \varepsilon_{it} \quad (1)$$

$$EfE_{it} = a_i + b_i \times GI_{it} + c_i \times CE_{it} + d_i \times EG_{it} + \varepsilon_{it} \quad (2)$$

$$EfS_{it} = a_i + b_i \times G_{it} + c_i \times CE_{it} + d_i \times EG_{it} + \varepsilon_{it} \quad (3)$$

Where: $EfEc_{it}$ represents the index of economic efficiency of investments in renewable energy;

EfE_{it} represents the index of ecological efficiency of investments in renewable energy;

EfS_{it} represents the index of social efficiency of investments in renewable energy;

RC_{it} represents the renewable energy consumption;

CG_{it} represents the CO_2 emissions released to obtain a unit of GDP;

EG_{it} represents the energy intensity;

GI_{it} represents the GDP per unit of investment;

CE_{it} represents the CO_2 intensity;

G_{it} represents GDP per capita; i represents the number of cross-sections, t is the period of time for which the analysis is made, ε_{it} is the error term, a_i is the intercept, which can vary within each cross-sectional unit, b_i ,c_i ,d_i are the coefficients to be estimated for the independent variables.

All three models are based on previous studies of other authors (Bruns & Gross, 2012).
The three independent variables were created to highlight the efficiency of investments in renewable energy at macroeconomic level. All variables include Investments in renewable energy for highlighting the efforts. The effects are revealed through GDP per capita, HDI and CO_2 emissions. Values for these indicators are included in table 1, for 2008 and 2009, where possible.

Table 1. Indicators used in econometric models

	GDP per capita		***HDI***		***CO_2 emissions***	
	2008	2009	2008	2009	2007	2008
Bulgaria	2660.986	2527.317	0.765	0.766	31.42	31.35
Romania	2844.642	2606.873	0.778	0.778	46.72	45.34
Portugal	11949.13	11590.61	0.802	0.805	22.08	20.92
Poland	6235.755	6331.607	0.804	0.807	174.01	166.79
Hungary	5947.158	5551.426	0.811	0.811	20.72	19.93
United Kingdom	29106.97	27646.02	0.86	0.86	234.64	227.36
Greece	14647.74	14114.24	0.862	0.863	51.66	49.86
Italy	19903.46	18785.01	0.871	0.87	160.05	164.52
Spain	16264.62	15538.79	0.871	0.874	135.78	119.65
Finland	28789.54	26258.49	0.883	0.877	33.29	27.01
France	23432.75	22667.89	0.879	0.88	71.58	69.65
Austria	27295.13	26166.22	0.876	0.879	23.54	23.63
Denmark	32320.1	30272.22	0.891	0.891	26.36	24.24
Sweden	32798.73	30838.51	0.9	0.898	10.11	10.48
Germany	25620.08	24368.2	0.902	0.9	385.25	363.28
Ireland	30130.39	27813.89	0.909	0.905	5.1	5.04
Netherlands	27348.47	26245.91	0.904	0.905	68.55	68.01

Source: World Bank (2012)

The order of presentation for all seventeen countries is not a random one, but dictated by HDI values in 2010. Only the first two countries are considered with high human development. The other fifteen are in the category of Very high human development.

If considering CO_2 emissions from electricity and heat production, we can observe the biggest polluters in European Union: Germany, United Kingdom, Italy and Spain.

Returning to the Investments in renewable energy, we will trace its tendency over the period 2000-2009 for countries in European Union in the next two figures. We used two figures in order to separate countries with smaller values obtained for Investments in renewable energy and those with greater values. It is important to understand these values not as higher investments or smaller investments, because the method of calculation was dividing electricity production from renewable sources to electricity production. It appears that by obtaining the renewable energy contribution to the total production, we indirectly express the amount of investments that conducted to that renewable production, even if is revealed as a percentage.

For instance, Belgium produced in 2009, 5439 million Kwh of electricity from renewable sources, from a total of 89796 million Kwh. This means that it has a percentage of renewable electricity in total electricity production of 0.0605%. Bulgaria produced in the same year a total of 3718 million Kwh renewable energy (less than Belgium) from a total of 42383 million Kwh. However, the percentage of renewable electricity in total electricity production is of 0.087% for Bulgaria. So, a greater percentage does not necessarily indicate a greater value for renewable investments. It can hide a greater electricity production and also a higher renewable electricity production. To conclude, the indicator Investments in renewable energy only shows the evolution of investments in a country and not the amount really invested to obtain production.

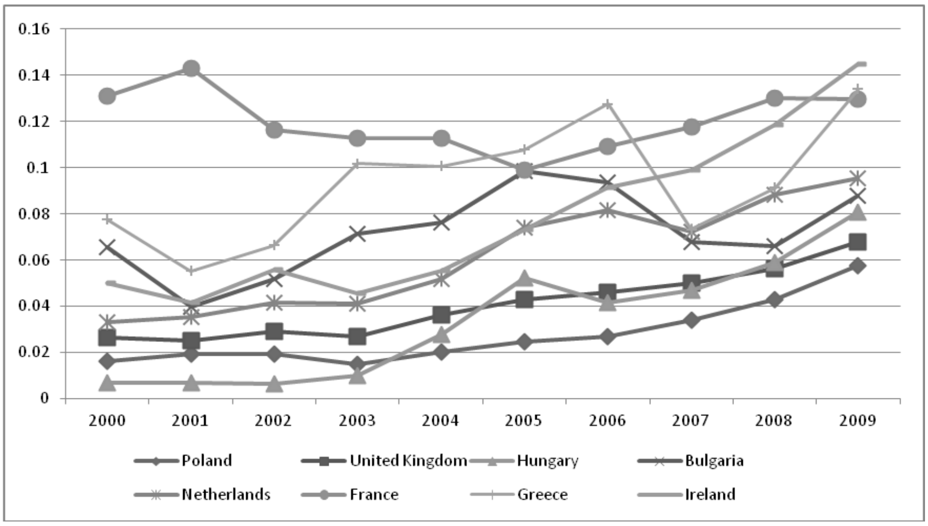

Figure 1a. The evolution of Investments in renewable energy for countries in EU
Source: authors after World Bank (2012c; 2012d)

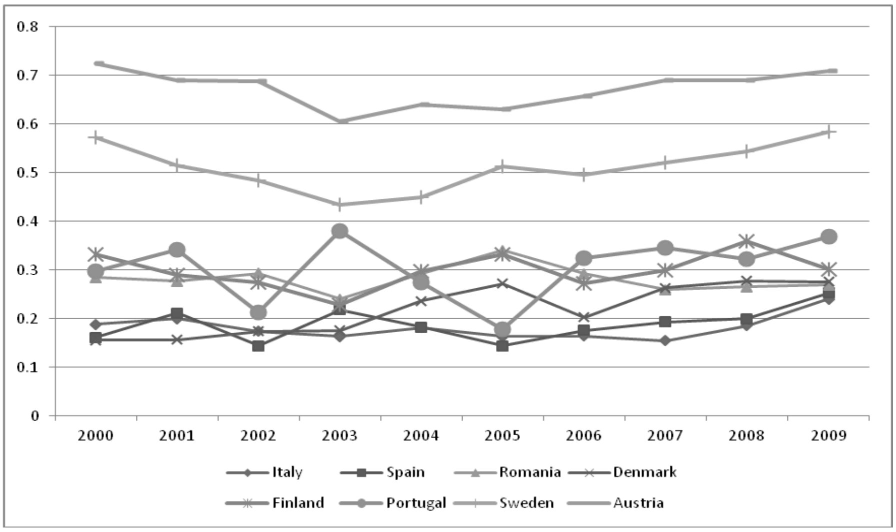

Figure 1b. The evolution of Investments in renewable energy for countries in EU
Source: authors after World Bank (2012c; 2012d)

The index of economic efficiency of investments in renewable energy, denoted by $EfEc_{it}$ is calculated as a ratio between GDP per capita and renewable energy investments indicator. The index of ecological efficiency of investments in renewable energy, EfE_{it} is calculated as a ratio between the level of emissions and the level of investments. The social efficiency of investments index, EfS_{it} ,is calculated as a ratio between the value of HDI_{it} and the value of renewable energy investments. One can observe that in each efficiency index, the efforts are expressed through the level in investments. The values for these three indices are presented in Table2.

Table 2. Efficiency indices for European Union's countries

	$EfEc_{it}$		EfE_{it}		EfS_{it}	
	2008	2009	2007	2008	2008	2009
Bulgaria	402.7068	288.0992	4.618557	4.7444277	0.115773	0.087319
Romania	107.2785	96.78096	1.800401	1.70988449	0.02934	0.028883
Portugal	371.1838	313.5567	0.638466	0.64985197	0.024913	0.021777
Poland	1460.39	1102.476	50.88599	39.0615817	0.188294	0.140517
Hungary	1009.907	688.5686	4.397086	3.38437951	0.137719	0.100592
United Kingdom	5186.95	4076.976	46.91535	40.5162452	0.153255	0.126825
Greece	1602.641	1053.507	7.051916	5.45529099	0.094313	0.064416
Italy	1072.909	781.2483	10.33866	8.86855636	0.046952	0.036182
Spain	812.1632	614.6494	7.039253	5.97464635	0.043493	0.034572
Finland	801.491	872.3616	1.112899	0.75194908	0.024582	0.029136
France	1803.233	1745.216	6.076117	5.35981346	0.067642	0.067752
Austria	395.3358	368.4529	0.341122	0.34225098	0.012688	0.012377
Denmark	1163.663	1095.124	0.9992	0.87274481	0.03208	0.032233
Sweden	603.9277	527.8298	0.194323	0.1929697	0.016572	0.01537
Germany	1790.665	1520.342	27.6987	25.3907422	0.063044	0.056151
Ireland	2541.421	1920.391	0.515624	0.42511119	0.076672	0.062485
Netherlands	3089.115	2749.136	9.509108	7.68198998	0.10211	0.094794

Source: authors' calculation

3. DISCUSSION

The interest in developing new renewable energy capacity production in European Union, is revealed by the increasing trend of Investments in renewable energy. Since 2006 till 2009, with few exceptions, this trend was an upward one; as for the 2000-2005 period the indicator had an alternating tendency for most countries.

The efficiency indices support the idea of investments efficiency at macroeconomic level and their interpretation could be as it follows. All indices refer to a specific dimension in which investments contribution is reflected as economic, social and environmental benefits. Therefore, the economic efficiency index $EfEc_{it}$ reflects the economic effects obtained as a consequence of investing in renewable energy. We are interested in high values of this index, like those of Poland, United Kingdom, France, which record more than 1000 US$ (GDP per capita) to a unit of investments in renewable energy in 2009.

The same interpretation could be given to the social efficiency index EfS_{it} where the social effects need to be as great as possible, to overcome the values of investments. Measured by HDI, these effects have a sub unitary value; the investments, expressed as a percentage, have also sub unitary values, so the ratio calculated between them should be above unit to indicate high efficiency. Unfortunately, there is no situation that could indicate high social efficiency of renewable energy investments. These values hide high values for HDI and small values for investments. Therefore, the other countries experience the situation of a great amount of investments, for which the propagated effects are not felt yet.

In the case of environmental efficiency index EfE_{it}, one must consider that the effects are represented by CO_2 emissions, for which ideal would be to decrease over time. So, smaller effects in this situation are to be obtained if investing in renewable energy. This is one of the many reasons for treating sources of green energy as important link in the process of climate change effects mitigation. Considering all this facts, the environmental efficiency index can indicate great efficiency if registers small values. In 2008, there are six countries with high environmental efficiency of investments: Portugal, Finland, Austria, Denmark, Sweden and Ireland.

It is obvious that these findings have some limits, according to the method of calculation. For instance, if for expressing the effects in all these indices, we use other indicators, then the results will change.

CONCLUSIONS

This paper represents a part of a larger analysis for investments efficiency. Understanding the indicators implied in the proposed analysis, facilitates the understanding of the econometric models that are to be further developed and estimated. In this study, the economic, social and environmental impact of renewable energy was implied. In the same time, the study offers a way to evaluate the development of renewable energy investments. By calculating efficiency indices, it results that all countries included in the analysis are characterized by economic efficiency of renewable energy investments. From a social point of view, the investments taken into consideration are giving low efficiency. The last aspect, the one regarding environment and the associated efficiency of investments state that greater pollutant countries should not delay the investments in green energy, because in this way they would not delay their positive effects. There still are many countries among these included in the analysis, that have low environmental efficiency when investing in renewable energy. It remains though the question about to what extent could a country simultaneously meet all three levels of efficiency.

Even though, new fossil fuel resources are continuously being discovered (for instance in Black Sea new resources of natural gas which will ensure energetic autonomy for Romania for at least 35 years), we consider that the future belongs, without any doubt, to renewable energy. This fact is important, as the consumption of this type of energy has no negative effect on the environment. In fact, starting in mid last century we can see a steady increase in renewable energy consumption, both nationally and globally.

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