Growth and natural resources: A meta-analysis contribution to the Energy–GDP causality and energy scarcity dialogue

Panos Kalimeris[1] **Kostas Bithas**
Research Team of Environmental Economics and Sustainable Development, Panteion University, 14 Aristotelous str, PC: 17671, Kallithea, Athens, Greece.

Abstract
The relationship between energy consumption and economic growth expressed in terms of gross domestic product (GDP), and the policy implications of the empirical and econometric findings have been extensively examined within the energy policy and resources economics research. The literature on the causal relationship between energy consumption and economic production dates back to the late '70s with the pioneering work by Kraft and Kraft in 1978, initiating an ongoing debate which counts more than 172 research papers since 2011 and covers various energy sources and energy measurement methods, different methodological approaches, several spatial levels (cities, countries and group of countries, etc) with various results about the existence of causality or not among variables. The main aim of present study is to review the studies of the Energy-GDP causality debate through a systematic Meta-analysis based on contemporary methods originated from operational research and multinominal logistic regression analysis. This is the first time, to our knowledge, that the meta-analysis tool has been applied as an alternative method of revealing the core of energy and GDP causal relationship.. The results of the meta-analysis application could be seen as one dimension of the critical question: can we possibly continue to assume that our economic growth engine will continue to grow, to serve the growing needs of an increasing population, taking into account with natural resources availability and scarcity and the technological advance?

Keywords
Energy consumption, Granger Causality, Rough set data analysis, Multinomial logistic regression, energy scarcity

1. Introduction
There has been a growing literature over the last three decades on the causal relationship between energy consumption and economic growth, measured in terms of GDP. This continuous debate on causality has produced more than 172 research papers. The causality debate presents a wide variety of approaches focusing on different countries, groups of countries or even parts of a country, employing different econometric methodologies, over various time periods and using different proxy variables. The direction of the causal relationship between energy consumption and economic growth can be grouped into four distinct categories, according to Ozturk (2010) and Payne (2010):

- **Neutrality hypothesis or no causality (E≠GDP):** no causality exists between GDP and energy consumption. It implies that energy consumption is not correlated with GDP growth.
- **Conservation hypothesis (GDP→E):** unidirectional causality running from GDP to energy consumption. It implies that GDP growth causes energy consumption.
- **Growth hypothesis (E→GDP)**: unidirectional causality running from energy consumption to GDP. It implies that energy consumption causes GDP growth.

[1] Corresponding author, presenter. Tel +30 2109249883. e-mail: pkalimeris@eesd.gr

- **Feedback hypothesis (E↔GDP) or bi-directional causality**: a bi-directional causality which flows between GDP and energy consumption. Both energy consumption and GDP growth cause each other.

The empirical findings on the energy consumption-economic growth nexus have resulted in mixed and sometimes conflicting results. These contradictions raise some very important questions (Beaudreau, 2010). Could the selected methodology be flawed? Or could the choice of variables be flawed? In the present work we survey the literature on the energy-growth causal relationship for the period 1978-2011. The purpose of this paper is dual: first, to give an integrated survey of the empirical literature on the energy-growth nexus since 2011 and, second, to examine these results with contemporary meta-analysis methods (rough set data-analysis and multinomial logistic regression analysis). The paper is organized as follows: Section 2 reviews the relevant causality debate literature from 1978 to 2011; Section 3 analyses the rough set meta-analysis methodology, application and estimated results; Section 4 describes the results of a multinomial logistic regression analysis; and, finally, Sections 5 and 6 present further discussion and the overall concluding remarks.

2. Literature review of causality debate between energy consumption and economic growth

The present study bases its literature review mainly on two previous literature surveys on the energy-GDP causality debate (Ozturk, 2010; Payne, 2010) as well as on personal research by the authors. The relevant literature can be categorized in various ways. We can condense the main common characteristics of energy-growth causality studies into five distinct categories:

- *Time period examined*. Some studies examine a very short period of time, up to 10 years (Sari et al., 2008; Abosedra et al., 2009), others examine a period between 10 and 40 years (Kraft & Kraft, 1978; Erol &Yu, 1987; Chang et al., 2001; Chontanawat et al., 2006), and many studies examine a period of 40 years or more (Stern, 1993; Cheng, 1999; Aqeel & Butt, 2001; Soytas & Sari, 2003; Jianhua & Zhaohua, 2011).

- *A single country or a group of countries is examined*. Countries may be grouped according to their economic status (Soytas & Sari, 2006; Acaravci and Ozturk, 2010; Apergis and Payne, 2010; Belke et al., 2011), geographical criteria (Narayan and Smyth, 2009; Mishra et al., 2009; Esso, 2010), their energy imports and exports profile (Mahadevan and Asafu-Adjaye, 2007; Squalli, 2007) or other country unions and trade agreements (Al-Ariani, 2006; Apergis and Payne, 2009, 2010). There are also studies referring to former country unions (Reynolds and Kolodziej, 2008) and separate parts, or economic sectors of a country. (Wolde-Rufael, 2004; Ho and Siu, 2007; Zhixin and Hin, 2011)

- *Methodology.* A broad variety of methodological approaches has been implemented in order to reveal the presence of causality between energy consumption and economic growth and in which direction this causality operates. These approaches can be classified into three broad classes (Beaudreau, 2010): early tests, cointegration tests and post-cointegration tests. Since the very beginning of the causality debate and until the mid-1990s, most studies (Kraft & Kraft, 1978; Yu & Hwang, 1984; Erol &Yu, 1987; Nachane et al., 1988; Abosedra & Baghestani, 1991; Stern, 1993) used a methodology generally based on both Granger (Granger, 1969) and Sims (Sims, 1972) econometric tests of causality, including the modified Engle-Granger causality test (Engle and Granger, 1987) and Hsiao's Granger causality test (Hsiao, 1981). In the 1990s the causality debate was enhanced by new methodological approaches (Johansen and Juselius, 1990) based on the cointegration method (Masih & Masih, 1996; Cheng, 1999; Stern, 2000; Yoo, 2005) and other alternatives such as Toda-Yamamoto causality tests (Toda and Yamamoto, 1995;

Fatai et al., 2002; Wolde-Rufael, 2005), Pedroni panel cointegration ((Pedroni, 1999; Lee, 2005; Mahadevan & Asafu-Adjaye, 2007; Costantini & Martini, 2010), ARDL bounds test (Shin et al., 2001; Fatai et al., 2002; Zachariadis, 2007; Ghosh, 2009; Ozturk & Acaravci, 2011) and more than 12 other methods (Thoma, 2004; Chiou-Wei et al, 2008; Belke et al., 2011).

- *Energy source type*. Various types of energy inputs have been examined in the energy-GDP causality debate. We can divide the literature into groups of studies estimating energy inputs contributions from fossil fuels at aggregate and disaggregate levels (Yoo, 2006; Zou & Chau, 2006; Narayan and Wong, 2009), electricity consumption (Ramcharran, 1990; Ghosh, 2002; Thoma, 2004; Zachariadis & Pashourtidou, 2007), nuclear energy consumption (Yoo & Jung, 2005; Payne and Taylor, 2008; Wolde-Rufael, 2010), renewable energy consumption (Tiwari, 2011), exergy approach (Warr et al., 2010) and divisia index of quality weighted energy consumption (Stern, 1993; Zarnikau, 1997; Stern, 2000).

- Four distinct types of direction of causality results can be described:

1. The **neutrality hypothesis** as documented by Akarca and Long (1980), Yu and Hwang (1984), Yu and Choi (1985), Erol and Yu (1987), Yu et al. (1988), Yu and Jin (1992), Cheng (1996), Masih and Masih (1996), Glasure and Lee (1997), Fatai et al. (2002), Soytas and Sari (2003), Altinay and Karagol (2004), Chontanawat et al. (2006), Jobert and Karanfil (2007), Lee (2006), Soytas et al. (2007), Zachariadis (2007), Chiou-Wei et al. (2008), Karanfil (2008), Yuan et al. (2008), Chontanawat et al. (2009), Halicioglu (2009), Payne (2009), Soytas and Sari (2009), Wolde-Rufael (2009), Acaravci & Ozturk (2010), Yoo & Kwak (2010), Payne & Taylor (2010), Payne (2011a.), Yanqin (2011).

2. The **conservation hypothesis** has empirical support from Kraft and Kraft (1978), Abosedra and Baghestani (1989), Masih and Masih (1996), Cheng and Lai (1997), Cheng (1998, 1999), Soytas et al. (2001), Aqeel and Butt (2001), Soytas and Sari (2003), Soytas and Sari (2006), Lee (2006), Zachariadis (2007), Zamani (2007), Mehrara (2007), Lise and Van Montfort (2007), Lee and Chang (2007b), Chiou-Wei et al. (2008), Ang (2008), Zhang and Cheng (2009), and Wolde-Rufael (2009), Chih Chang (2010), Ozturk et al. (2010), Lean & Smyth (2010), Costantini & Martini (2010), Esso (2010), Kumar (2011), Chih Chang et al. (2011).

3. The **growth hypothesis** is supported by empirical findings in Stern (1993), Masih and Masih (1996), Glasure and Lee (1997), Stern (2000), Asafu-Adjaye (2000), Soytas and Sari (2003), Wolde-Rufael (2004), Thoma (2004), Lee (2005), Lee and Chang (2005), Soytas and Sari (2006), Lee (2006), Lee and Chang (2007b), Ho and Siu (2007), Climent and Pardo (2007), Ang (2007), Narayan and Smyth (2008), Chiou-Wei et al. (2008), Wolde-Rufael (2009), Odhiambo (2009), Tsani (2010), Magazzinno (2011), Fatros & Maabudi (2011), Heo et al. (2011), Alam et al. (2011), Tiwari (2011), Jianhua & Zhaohua (2011), Zhixin & Xin (2011), Arifin & Syahruddin (2011).

4. The **feedback hypothesis** is documented by Hwang and Gum (1991), Masih and Masih (1996,1997), Asafu-Adjaye (2000), Yang (2000), Hondroyiannis et al. (2000), Glasure (2002), Soytas and Sari (2003), Paul and Bhattacharya (2004), Oh and Lee (2004a, 2004b), Ghali and El Sakka (2004), Soytas and Sari (2006), Lee (2006), Zachariadis (2007), Mahadevan and Asafu-Adjaye (2007), Erdal et al. (2008), Belloumi (2009), Mishra et al. (2009), Wolde-Rufael (2009), Apergis & Payne (2010), Belke et al. (2011), Kahsai et al. (2011), Eggoh et al.(2011), Shuyun & Donghu (2011), Kouakou (2011).

The literature survey reveals more than 172 studies. However, due to lack of the specific data required, accessibility and other reasons, we used 158 studies in our meta analysis (further details in Section 3).

To sum up, although the literature on the relationship between energy consumption and economic growth is quite vast, it provides mixed results and fails to reach a consensus as far as the direction of causality considered. Under these conditions, the present study tries to reveal the core of the causality debate by using the alternative approach of rough set meta analysis and a multinomial logistic regression method, for the first time in the history of this ongoing dialogue.

3. Methodology analysis.

The present paper tries to evaluate the contribution of the causality debate by testing the reliability of used methods and derived results under a meta-analysis re-examination. According to Glass (1976), meta-analysis is the statistical analysis of the results of a large collection of analyses for the purpose of integrating their findings (analysis of the analyses). A meta-analysis establishes the presence of an effect and could be a valuable tool for resolving differences in a debate or determining important moderators of an effect (De Coster, 2004). In other words, the basic purpose of meta-analysis is to provide the same methodological rigour to a literature review that is required from experimental research. According to Hawcroft and Milfont (2010), the procedure of meta-analysis can be described in three steps: (1) a search for studies (the database), (2) selection of studies that meet criteria for inclusion in the meta-analysis and, (3) coding of relevant study attributes. Following all of the above, special focus will be given to the way that our dataset is organized. For the 158 studies comprising our database, the following 8 categories (attributes) are recorded:

- The year of publication
- The time series period that is being examined
- The econometric method utilized to answer the question of causality
- A single country or a group of countries is being examined
- The wealth categorization of the country or group of countries
- The type of energy input
- The energy measuring method
- The causality direction of the result (the decision attribute)

Because of this categorization of attributes, we excluded some studies from the initial sample of more than 172 studies. Among the exclusions are literature reviews (Ozturk, 2010; Payne, 2010), special view points (Karnafil, 2009; Beaudreau, 2010) and a few studies that failed to give substantial input for the requisite categories (Suri, 1998; Holtedahl and Joutz, 2004; Adams and Shachmurove, 2008), or studies lacking accessibility to further details of the research beyond the study's abstract. Furthermore, we excluded studies or parts of studies examining other variables (e.g. causality between employment and GDP, employment and energy consumption etc). However, studies estimating the causality among a specific industry sector and relevant industrial production, business cycle or economic structure (Thoma, 2004; Ziramba, 2009; Feng et al., 2009) instead of GDP, are included in our estimations as part of the specified country. Variations in usage of GNP instead of GDP in earlier studies are considered as the same variable in our analysis, since the majority of the studies use GDP. Hence, it is our concern that the categorization of relevant studies according GDP and GNP is meaningless in the present meta-analysis set. Another element excluded from the meta-analysis was the distinction between causality results in the short run and the long run. Distinctions between periods were estimated only in a few studies (Apergis & Payne, 2009b; Belloumi, 2009; Ciarreta & Zarraga, 2009; Magazzinno, 2011; Ozturk & Acaravci, 2011; Alam et al., 2011; Zhixin & Xin, 2011) and for these we take into account only the results of the short run period. Studies which estimate causality for a group of countries are broken down into its component countries. The category "*single country or a group of countries*" was created for those studies where this separation was not possible.

Our research emphasizes the fundamental issue of causality, focusing on the direction of causality (or the lack of any relationship between GDP and Energy consumption). One advantage of meta-analysis is the investigation of the credibility of different methods and results, and the critical synthesis of them into an overall picture of the whole debate contribution. The Meta Analysis tool we apply is the Rough Set Data Analysis (RSDA) method which is further presented in the next section. The model used in the present study can be described in three general stages:

1. Data preparation (Data Coding)
2. Rough Set Analysis (Data Reduction, Rules Generation)
3. Validation of the results (Choise of Decision rules that better explain the dataset)

A forth stage of a multinomial logistic regression was applied in order to further investigate the strength of each attribute's contribution to the causality results.

3.1 Data preparation: coding attributes for Rough Set Data Analysis (RSDA)

In this section we analyze the method we used for preparing the dataset coding, thus we further discuss the first step presented in the previous section. We selected RSDA mainly because it is a simplified method used to discover information overlooked by other methods, to preprocess the data for further studying and to strengthen results previously found by other methods (Rupp, 2005). RSDA has been developed as an alternative data mining tool by Pawlak (1982, 1991) and further developed by Slowinski (1993). A rough set is a set for which it is uncertain in advance which objects belong precisely to that set. Rough set theory takes for granted the existence of a finite set of objects for which some information is known in terms of factual (qualitative or numerical) knowledge on a class of attributes (features, characteristics) (Bithas and Nijkamp, 1997a, 1997b). The rough set model is intended to be a structural, non-numerical method of information analysis, thus its quantitative aspects are of secondary interest (Duntsch and Gediga, 1998). Table 1 (see Appendix A) represents the "raw data", the coding of our dataset. The dataset of 158 studies produced 686 cases. The Table 1 interpreted as follows: first column includes the unique number ID of each examined case. Second column is a brief reference of the relevant case study (e.g. name of the author/s and year of publication). Columns 3-10 describe the examined attributes concerning our cases. Last column d (decision), contains the decision variable, thus, the causality estimation for each case. The attributes and the decision variable respectively examined in following sub-sections.

3.1.1 Year of study publication

The coding of the attribute "*year of study publication*" is explained in Table 2 (see Appendix A). We divided publication years into four distinct categories: 1. 1970s, 2. 1980s, 3. 1990s and 4. 2000-2011 period. Table 1 presents only the coded value of the time period, thus 1,2,3 or 4.

3.1.2 Examined time period

The coding of the attribute "*examined time period*" is explained in Table 3 (see Appendix A). Six distinct categories were used: 1. Less than 10 years, 2. between 10-20 years, 3. between

20-30 years, 4. between 30-40 years, 5. More than 40 years and 6. No period defined. Table 1 presents only the coded value of the examined time period, thus 1, 2,3,4,5 or 6.

3.1.3 Country categorization

The coding of the attribute "*country categorization*" is explained in Table 4 (see Appendix A). Countries are categorized into 5 groups: 1. G7 member countries, 2. OECD member countries, 3. Non-OECD High Development Countries, 4. Other non-OECD countries, 5. Part (city or region) or Economic Sector of a country. Table 1 presents only the coded value of the country categorization, thus 1,2,3,4 or 5.

3.1.4 Methodology

The coding of the attribute "*methodology*" is explained in Table 5 (see Appendix A). Methodology was categorized into 6 distinct groups, described briefly as: 1. Sims & Engle-Granger Causality, 2. Johansen-Juselius, 3. Toda-Yamamoto Causality, 4. Pedroni Panel Cointegration, 5. ARDL Bounds test and 6. Others. Table 1 presents only the coded value of the methodology categorization, thus 1,2,3,4, 5 or 6.

3.1.5 Energy type

We examined each energy type separately in order to test causality results among different energy source inputs. The coding of the attribute "*energy type*" is explained in Table 6 (see Appendix A). The energy types examined in the causality debate are categorized into 9 distinct types: 1. Total fossil fuels consumption (Coal, Oil, Gas), 2. Electricity consumption (or production), 3. Energy consumption per capita (primary or electricity etc), 4. Total energy consumption (primary fuels+electricity), 5. Oil or petroleum consumption (or production), 6. Coal consumption (or production), 7. Gas consumption (or production), 8. Nuclear energy consumption (or production) and 9. Renewables energy consumption. Table 1 presents only the coded value of the methodology categorization, thus 1, 2, 3,4, 5, 6, 7, 8 or 9.

3.1.6 Energy measurement method

The way in which energy is measured is a crucial issue in the relationship between energy consumption, useful work and economic growth (Kaufmann, 1992; Warr et al., 2010; Stern, 2011). Since the causality debate plays a very important role in energy policy decisions, this attribute can be considered to be a significant component of our meta analysis study. The coding of the attribute "*energy measurement method*"is explained in Table 7 (see Appendix A). The energy measurement methods used in the causality debate are categorized into 9 distinct types: 1. Btu's, 2. Oil equivalent, 3. Electricity (watt), 4. Coal equivalent, 5. Exergy, 6. Crude quantity, 7. Devisia Index, 8. Joule and 9. Not defined (for those studies that do not specify the unit of measurement of energy). Table 1 presents only the coded value of the energy measurement method, thus 1, 2, 3,4, 5, 6, 7, 8 or 9.

3.1.7 Single country or group of countries

The coding of the attribute "*Single country or group of countries*" is explained in Table 8 (see Appendix A). This categorization created for those studies could not been managed as individual countries causality estimations. The dataset divided into two distinct categories: 1. Single country, if the estimated causality result referred to one sinle country and, 2. Group of countries, if the estimated causality result referred to an overall group of countries. Table 1 presents only the coded value of this category, either 1 or 2.

3.1.8 Decision variable coding. The causality results

The decision variable in present study is the causality result. The coding of the decision variable is explained by Table 9 (see Appendix A). As we defined in Section 1, the causality results can be divided into four distinct categories: 1. Growth hypothesis ($E \rightarrow GDP$), 2. Conservation hypothesis ($GDP \rightarrow E$), 3. Feedback hypothesis ($E \leftrightarrow GDP$) and, 4. Neutrality hypothesis or No causality ($E \neq GDP$). Table 1 presents in its final column only the coded value of the decision variable, thus 1, 2, 3 or 4.

3.2 RSDA Analysis

In order to analyze data successfully with RSDA, a decision table must be created. This expresses all the knowledge about the model. In our case, the decision table, containing all the attributes and the decision attribute, is given by Table 1 (see Appendix A). A crucial step is the decision table coding which has been described extensively in the previous section. Rough set analysis of the data is used to obtain preliminary information. For this purpose we used the Rosetta Rough Set Toolkit (Øhrn and Komorowski, 1997) which offers a wide range of "ready to apply" statistical tools and filters. After the decision table has been defined and coded, any objects with incomplete values must be removed. As we have no such objects, we proceed to the next step. The decision table is unnecessarily large in part because it is redundant. The same or indistinguishable objects may be represented several times. This requires the reduction of repeated attributes. The rejected attributes are redundant since their removal cannot worsen the decision attribute values (classification). Computing reducts is rather a complex procedure. Fortunately, there exist good heuristics based on genetic algorithms (Komorowski et al., 2002) that compute sufficiently many reducts by using the Rosetta Toolkit. The discernibility procedure of a genetic algorithm produces a set of minimum attribute subsets that define functional dependencies. An example of the discernibility function is given below:

f(6) =
*(A3 Country + D Causality results) **
*(A2 time period + A3 Country) **
*(A2 time period + A5 Energy Category + A6 Energy Measurement) **
*(A1 Year of publication + A5 Energy Category + A6 Energy Measurement) **
*(A1 Year of publication + A6 Energy Measurement + D Causality results) **
*(A1 Year of publication + A3 Country + A6 Energy Measurement) **
*(A1 Year of publication + A4 Methodology + A6 Energy Measurement) **
*(A1 Year of publication + A4 Methodology + A5 Energy Category + A7 Single or group of countries + D Causality results) **
(A1 Year of publication + A2 time period + A4 Methodology + D Causality results)

end

A part of the reducts generated from the data analysis is shown in Figure 1 below:

	Reduct
1	{A1 Year of publication}
2	{A1 Year of publication, A2 time period, A3 Country}
3	{A1 Year of publication, A2 time period, A5 Energy Category}
4	{A2 time period, A3 Country, A6 Energy Measurement}
5	{A1 Year of publication, A2 time period, A6 Energy Measurement}
6	{A2 time period, A4 Methodology, A6 Energy Measurement}
7	{A2 time period, A3 Country, A4 Methodology, A5 Energy Category}
8	{A3 Country, A4 Methodology, A6 Energy Measurement}
9	{A1 Year of publication, A3 Country, A5 Energy Category}
10	{A1 Year of publication, A3 Country, A6 Energy Measurement}
11	{A2 time period, A3 Country, A5 Energy Category, A6 Energy Measurement}
12	{A2 time period, A3 Country, A6 Energy Measurement, A7 Single or group of countries}
13	{A3 Country, A5 Energy Category, A6 Energy Measurement}
14	{A1 Year of publication, A3 Country}
15	{A2 time period, A3 Country, A4 Methodology}
16	{A3 Country, A4 Methodology, A5 Energy Category}
17	{A2 time period, A3 Country, A4 Methodology, A6 Energy Measurement}
18	{A2 time period, A6 Energy Measurement}
19	{A1 Year of publication, A2 time period}
20	{A2 time period, A4 Methodology}
21	{A1 Year of publication, A2 time period, A3 Country, A6 Energy Measurement}
22	{A1 Year of publication, A2 time period, A3 Country, A5 Energy Category}
23	{A1 Year of publication, A2 time period, A3 Country, A4 Methodology}
24	{A1 Year of publication, A3 Country, A4 Methodology}
25	{A2 time period, A3 Country, A4 Methodology, A5 Energy Category, A6 Energy Measurement}
26	{A3 Country, A4 Methodology, A5 Energy Category, A6 Energy Measurement}
27	{A1 Year of publication, A3 Country, A4 Methodology, A6 Energy Measurement}
28	{A1 Year of publication, A6 Energy Measurement}

Figure 1: Example of reducts generated by the Rosetta toolkit

Once the reducts have been computed, the rules are easily constructed by overlaying the reducts over the originating decision table and reading the values by using the Rosetta Toolkit. 235 Rules were generated from the acquired reducts. An example of the rules generated is given in Figure 2.

	Rule
128	A1(3) AND A3 (3) AND A6 (3) => D (1) OR D (4) OR D (2) OR D (3)
129	A1(3) AND A3 (2) AND A6 (3) => D (4) OR D (2) OR D (3) OR D (1)
130	A1(4) AND A3 (1) AND A6 (7) => D (1)
131	A1(4) AND A3 (2) AND A6 (9) => D (4)
132	A1(4) AND A3 (4) AND A6 (1) => D (3)
133	A2 (3) AND A3 (4) AND A5(4) AND A6 (1) => D (1)
134	A2 (4) AND A3 (2) AND A5(4) AND A6 (9) => D (4)
135	A2 (4) AND A3 (2) AND A5(4) AND A6 (1) => D (2)
136	A2 (3) AND A3 (4) AND A5(4) AND A6 (2) => D (1)
137	A2 (3) AND A3 (4) AND A5(3) AND A6 (3) => D (2)
138	A2 (3) AND A3 (3) AND A5(3) AND A6 (3) => D (1)
139	A2 (3) AND A3 (4) AND A6 (1) AND A7 (1) => D (1)
140	A2 (4) AND A3 (2) AND A6 (2) AND A7 (2) => D (3)
141	A2 (3) AND A3 (3) AND A6 (2) AND A7 (2) => D (2)
142	A2 (4) AND A3 (2) AND A6 (3) AND A7 (2) => D (2)

Figure 2: Example of original rules generated by the Rosetta toolkit

Let us give an example of a rule obtained from a reduct and its interpretation:

If A2 (5) AND A4 (3) AND A5(4) AND A6 (9) then decision for causality: => D (1)

(LHS) Support=3
(LHS) coverage= 0.004373
(RHS) Accuracy= 100%

From this rule, the conditional attributes have a support of 3 objects from the total of 686 objects (LHS support), which accounts for 0.43% of the total objects in the decision table (LHS coverage) and 100% of these 3 objects (RHS Accuracy) have a decision value=D4. It can be easily concluded that only rules with relatively high support (hence, higher coverage) and high accuracy should be considered. To continue with the previous example, despite the fact that this rule presents the highest possible level of accuracy (100%), it fails as far as its support and coverage level are concerned. In other words, this means that the former rule fails to define an accredited functional dependency considering the dataset as a whole.

Since the original reduction generated 235 rules, which are rather too many to comprehend, a ready to apply Quality Filtering within the Rosetta Toolkit was used in order to gather only those rules that met the minimum support threshold. Filtering the set of 235 rules originally generated produced a subset of 173 decision rules. Due to lack of space only part of the derived results is presented below:

QualityRuleFilterLoop
{FILTERING=Torgo; REMOVE.UNDEFINED=T; INVERT=F; RESOLUTION=Dynamic; RESOLUTION.THRESHOLD=100; RESOLUTION.FRACTION=0.01; FILENAME=Undefined; DECISIONTABLE=causality$, CLASSIFIER=StandardVoter; RULES=No name; FRACTION=0.0; IDG=F; SPECIFIC=F; VOTING=Support; NORMALIZATION=Firing; ROC.CLASS=1; FALLBACK.CERTAINTY=0.5}

Threshold	Rules	AUC	SE
0.764249	1.0	0.510358	0.026466

0.757669	2.0	0.515066	0.026504
0.755181	3.0	0.518832	0.026532
0.754839	4.0	0.528145	0.026592
0.754601	5.0	0.530915	0.026608
0.753886	6.0	0.533686	0.026623
0.753226	9.0	0.552093	0.026694
0.753067	12.0	0.557414	0.026706
0.752857	20.0	0.571606	0.026719
0.752591	26.0	0.582249	0.02671
0.751613	50.0	0.65092	0.026262
0.751534	94.0	0.683531	0.025797
etc			

Quality	Rule index
0.764249	90
0.757669	106
0.755181	89
0.754839	1
0.754601	202
0.753886	88
0.753226	60
0.753226	64
0.753226	174
etc	

Once preliminary results have been obtained, validation procedures ensure that the knowledge obtained by rules is correct. The rules filtering further performed in order to find the rules that are accurate representations of the data. However, the quality filtering results showed that the quality and the minimum threshold support are extremely close between rules. Almost all the 173 rules derived from the filtering support the same quality level. For instance, there are 94 rules with quality level between 0.764249 and 0.751534. Hence, even after filtering, the new decision rules set fails to explain the data adequately. This can be easily explained by a carefull examination of the generated quality index. The great majority of the obtained rules failed to fulfil the high support and high accuracy conditions previously described. There are rules with, on the one hand, high support (e.g. 66) and coverage (9.62%), that on the other hand present very low accuracy (e.g. less than 20%).

The results remained insignificant for every alternative combination of statistical methods and altering filter procedures we applied by using the Rosetta Toolkit. The procedure always resulted in too many rules with high RHS Accuracy (100%) but low LHS Support (only few objects), while other rules had high LHS support but low Accuracy. There were also rule cases with different accuracy between identical rules. Every filtering procedure failed to reduce the original rules set significantly. Under these circumstances, it is impossible to choose, with accuracy and consistency, between rules with high accuracy but low support and rules with low accuracy but high support. Due to lack of concrete and effective results, no accurate rules can be derived from the Rough Set Data Analysis concerning the causality debate.

4. Multinomial Logistic Regression Analysis

Logistic regression analysis examines the influence of various factors on a dichotomous outcome by estimating the probability of the event's occurrence (Anderson, 1982). It does this by examining the relationship between one or more independent variables and the log odds of the dichotomous outcome by calculating changes in the log odds of the dependent variable as opposed to the value of the dependent variable itself. In the present study, the dependent variable is the causality result, which is not dichotomous but is comprised of four categories. We therefore apply the multinomial logistic regression model (Agresti, 1996). This analysis fits simultaneously three models, holding one result category as reference category and comparing each of the other three categories to it. Hence, taking E≠GDP as reference decision category, the three regression models are:

1. E→GDP compared to E≠GDP
2. GDP→E compared to E≠GDP
3. E↔GDP compared to E≠GDP

Let π_j be the probability that the causality result is the category j, then these regression models are of the logit form:

$$\log \frac{\pi_j}{\pi_4} = \alpha_j + \beta_{1j} x_1 + \beta_{2j} x_2 + ... \beta_{Pj} x_P$$

for $j=1,2,3$, where the constants α_j and regression parameters β_{Pj} are to be estimated by maximum likelihood from the data table. Because all our explanatory variables are categorical, x_1, $x_2 \ldots x_P$ will be dummy variables and, for each of the attributes considered, we must also set an attribute reference category. For example, for the attribute "Methodology" we choose the subcategory "others", coded as "6" in previous sections. It must be clarified that the choice of reference category does not affect the overall statistical significance of a variable, such as the "Methodology" attribute, nor the probabilities derived at the end.

Likelihood ratio tests in the analysis with all six explanatory variables identified two attributes as statistically significant: "Methodology" ($P<0.001$) and "Energy Measurement" ($P=0.016$). Each of the other attributes had $P>0.1$. We repeat the analysis using only these two attributes as explanatory variables to obtain the final results.

- For the "Energy Measurement" attribute we obtain:

The value 1="Btu's" of the "Energy Measurement" attribute seems to reduce the probabilities of E→GDP or E↔GDP versus E≠GDP, but not of GDP→E versus E≠GDP, compared to category 9="undefined" of energy measurement. This appears to be the only category of energy measurement that is differentiated from the rest.

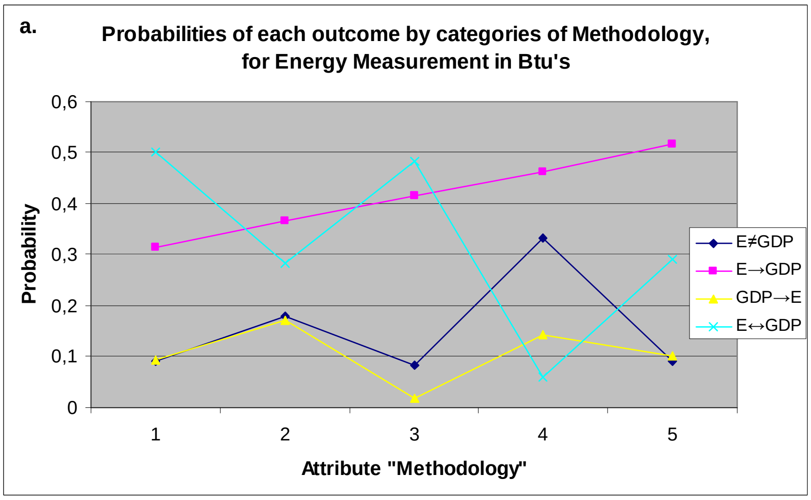
Regression models	**Rate Ratio**	**95% Confidence interval**
E→GDP versus E≠GDP	0.18	0.06 - 0.58
GDP→E versus E≠GDP	1.28	0.45 - 3.61
E↔GDP versus E≠GDP	0.13	0.04 - 0.47

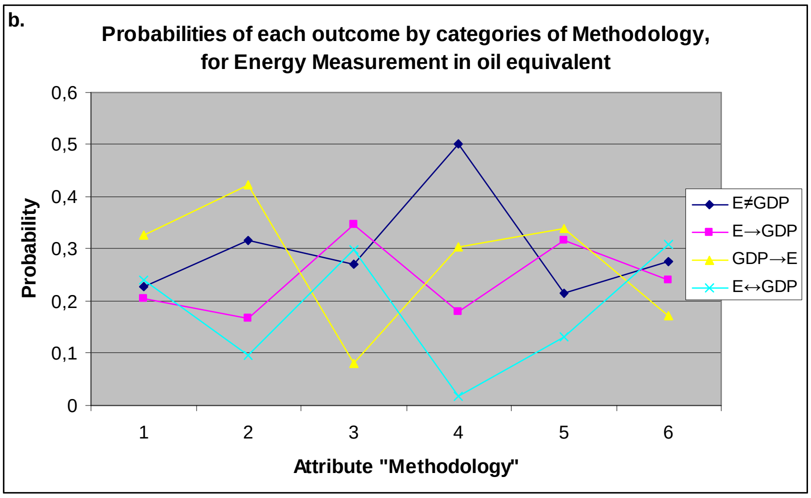
- For the "Methodology" attribute we obtain:

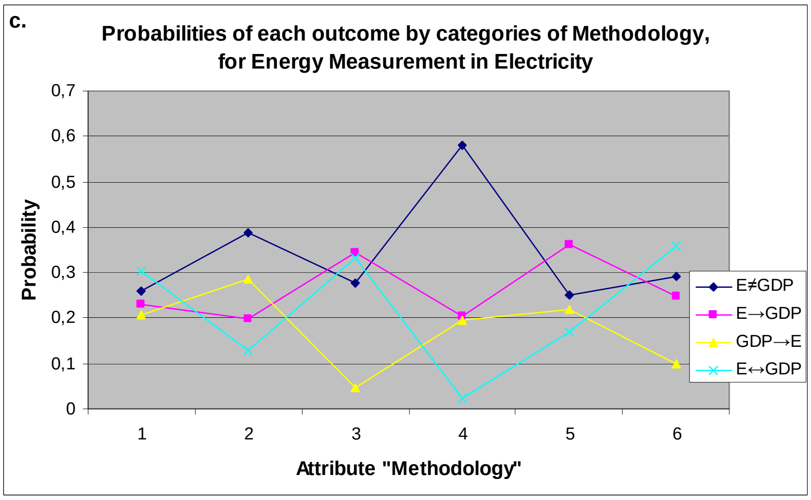
Values 2="Johansen Juselius", 4="Pedroni Panel" and 5="ARDL" increase the probability of other results compared to E≠GDP, in comparison to the reference category 6="Others" and also to 1="Sims-Granger causality" and 3="Toda_Yamamoto causality test", which do not differ significantly from the reference category.

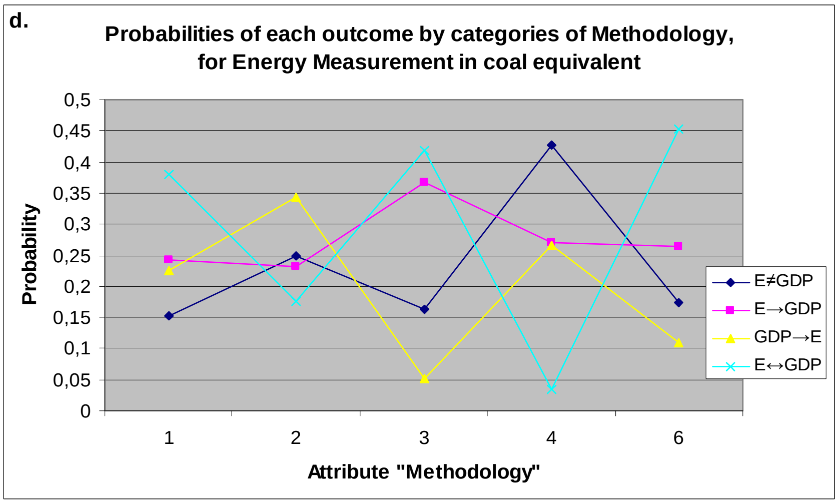
Regression models (versus E≠GDP)	**Johansen Juselius**	**Pedroni Panel**	**ARDL**
	RR (95%. ci)	RR (95%. ci)	RR (95%. ci)
E→GDP	4.34 (1.90 - 9.94)	2.39 (1.00 – 5.72)	8.80 (3.4 – 22.8)
GDP→E	35.5 (4,29 - 293)	14.0 (1.60 - 123)	33.0 (3.69 - 295)
E↔GDP	1.95 (0.66 - 5.78)	3.14 (1.13 – 8.75)	4.70 (1.46 – 15.1)

Table 10 (see Appendix A) shows the fitted probabilities of each causality result estimated by using only the most significant attributes, “Energy Measurement” and “Methodology”. The following diagrams a., b., c., d., and e., present the probabilities of Table 10.









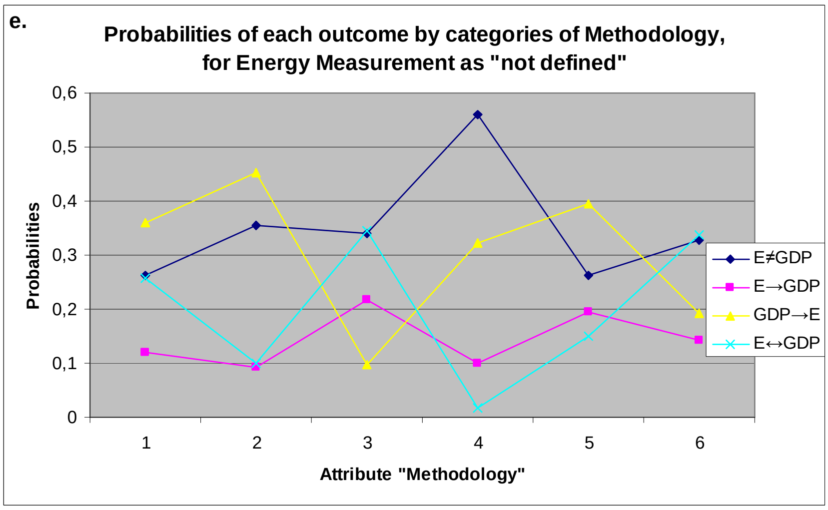


Figure 3: Representation of Table 10.

According to the probabilities of each causality result presented in Table 10 and further visualized in Figure 3, we can find the combination of attributes with the highest probability of each causality direction. From Figure 3a, we can pick the attribute pairs with the higher probability, hence:

1. ARDL Bounds test with Btu's gives probability 0.517 of outcome 2 (E→GDP)
2. Sims & Engle-Granger with Btu's gives probability 0.502 of outcome 4 (E↔GDP)

Both results give a more than 50% probability. However, considering the support of the results in the total n=686 objects of our dataset we have: first case=1.16% of the total and second case=2.33% of the total, respectively. According to the aforementioned assumptions and Figure 3, we can categorize the most significant results as:

N	**"Methodology" attribute category**	**"Energy Measurement" category**	**Causality result and probability**	**Support in n=686**
1	Pedroni Panel	Electricity	E≠GDP with Prob. 0.58	0.58%
2	Pedroni Panel	Not defined	E≠GDP with Prob. 0.559	0.14%
3	ARDL	Btu's	E→GDP with Prob.0.517	1.16%
4	Sims&Engle-Gr.	Btu's	E↔GDP with Prob. 0.502	2.33%
5	Pedroni Panel	Oil equivalent	E≠GDP with Prob. 0.501	6.41%
6	Johansen- Juselius	Oil equivalent	GDP→E with Prob. 0.423	14.43%
7	Others	Coal equivalent	E↔GDP with Prob. 0.452	0.14%

It must be underlined that, as rough set analysis showed, the support level of each probability is so important as the probability itself. To continue with our analysis, we can conclude that in most cases the high probability is not associated with a high support level of the dataset. According to previous categorization of the results, only the 6th result has a considering support level. The higher support level is valid for the following results:

- Johansen- Juselius (Methodology) AND Oil equivalent (Energy Measurement) = GDP→E (with probability =0.423) and Support=99 objects (14.43%)

- Sims&Engle-Granger (Methodology) AND Oil equivalent (Energy Measurement) = GDP→E (with probability=0.327) and Support=122 objects (17.78%)

Concluding the findings of multinomial logistic regression, we can accept that the Johansen-Juselius Methodology and Oil equivalent energy measurement method, support the conservation hypothesis (GDP→E) with probability=0.423 and support=14.43%.

5. Discussion of results

The main purpose of the present study was to estimate whether or not there is a general pattern of causality which holds regardless of the specific micro characteristics of each case study included in our survey, considering and categorizing only the most common attributes (country, methodology, period of time, etc). The investigation was based on standard statistical methods as well as on relatively new methods of operational research. We tried to identify those conditions (attributes) that determine or at least influence the direction of causality. We assumed that all four causality relationships are possibly empirically valid depending on the seven main common attributes of each case study at hand. We performed a Rough Set Data Analysis and a multinomial logistic regression on a database consisting of 158 case studies. In this context we tried to investigate if it is possible in the whole dataset to efficiently define a set of decision rules and thus, to determine which attributes-characteristics best explain the causality direction. In addition, we performed a number of classical statistical tests, regression and filtering methods. Unfortunately, no general rules that lead to each direction of causality can be identified According to the results of multinomial logistic regression, the most statistical significant attributes among all were the "Methodology" and "Energy Measurement". Specifically the Johansen-Juselius methodology and oil equivalent energy measurement seems to mainly support the conservation hypothesis.

One possible limitation of the present study may be the unequal distribution between countries within a group. Differences in productivity, energy consumption, level of industrialization, economic sectors and GDP characteristics among the countries comprising a group (e.g. Non OECD countries), may further complicate our results. It is possible that a more accurate country grouping would lead to better estimation, or the use of more than seven attributes would explain the decision attribute better. Furthermore, the attribute "Methodology" would be better represented if the comparison had been made among the numerical results of each econometric method instead of comparing methods simply with respect to the direction of causality. Nevertheless, the main aim of the present study was to examine the most common attributes, in order to build a more concrete picture of the results of the entire causality debate. In this context, and due to the mixed results from Rough Set analysis, we are forced to choose among three alternative scenarios:

- First, the methods and/or the attributes we chose are inappropriate
- Second, the methods applied in individual case studies are inappropriate and lead to biased and sometimes conflicting results.
- Third, there are no general rules that describe a functional causal relationship between economic growth and energy consumption.

We choose the third alternative and in this context we share the opinion of Mehrara (2007) who comments on the energy-GDP growth causality debate: ''*when it comes to whether energy use is a result of, or a prerequisite for, economic growth, there are no clear trends in the literature. Depending on the methodology used, and country and time period studied, the direction of causality between energy consumption and economic variables has remained empirically elusive and controversial*''.

6 .Concluding remarks

Given that there is a huge concern of policy makers for robust and reliable results so that they may be in a position to design effective energy policies, the causality debate should offer a more coherent understanding of the energy-growth nexus and find better ways to do so.

Over the last three decades the ongoing debate on causality between energy consumption and economic growth - following closely the advances in econometric theory, energy and environmental economics – has produced a significant amount of working papers. However, in spite of this growing research, the state of knowledge still remains quite indeterminate and controversial. The present study aimed, firstly, to provide an exhaustive survey of the whole energy-GDP causality debate between 1978-2011 and, secondly, to be the first effort at examining the concreteness and the consistency of the debate's results using contemporary analytical tools (Rough Set Data Analysis and multinomial logistic regression). The weak results of multinomial logistic regression and the inability of the RSDA tool to produce a sufficient number of rigid rules by using various filtering tools, probably reflect the contradictive results that the debate itself presents. These contradictions and conflicts within the empirical results have been mentioned recently by many researchers (Mehrara, 2007; Beaudreau, 2010; Ozturk, 2010). Although progress in econometric methods provides several powerful tools for the analysis and understanding of the energy-economic growth relationship, applied studies using these tools are open to the criticism that many of these studies yield conflicting and even contradictory findings which makes it difficult to draw out any reliable policy implications for energy and environmental policy makers (Karanfil, 2009). Motivated by the fact that contradictory results are still being reported in this ongoing debate, we attempted to define the causality direction based on the core of attributes-characteristics while leaving out other microcharacteristics of each and every case. As Karanfil (2009) and Ozturk (2010) characteristically mention, research papers using the same methods with the same variables, just by changing the time period examined, have no more potential to make a contribution to the existing energy–growth literature. On the contrary, it seems that they contribute further complication and conflict, something which is unavoidably reflected in the present study. Nevertheless, the most crucial conclusion of the causality debate so far, for most authors, is that energy is an important determinant of economic growth. Beyond that, the remaining query goes like this: is it really crucial to investigate whether energy consumption causes GDP growth, or the opposite? The interest of our future research focuses on trends in GDP in relation to energy use trends. Beyond its prima facie interest this relation reflects to some extent the direction of causality indirectly but probably more substantially.

Acknowledgements

Deep thanks to Professor Clive Richardson, for reviewing the paper and for considerable help with the multinomial logistic regression method. This research has been co-financed by the European Union (European Social Fund – ESF) and Greek national funds through the Operational Program "Education and Lifelong Learning" of the National Strategic Reference Framework (NSRF) - Research Funding Program: Heracleitus II. Investing in knowledge society through the European Social Fund.

Appendix A.

Table 1. The "raw data" of out Dataset cases. The right part consists of the Decision Table used in Rough Set Analysis and multinomial logistic regression.

No	paper	1.	2.	3.	4.	5.	6.	7.	d.
1	Kraft & Kraft (1978)	1	3	1	1	4	1	1	2
2	Akarca & Long (1980)	2	3	1	1	4	1	1	4
3	Yu & Hwang (1984)	2	4	1	1	4	1	1	4
…	…..	...	…	..	..	..	..	..	…

(Due to space shortage the full decision table of 686 objects could be available after request)

Table 2. Attribute "year of publication" Coding

Decade of Publication	year	publications	decade Total
70s	1978	1	1
	1979	0	
80s	1980	1	5
	1981	0	
	1982	0	
	1983	0	
	1984	1	
	1985	1	
	1986	0	
	1987	1	
	1988	1	
	1989	0	
90s	1990	1	16
	1991	2	
	1992	1	
	1993	1	
	1994	0	
	1995	1	
	1996	2	
	1997	5	
	1998	2	
	1999	1	
2000-2011	2000	4	136
	2001	3	
	2002	4	
	2003	1	
	2004	14	
	2005	8	
	2006	8	
	2007	23	
	2008	17	
	2009	20	

	2010	14	
	2011	20	
Total			**158**

Table 3. Attribute "examined time period" Coding

coding	Time period	number of cases
1	***less than 10***	5
2	***between 10-20 years***	8
3	***Between 20-30 years***	191
4	***Between 30-40 years***	353
5	***more than 40 years***	127
6	***no period defined***	2
	Total	686

Table 4. Attribute "Country categorization" Coding

1.	**G7**	France	121
		Germany	
		Italy	
		Japan	
		United Kingdom	
		USA	
		Canada	
2.	**OECD countries (-G7) According to www.oecd.org 2012**	Australia	163
		Austria	
		Belgium	
		Chile	
		Czech Republic	
		Denmark	
		Estonia	
		Finland	
		Greece	
		Hungary	
		Iceland	
		Ireland	

		Israel	
		S. Korea	
		Mexico	
		Luxeburg	
		Netherlands	
		New Zealand	
		Norway	
		Poland	
		Portugal	
		Slovak Republic	
		Slovenia	
		Spain	
		Sweden	
		Switzerland	
		Turkey	
3.	**High Developing Countries (non-OECD members)**	Russia	148
		China	
		India	
		Brazil	
		Indonesia	
		Taiwan	
		Singapore	
		Hong Kong	
		Malaysia	
		Gulf Cooperation Countries	
		South Africa	
4.	**Non-OECD**	Remaining countries not included in previous grouping	245
5.	**City or part or sector of a country**		9
Total			686

Table 5. Attribute "Methodology" Coding

coding	Methodology	Methodology categories	Total
1	Sims & Engle-Granger Causality	Sims Causality	207
		Granger Causality	
		Hsiao's Granger causality	
		Engle-Granger Causality	
2	Johansen- Juselius for Cointegration	with VDC	189
		with VECM	
		with Pair-wise	
		with IRF	
3	Toda Yamamoto Causality		116
4	Pedroni Panel Cointegration	(all combination forms used)	52
5	ARDL Bounds test		52
6	Others	VAR	70
		Dolado Lutkepohl causality	
		Beak & Broch non-linear	
		Dynamic Panel estimation causality	
		Hodrick-Prescott filter	
		Carrion-i-Silvestre	
		Hansen and Seo threshold co-integration test	
		Westerlund(2006) panel cointegrationtest	
		Gregory and Hansen	
		Graph Theoretic Approach	
		Markov-switching vector autoregressive (MS-VAR)	
		Erik-Gunnar (E-G) two steps method	
		GLS	
		Bootstrapped Granger causality	
TOTAL			686

Table 6. Attribute “Energy Type” Coding

Energy Type		
1	Total Fossil fuels Consumption (Coal, Oil, Gas)	3
2	Electricity Consumption (or production)	139
3	Energy Consumption per capita (primary or electricity etc)	272
4	Total (Primary fuels+electricity) Energy Consumption	214
5	Oil &/or petroleum Consumption (or production)	14
6	Coal Consumption (or production)	22
7	Gas Consumption (or production)	13
8	Nuclear Energy Consumption (or production)	5
9	Renewables energy consumption	4
Total		686

Table 7. Attribute “Energy measurement method” Coding

Energy Measurement method		
1	***Btu's***	49
2	***Oil equivalent***	357
3	***Electricity (watt)***	168
4	***Coal equivalent***	25
5	***EXERGY***	1
6	***Crude quantity***	12
7	***Devisia Index***	5
8	***Joule***	2
9	***Not defined***	67
Total		686

Table 8. Attribute “Single country or group of countries” Coding

Group of countries or single country		
1	Single Country examined	637
2	Group of countries examined	49
total		686

Table 9. Decision variable (causality result) Coding

Causality results		
1	E→GDP	193
2	E←GDP	163
3	E↔GDP	175
4	E≠GDP	155
Total		686

Table 10. Multinomial logistic regression: fitted probabilities of each outcome for each combination of the attributes "Methodology" and “Energy Measurement”

a/a	"Methodology" attribute	“Energy Measurement” attribute	Probabilities				n
			E→GDP	GDP→E	E↔GDP	E≠GDP	
1	1	1	0,09	0,315	0,093	0,502	16
2	1	2	0,227	0,205	0,327	0,241	122
3	1	3	0,26	0,229	0,207	0,304	31
4	1	4	0,153	0,243	0,226	0,379	11
5	1	9	0,263	0,119	0,361	0,258	27
6	2	1	0,179	0,365	0,172	0,284	13
7	2	2	0,316	0,166	0,423	0,095	99
8	2	3	0,387	0,198	0,287	0,128	35
9	2	4	0,249	0,231	0,344	0,176	29
10	2	9	0,355	0,093	0,453	0,099	13
11	3	1	0,084	0,416	0,018	0,483	10
12	3	2	0,272	0,348	0,082	0,298	47
13	3	3	0,276	0,345	0,046	0,333	33
14	3	4	0,163	0,368	0,051	0,418	3
15	3	9	0,34	0,218	0,098	0,344	23
16	4	1	0,333	0,463	0,144	0,059	2
17	4	2	0,501	0,179	0,303	0,017	44
18	4	3	0,58	0,203	0,195	0,022	4
19	4	4	0,428	0,271	0,267	0,034	1
20	4	9	0,559	0,1	0,323	0,017	1
21	5	1	0,09	0,517	0,102	0,291	8
22	5	2	0,214	0,317	0,338	0,132	20
23	5	3	0,25	0,362	0,219	0,169	23
24	5	9	0,262	0,194	0,395	0,149	1
25	6	2	0,277	0,241	0,172	0,31	25
26	6	3	0,292	0,248	0,1	0,36	42
27	6	4	0,173	0,265	0,11	0,452	1
28	6	9	0,327	0,142	0,193	0,338	2
						Total objects	686

Appendix B.

References referred to causality debate survey, rough set and multinomial logistic regression dataset

Abosedra, S., Baghestani, H., 1989. New evidence on the causal relationship between U.S. energy consumption and gross national product. Journal of Energy Development, 14, 285–292

Abosedra, S., Dah, A., Ghosh, S., 2009. Electricity consumption and economic growth, the case of Lebanon. Applied Energy, 86(4), 429-432. doi:10.1016/j.apenergy.2008.06.011

Acaravci, A., Ozturk, I., 2010. Electricity consumption-growth nexus: Evidence from panel data for transition countries. Energy Economics, 32(3), 604-608. doi:10.1016/j.eneco.2009.10.016

Adams, F. G., Shachmurove, Y., 2008. Modeling and forecasting energy consumption in China: Implications for Chinese energy demand and imports in 2020. Energy Economics, 30(3), 1263-1278. doi:10.1016/j.eneco.2007.02.010

Akinlo, A. E., 2008. Energy consumption and economic growth: evidence from 11 Sub-Sahara African countries. Energy Economics, 30(5), 2391–2400.

Akinlo, A. E., 2009. Electricity consumption and economic growth in Nigeria: Evidence from cointegration and co-feature analysis. Journal of Policy Modeling, 31(5), 681-693. doi:10.1016/j.jpolmod.2009.03.004

Akarca, A. T., Long, T., V., 1980. On the relationship between energy and GNP: a reexamination. Journal of Energy Development, 5, 326–331.

Al-Iriani, M. A., 2006. Energy–GDP relationship revisited: An example from GCC countries using panel causality. Energy Policy, 34(17), 3342-3350. doi:10.1016/j.enpol.2005.07.005

Alam, M. J., Begum, I. A., Buysse, J., Rahman, S.,Van Huylenbroeck, G., 2011. Dynamic modeling of causal relationship between energy consumption, CO2 emissions and economic growth in India. Renewable and Sustainable Energy Reviews, 15(6), 3243-3251. doi:10.1016/j.rser.2011.04.029

Altinay, G., Karagol, E., 2004. Structural break , unit root , and the causality between energy consumption and GDP in Turkey, Energy Economics 26, 985-994. doi:10.1016/j.eneco.2004.07.001

Altinay, G., Karagol, E., 2005. Electricity consumption and economic growth: Evidence from Turkey. Energy Economics, 27(6), 849-856. doi:10.1016/j.eneco.2005.07.002

Ang, J. B., 2007. CO2 emissions, energy consumption, and output in France. Energy Policy, 35, 4772–4778.

Ang, J. B., 2008. Economic development, pollutant emissions and energy consumption in Malaysia. Journal of Policy Modeling, 30(2), 271-278. doi:10.1016/j.jpolmod.2007.04.010

Apergis, N., Payne, J. E., 2009a. CO2 emissions, energy usage, and output in Central America. Energy Policy, 37(8), 3282-3286. doi:10.1016/j.enpol.2009.03.048

Apergis, N., Payne, J. E., 2009b. Energy consumption and economic growth in Central America: Evidence from a panel cointegration and error correction model. Energy Economics, 31(2), 211-216. Elsevier B.V. doi:10.1016/j.eneco.2008.09.002

Apergis, N., Payne, J. E., 2009c. Energy consumption and economic growth: Evidence from the Common wealth of Independent States, 31, 641-647. doi:10.1016/j.eneco.2009.01.011

Apergis, N., Payne, J. E., 2010a. Renewable energy consumption and economic growth: Evidence from a panel of OECD countries. Energy Policy, 38(1), 656-660. doi:10.1016/j.enpol.2009.09.002

Apergis, N., Payne, J. E., 2010b. The causal dynamics between coal consumption and growth: Evidence from emerging market economies. Applied Energy, 87(6), 1972-1977. doi:10.1016/j.apenergy.2009.11.035

Apergis, N., Payne, J. E., 2010c. The emissions, energy consumption, and growth nexus: Evidence from the commonwealth of independent states. Energy Policy, 38(1), 650-655. doi:10.1016/j.enpol.2009.08.029

Apergis, N., Payne, J. E., 2011a. The renewable energy consumption–growth nexus in Central America. Applied Energy, 88(1), 343–347

Apergis, N., Payne, J. E., 2012. Renewable and non-renewable energy consumption-growth nexus: Evidence from a panel error correction model. Energy Economics, 34(3), 733–738

Aqeel, A., Butt, M. S., 2001. The relationship between energy consumption and economic growth in Pakistan. Asia Pacific Development Journal, 8(2), 101–110.

Arifin, J., Syahruddin, N., 2011. Causality Relationship between Renewable and Non-Renewable Energy Consumption and GDP in Indonesia. Economics and Finance in Indonesia, 59(1) , 1-18.

Asafu-Adjaye, J., 2000. The relationship between energy consumption, energy prices and economic growth: time series evidence from Asian developing countries. Energy Economics, 22(6), 615-625. doi:10.1016/S0140-9883(00)00050-5

Asghar, Z., Rahat, T., 2011. Energy-Gdp Causal Relationship For Pakistan: A Graph Theoretic Approach. Applied Econometrics and International Development, Euro-American Association of Economic Development, 11(1). Available at: http://ideas.repec.org/a/eaa/aeinde/v11y2011i1_16.html

Belke, A., Dobnik, F., Dreger, C., 2011. Energy consumption and economic growth: New insights into the cointegration relationship. Energy Economics, 33(5), 782-789. doi:10.1016/j.eneco.2011.02.005

Belloumi, M., 2009. Energy consumption and GDP in Tunisia: Cointegration and causality analysis. Energy Policy, 37(7), 2745-2753. doi:10.1016/j.enpol.2009.03.027

Bowden, N., Payne, J. E., 2009. The causal relationship between U.S. energy consumption and real output: A disaggregated analysis. Journal of Policy Modeling, 31(2), 180-188. doi:10.1016/j.jpolmod.2008.09.001

Carrion-i-Silvestre, J., Castro, T., Lopes-Bazo, E., 2005. Breaking the panels: an application to GDP per capita. Econometrics Journal, 8, 159–175

Chang, T., Fang, W., Wen, L. F., 2001. Energy consumption, employment, output, and temporal causality: evidence from Taiwan based on cointegration and error-correction modelling techniques .Applied Economics, 33(8), 1045-1056. DOI: 10.1080/00036840122484

Chang, C. C., 2010. A multivariate causality test of carbon dioxide emissions, energy consumption and economic growth in China. Applied Energy, 87(11), 3533-3537. doi:10.1016/j.apenergy.2010.05.004

Chang, C. C., Soruco Carballo, C. F., 2011. Energy conservation and sustainable economic growth: The case of Latin America and the Caribbean. Energy Policy, 39(7), 4215-4221. doi:10.1016/j.enpol.2011.04.035

Chen, S. T., Kuo, H. I., Chen, C. C., 2007. The relationship between GDP and electricity consumption in 10 Asian Countries. Energy Policy, 35, 2611–2621.

Cheng, B. S., 1995. An investigation of cointegration and causality between energy consumption and economic growth. Journal of Energy Development, 21, 73–84.

Cheng, B. S., Lai, T. W., 1997. An investigation of co-integration and causality between energy consumption and economic activity in Taiwan. Energy Economics, 19(4), 435-444. doi:10.1016/S0140-9883(97)01023-2

Cheng, B. S., 1997. Energy consumption and economic growth in Brazil, Mexico and Venezuela: a time series analysis. Applied Economics Letters, 4(11), 671-674. doi:10.1080/758530646

Cheng, B. S., 1998. Energy consumption, employment and causality in Japan: a multivariate approach. Indian Economic Review, 33(1), 19–29.

Cheng, B. S., 1999. Causality between energy consumption and economic growth in India: an application of cointegration and error-correction modeling. Indian Economic Review, 34, 39–49.

Chiou-Wei, S. Z., Chen, C. F., Zhu, Z., 2008. Economic growth and energy consumption revisited — Evidence from linear and nonlinear Granger causality. Energy Economics, 30(6), 3063-3076. doi:10.1016/j.eneco.2008.02.002

Chontanawat, J., Hunt, L. C., Pierse, R., 2006. Causality between Energy Consumption and GDP: Evidence from 30 OECD and 78 Non-OECD Countries. Discussion paper Series, Department of Economics, University of Surrey. SEEDS 113, ISSN 1749-8384.

Chontanawat, J., Hunt, L. C., Pierse, R., 2008. Does energy consumption cause economic growth? Evidence from a systematic study of over 100 countries. Journal of Policy Modeling, 30(2), 209-220. doi:10.1016/j.jpolmod.2006.10.003

Ciarreta, A., Zarraga, A., 2009. Economic growth and electricity consumption in 12 European countries: A causality analysis using panel data. 2009 6th International Conference on the European Energy Market, 1-8. Ieee. doi:10.1109/EEM.2009.5207221

Climent, F., Pardo, A., 2007. Decoupling factors on the energy–output linkage: The Spanish case. Energy Policy 35(1), 522–528. dx.doi.org/10.1016/j.enpol.2005.12.022

Costantini, V., Martini, C., 2010. The causality between energy consumption and economic growth: A multi-sectoral analysis using non-stationary cointegrated panel data. Energy Economics, 32(3), 591-603. doi:10.1016/j.eneco.2009.09.013

De Janosi, P. E., Grayson, L. E., 1992. Patterns of energy consumption and economic growth and structure. Journal of Development Studies, 8(2), 241–249.

Duro, J. A., Alcántara, V., Padilla, E., 2010. International inequality in energy intensity levels and the role of production composition and energy efficiency: An analysis of OECD countries. Ecological Economics, 69(12), 2468-2474. doi:10.1016/j.ecolecon.2010.07.022

Ebohon, O. J.. 1996. Energy , economic growth and causality in developing countries: A case study of Tanzania and Nigeria. Energy Policy, 24(5), 447–453. dx.doi.org/10.1016/0301-4215(96)00027-4

Eggoh, J. C., Ifo, C. E. S., Aper, W. O. P., 2011. Energy Consumption and Economic Growth Revisited in African Countries. CESifo Working Paper Series No. 3590.

Erdal, G., Erdal, H., Esengün, K., 2008. The causality between energy consumption and economic growth in Turkey. Energy Policy, 36(10), 3838-3842. doi:10.1016/j.enpol.2008.07.012

Erol, U., Yu, E. S. H., 1987. On the causal relationship between energy and income for industrialized countries. Journal of Energy Development, 13, 113–122.

Esso, L. J., 2010. Threshold cointegration and causality relationship between energy use and growth in seven African countries, 32, 1383-1391. doi:10.1016/j.eneco.2010.08.003

Fallahi, F., 2011. Causal relationship between energy consumption (EC) and GDP: A Markov-switching (MS) causality. Energy, 36(7), 4165-4170. doi:10.1016/j.energy.2011.04.027

Fatai, K., Oxley, L., Scrimgeour, F., 2002. Energy consumption and employment in New Zealand: searching for causality. In: Paper presented at NZAE Conference, Wellington, 26–28 June 2002.

Fatai, K., Oxley, L., Scrimgeour, F., 2004. Modelling the causal relationship between energy consumption and GDP in New Zealand, Australia, India, Indonesia, The Philippines and Thailand. Mathematics and Computers in Simulation, 64(3-4), 431-445. doi:10.1016/S0378-4754(03)00109-5

Feng, T., 2009. The relationship between energy consumption structure, economic structure and energy intensity in China. Energy Policy, 37(12), 5475-5483. doi:10.1016/j.enpol.2009.08.008

Ferguson, R., Wilkinson, W., Hill, R., 2000. Electricity use and economic development. Energy Policy, 28 (13), 923–934.

Fotros, M. H., Maabudi, R., 2011. Causality relationship between energy consumption, urban population, and environmental degredation in Iran, 1981-2006, Quarterly Energy Economics Review,7(27), 1-17

Francis, B. M., Moseley, L., Osaretin, S., 2007. Energy consumption and projected growth in selected Caribbean countries, 29, 1224-1232. doi:10.1016/j.eneco.2007.01.009

Ghali, K. H., El-Sakka, M.I.T., 2004. Energy use and output growth in Canada: a multivariate cointegration analysis. Energy, 26(2), 225-238. dx.doi.org/10.1016/S0140-9883(03)00056-2

Ghosh, S., 2002. Electricity consumption and economic growth in India. Energy Policy, 30,125–129.

Ghosh, S., 2009. Electricity supply, employment and real GDP in India: evidence from cointegration and Granger-causality tests. Energy Policy, 37(8), 2926-2929. doi:10.1016/j.enpol.2009.03.022

Glasure, Y. U., Lee, A., 1997. Cointegration, error correction and the relationship between GDP and energy: the case of South Korea and Singapore. Resource and Energy Economics, 20, 17–25.

Glasure, Y. U., 2002. Energy and national income in Korea: further evidence on the role of omitted variables. Energy Economics, 24, 355–365.

Halicioglu, F., 2007. Residential electricity demand dynamics in Turkey. Energy Economics, 29(2), 199–210.

Halicioglu, F., 2009. An econometric study of CO2 emissions, energy consumption, income and foreign trade in Turkey. Energy Policy, 37(3), 1156-1164. doi:10.1016/j.enpol.2008.11.012

Han Z.Y., Wei, Y. M., Jiao, J.L., Fan, Y., Zhang, J. T., 2004. On the Cointegration and Causality between Chinese GDP and Energy Consumption. Systems Engineering, 12. doi:CNKI:SUN:GCXT.0.2004-12-004

Hansen, B. E., Seo, B., 2002. Testing for two-regime threshold cointegration in vector error-correction models. Journal of Econometrics, 110, 293–318.

Hao-Yen, Y., 2000. A note on the causal relationship between energy and GDP in Taiwan. Energy Economics, 22(3), 309–317. dx.doi.org/10.1016/S0140-9883(99)00044-4

Heo, J. Y., Yoo, S. H., Kwak, S.J., 2011. The Causal Relationship Between Nuclear Energy Consumption and Economic Growth in India, Energy Sources, Part B: Economics, Planning, and Policy, 6(2), 111-117. doi:10.1080/15567240802533971

Ho, C. Y., Siu, K. W., 2007. A dynamic equilibrium of electricity consumption and GDP in Hong Kong: An empirical investigation. Energy Policy, 35(4), 2507-2513. doi:10.1016/j.enpol.2006.09.018

Holtedahl, P., Joutz, F. L., 2004. Residential electricity demand in Taiwan. Energy Economics, 26, 201–224

Hondroyiannis, G., 2002. Energy consumption and economic growth: assessing the evidence from Greece. Energy Economics, 24(4), 319-336. doi:10.1016/S0140-9883(02)00006-3

Hondroyiannis, G., Lolos, S., Papapetrou, E., 2002. Energy consumption and economic growth: assessing the evidence from Greece. Energy Economics, 24, 319–336.

Hu, J. L., Lin, C. H., 2008. Disaggregated energy consumption and GDP in Taiwan: A threshold co-integration analysis. Energy Economics, 30(5), 2342-2358. doi:10.1016/j.eneco.2007.11.007

Huang, J. P., 1993. Electricity consumption and economic growth: a case study of China. Energy Policy 21, 717–720.

Huang, B. N., Hwang, M. J., Yang, C. W., 2008. Causal relationship between energy consumption and GDP growth revisited: A dynamic panel data approach. Ecological Economics, 67(1), 41-54. doi:10.1016/j.ecolecon.2007.11.006

Hwang, D., Gum, B., 1991. The causal relationship between energy and GNP: the case of Taiwan. Journal of Energy Development, 16, 219–226.

Jinke, L., Hualing, S., Dianming, G., 2008. Causality relationship between coal consumption and GDP: Difference of major OECD and non-OECD countries. Applied Energy, 85(6), 421–429. dx.doi.org/10.1016/j.apenergy.2007.10.007

Jobert, T., Karanfil, F., 2007. Sectoral energy consumption by source and economic growth in Turkey. Energy Policy, 35, 5447–5456.

Jumbe, C., 2004. Cointegration and causality between electricity consumption and GDP: empirical evidence from Malawi. Energy Economics, 26(1), 61-68. doi:10.1016/S0140-9883(03)00058-6

Kahsai, M. S., Nondo, C., Schaeffer, P. V., Gebremedhin, T. G., 2012. Income level and the energy consumption–GDP nexus: Evidence from Sub-Saharan Africa. Energy Economics, 34(3), 739-746. doi:10.1016/j.eneco.2011.06.006

Karanfil, F., 2008. Energy consumption and economic growth revisited: Does the size of unrecorded economy matter? Energy Policy, 36(8), 3029-3035. doi:10.1016/j.enpol.2008.04.002

Kouakou, A. K., 2011. Economic growth and electricity consumption in Cote d'Ivoire: Evidence from time series analysis. Energy Policy, 39(6), 3638-3644. doi:10.1016/j.enpol.2011.03.069

Kraft, J., Kraft, A., 1978. On the relationship between energy and GNP. Journal of Energy and Development, 3, 401–403.

Kumar, S., 2011. Cointegration and the demand for energy in Fiji. International Journal of Global Energy Issues, 35(1), 85. doi:10.1504/IJGEI.2011.039986

Lean, H. H., Smyth, R., 2010. Multivariate Granger causality between electricity generation, exports, prices and GDP in Malaysia. Energy, 35(9), 3640-3648. doi:10.1016/j.energy.2010.05.008

Lee, C. C., 2005. Energy consumption and GDP in developing countries: A cointegrated panel analysis. Energy Economics, 27(3), 415-427. doi:10.1016/j.eneco.2005.03.003

Lee, C. C., Chang, C. P., 2005. Structural breaks, energy consumption, and economic growth revisited: Evidence from Taiwan. Energy Economics, 27(6), 857-872. doi:10.1016/j.eneco.2005.08.003

Lee, C., 2006. The causality relationship between energy consumption and GDP in G-11 countries revisited. Energy Policy, 34(9), 1086-1093. doi:10.1016/j.enpol.2005.04.023

Lee, C. C., Chang, C. P., 2007a. Energy consumption and GDP revisited: A panel analysis of developed and developing countries. Energy Economics, 29(6), 1206-1223. doi:10.1016/j.eneco.2007.01.001

Lee, C. C., Chang, C. P., 2007b. The impact of energy consumption on economic growth: evidence from linear and nonlinear models in Taiwan. Energy, 32(12), 2282-2294. doi:10.1016/j.energy.2006.01.017

Lee, C. C., Chang, C. P., 2008. Energy consumption and economic growth in Asian economies: A more comprehensive analysis using panel data. Resource and Energy Economics, 30(1), 50-65. doi:10.1016/j.reseneeco.2007.03.003

Lee, C. C., Chang, C. P., Chen, P. F., 2008. Energy–income causality in OECD countries revisited: the key role of capital stock. Energy Economics, 30, 2359–2373.

Lise, W., Van Montfort, K., 2007. Energy consumption and GDP in Turkey: is there a co-integration relationship?. Energy Economics, 29, 1166–1178.

Magazzino, C., 2011. Energy consumption and aggregate income in Italy: cointegration and causality analysis. Unpublished. Available at: http://mpra.ub.uni-muenchen.de/28494/

Mahadevan, R., Asafu-Adjaye, J., 2007. Energy consumption, economic growth and prices: A reassessment using panel VECM for developed and developing countries. Energy Policy, 35(4), 2481-2490. doi:10.1016/j.enpol.2006.08.019

Masih, A., Masih, R., 1996. Energy consumption and real income temporal causality, results for a multi-country study based on cointegration and error- correction techniques. Energy Economics, 18, 165–183

Masih, A. M. M., Masih, R., 1997. On temporal causal relationship between energy consumption, real income and prices; some new evidence from Asian energy dependent NICs based on a multivariate cointegration/vector error correction approach. Journal of Policy Modeling, 19(4), 417–440.

Masih, A. M. M., Masih, R., 1998. A multivariate cointegrated modelling approach in testing temporal causality between energy consumption, real income and prices with an application to two Asian LDCs. Applied Economics, 30(10), 1287-1298. doi**:** 10.1080/000368498324904

Mehrara, M., 2007. Energy consumption and economic growth: The case of oil exporting countries. Energy Policy, 35(5), 2939-2945. doi:10.1016/j.enpol.2006.10.018

Mishra, V., Sharma, S., Smyth, R., 2009a. Are fluctuations in energy consumption per capita transitory? Evidence from a panel of Pacific Island countries. Energy Policy, 37(6), 2318–2326.

Mishra, V., Smyth, R., Sharma, S., 2009b. The energy-GDP nexus: Evidence from a panel of Pacific Island countries. Resource and Energy Economics, 31(3), 210-220. doi:10.1016/j.reseneeco.2009.04.002

Morimoto, R., Hope, C., 2004. The impact of electricity supply on economic growth in Sri Lanka. Energy Economics. doi:10.1016/S0140-9883(03)00034-3

Mozumder, P., Marathe, A., 2007. Causality relationship between electricity consumption and GDP in Bangladesh. Energy Policy, 35, 395–402.

Murray, D. A., Nan, G. D., 1996. A definition of the gross domestic product- electrification interrelationship. Journal of Energy and Development, 19, 275–283.

Nachane, D. M., Nadkarni, R. M., Karnik, A. V., 1988. Cointegration and causality testing of the energy–GDP relationship: a cross-country study. Applied Economics, 20(11), 1511–1531.

Narayan, P. K., Smyth, R., 2005. Electricity consumption , employment and real income in Australia evidence from multivariate Granger causality tests. Energy Policy, 33, 1109-1116. doi:10.1016/j.enpol.2003.11.010

Narayan, P. K., Singh, B., 2007. The electricity consumption and GDP nexus dynamic Fiji Islands. Energy Economics, 29, 1141–1150.

Narayan, P. K., Prasad, A., 2008. Electricity consumption–real GDP causality nexus: evidence from a boots trapped causality test for 30 OECD countries. Energy Policy, 36, 910–918.

Narayan, P. K., Smyth, R., 2008. Energy consumption and real GDP in G7 countries: new evidence from panel cointegration with structural breaks. Energy Economics, 30, 2331–2341.

Narayan, P. K., Smyth, R., 2009. Multivariate Granger causality between electricity consumption, exports and GDP: Evidence from a panel of Middle Eastern countries. Energy Policy, 37(1), 229-236. doi:10.1016/j.enpol.2008.08.020

Narayan, P. K., Wong, P., 2009. A panel data analysis of the determinants of oil consumption: The case of Australia. Applied Energy, 86(12), 2771-2775. doi:10.1016/j.apenergy.2009.04.035

Narayan, P. K., Narayan, S., Popp, S., 2010. A note on the long-run elasticities from the energy consumption–GDP relationship. Applied Energy, 87(3), 1054-1057. doi:10.1016/j.apenergy.2009.08.037

Odhiambo, N. M., 2009a. Electricity consumption and economic growth in South Africa: A trivariate causality test. Energy Economics, 31(5), 635-640. Elsevier B.V. doi:10.1016/j.eneco.2009.01.005

Odhiambo, N. M., 2009b. Energy consumption and economic growth nexus in Tanzania: An ARDL bounds testing approach. Energy Policy, 37(2), 617-622. doi:10.1016/j.enpol.2008.09.077

Oh, W., Lee, K., 2004a. Causal relationship between energy consumption and GDP: the case of Korea 1970–1999. Energy Economics, 26(1), 51–59.

Oh, W., Lee, K., 2004b. Causal relationship between energy consumption and GDP revisited: the case of Korea 1970–1999. Energy Economics, 26(1), 51-59. doi:10.1016/S0140-9883(03)00030-6

Ozturk, I., Acaravci, A., 2010. The causal relationship between energy consumption and GDP in Albania, Bulgaria, Hungary and Romania: Evidence from ARDL bound testing approach. Applied Energy, 87(6), 1938-1943. doi:10.1016/j.apenergy.2009.10.010

Ozturk, I., Aslan, A., Kalyoncu, H., 2010. Energy consumption and economic growth relationship: Evidence from panel data for low and middle income countries. Energy Policy, 38(8), 4422-4428. doi:10.1016/j.enpol.2010.03.071

Ozturk, I., Acaravci, A., 2011. Electricity consumption and real GDP causality nexus: Evidence from ARDL bounds testing approach for 11 MENA countries. Applied Energy, 88(8), 2885-2892. doi:10.1016/j.apenergy.2011.01.065

Paul, S., Bhattacharya, R., 2004. Causality between energy consumption and economic growth in India: a note on conflicting results. Energy Economics, 26(6), 977-983. doi:10.1016/j.eneco.2004.07.002

Payne, J. E., 2009. On the dynamics of energy consumption and output in the US. Applied Energy, 86(4), 575-577. doi:10.1016/j.apenergy.2008.07.003

Payne, J. E., Taylor, J. P., 2010. Nuclear Energy Consumption and Economic Growth in the U.S.: An Empirical Note. Energy Sources, Part B: Economics, Planning, and Policy, 5(3), 301-307. doi:10.1080/15567240802533955

Pesaran, H. M., Shin, Y., Smith, R. J., 2001.Bounds testing approaches to the analysis of long-run relationships. Journal of Applied Econometrics, 16, 289–326.
Ramcharran, H., 1990. Electricity consumption and economic growth in Jamaica. Energy Economics, 12(1), 65-70. doi:10.1016/0140-9883(90)90009-5

Reynolds, D. B., Kolodziej, M., 2008. Former Soviet Union oil production and GDP decline: Granger causality and the multi-cycle Hubbert curve. Energy Economics, 30(2), 271–289. dx.doi.org/10.1016/j.eneco.2006.05.021

Sari, R., Soytas, U., 2007. The growth of income and energy consumption in six developing countries. Energy Policy, 35, 889–898.

Sari, R., Ewing, B. T., Soytas, U., 2008. The relationship between disaggregate energy consumption and industrial production in the United States: An ARDL approach. Energy Economics, 30(5), 2302–2313. dx.doi.org/10.1016/j.eneco.2007.10.002

Shin, Y., Smith, R. J., 2001. Bounds testing approaches to the analysis. Journal of Applied Econometrics, 16(3), 289- 326. doi:10.1002/jae.616

Shiu, A., Lam, P. L., 2004. Electricity consumption and economic growth in China. Energy Policy, 32(1), 47-54. doi:10.1016/S0301-4215(02)00250-1

Shuyun, Y., Donghu, Y., 2011. The Causality between Energy Consumption and Economic Growth in China: Using Panel Method in a Multivariate Framework. Energy Procedia, 5, 808-812. doi:10.1016/j.egypro.2011.03.142

Soytas, U., Sari, R., Ozdemir, O., 2001. Energy Consumption and GDP Relations in Turkey: A Cointegration and Vector Error Correction Analysis. Economies and Business in Transition: Facilitating Competitiveness and Change in the Global Environment Proceedings, Global Business and Technology Association", 838-844. Available at: /http://sari_r2.web.ibu.edu.tr/yayinlarim/Ener gy%20Soytas_Sari_Ozdemir.pdfS.

Soytas, U., Sari, R., 2003. Energy consumption and GDP: causality relationship in G-7 countries and emerging markets Soytas, U. and Sari, R. Energy Economics, 2003, 25, (1), 33–37. Fuel and Energy Abstracts, 44(4), 266. doi:10.1016/S0140-6701(03)82242-7

Soytas, U., Sari, R., 2006a. Can China contribute more to the fight against global warming? Journal of Policy Modeling, 28(8), 837-846. doi:10.1016/j.jpolmod.2006.06.016

Soytas, U., Sari, R., 2006b. Energy consumption and income in G-7 countries, 28, 739-750. doi:10.1016/j.jpolmod.2006.02.003

Soytas, U., Sari, R., 2007. The relationship between energy and production: Evidence from Turkish manufacturing industry. Energy Economics, 29(6), 1151-1165. doi:10.1016/j.eneco.2006.05.019

Soytas, U., Sari, R., 2009. Energy consumption, economic growth, and carbon emissions: Challenges faced by an EU candidate member. Ecological Economics, 68(6), 1667-1675. doi:10.1016/j.ecolecon.2007.06.014

Squalli, J., 2007. Electricity consumption and economic growth: bounds and causality analyses for OPEC members. Energy Economics, 29, 1192–1205.

Stern, D. I., 1993. Energy and economic growth in the USA. A multivariate approach. Energy Economics, 15, 137–150.

Stern, D. I., 2000. A multivariate cointegration analysis of the role of energy in the US macroeconomy. Energy Economics, 22(2), 267-283. doi:10.1016/S0140-9883(99)00028-6

Suri, V., 1998. Economic growth, trade and energy: implications for the environmental Kuznets curve. Ecological Economics, 25(2), 195-208. doi:10.1016/S0921-8009(97)00180-8

Tang, C. F., 2008. A re-examination of the relationship between electricity consumption and economic growth in Malaysia. Energy Policy, 36(8), 3077-3085. doi:10.1016/j.enpol.2008.04.026

Thoma, M., 2004. Electrical energy usage over the business cycle. Energy Economics, 26(3), 463-485. doi:10.1016/j.eneco.2004.04.006

Tiwari, A. K., 2011. A structural VAR analysis of renewable energy consumption , real GDP and and CO2 emissions: Evidence from India. Economics Bulletin, 31(2), 1793-1806.

Tsani, S. Z., 2010. Energy consumption and economic growth: A causality analysis for Greece. Energy Economics, 32(3), 582-590. doi:10.1016/j.eneco.2009.09.007

Warr, B. S., Ayres, R. U., 2010. Evidence of causality between the quantity and quality of energy consumption and economic growth. Energy, 35(4), 1688–1693. dx.doi.org/10.1016/j.energy.2009.12.017

Wolde-Rufael, Y., 2004. Disaggregated industrial energy consumption and GDP: the case of Shanghai, 1952 – 1999. Energy Economics, 26(1), 69-75. dx.doi.org/10.1016/S0140-9883(03)00032-X

Wolde-Rufael, Y., 2005. Energy demand and economic growth: The African experience. Journal of Policy Modeling, 27(8), 891-903. doi:10.1016/j.jpolmod.2005.06.003

Wolde-Rufael, Y., 2006. Electricity consumption and economic growth: a time series experience for 17 African countries. Energy Policy, 34, 1106–1114.

Wolde-Rufael, Y., 2009. Energy consumption and economic growth: The experience of African countries revisited. Energy Economics, 31(2), 217-224. doi:10.1016/j.eneco.2008.11.005

Wolde-Rufael, Y., 2010a. Bounds test approach to cointegration and causality between nuclear energy consumption and economic growth in India. Energy Policy, 38(1), 52-58. doi:10.1016/j.enpol.2009.08.053

Wolde-Rufael, Y., 2010b. Coal consumption and economic growth revisited. Applied Energy, 87(1), 160-167. doi:10.1016/j.apenergy.2009.05.001

Yang, H. Y., 2000. A note on the causal relationship between energy and GDP in Taiwan. Energy Economics, 22(3), 309-317. doi:10.1016/S0140-9883(99)00044-4

Yanqin, M., 2011. Study on energy consumption ingredients and economic growth in Henan based on co-integration and granger test. International Conference on Management Science and Industrial Engineering (MSIE), IEEE Conference Publication, 307-311. doi:10.1109/MSIE.2011.5707723

Yin J., Wang, Z., 2011. The relationship between energy consumption and economic growth in China, based the on data in the period of 1953-2008, Science research Management, 7.

Yoo, S. H., 2005. Electricity consumption and economic growth: evidence from Korea. Energy Policy, 33(12), 1627-1632. doi:10.1016/j.enpol.2004.02.002

Yoo, S. H., Jung, K. O., 2005. Nuclear energy consumption and economic growth in Korea. Progress in Nuclear Energy, 46(2), 101–109. dx.doi.org/10.1016/j.pnucene.2005.01.001

Yoo, S. H., 2006. Causal relationship between coal consumption and economic growth in Korea. Applied Energy, 83(11), 1181-1189. doi:10.1016/j.apenergy.2006.01.010

Yoo, S. H., Kim,Y., 2006. Electricity generation and economic growth in Indonesia. Energy, 31(14), 2890–2899.

Yoo, S. H., 2006. The causal relationship between electricity consumption and economic growth in the ASEAN countries. Energy Policy, 34(18), 3573-3582. doi:10.1016/j.enpol.2005.07.011

Yoo, S. H., Lee, J. S., 2010. Electricity consumption and economic growth: a cross-country analysis. Energy Policy, 38 , 622–625

Yoo, S. H., Kwak, S. Y., 2010. Electricity consumption and economic growth in seven South American countries. Energy Policy, 38(1), 181-188. doi:10.1016/j.enpol.2009.09.003

Yu, E. S. H., Hwang, B. K., 1984. The relationship between energy and GNP: Further results. Energy Economics, 6(3), 186-190. doi:10.1016/0140-9883(84)90015-X

Yu, E. S. H., Choi, J. Y., 1985. The causal relationship between energy and GNP: an international comparison. Journal of Energy and Development, 10, 249–272.

Yu, E. S. H., Jin, J. C., 1992. Cointegration consumption, tests of energy income , and employment. Journal Of Energy And Development, 14(3), 259-266. dx.doi.org/10.1016/0165-0572(92)90010-E

Yuan, J., Zhao, C., Yu, S., Hu, Z., 2007. Electricity consumption and economic growth in China: cointegration and co-feature analysis. Energy Economics, 29, 1179–1191.

Yuan, J., Kang, J. G., Zhao, C., Hu, Z., 2008. Energy consumption and economic growth: evidence from China at both aggregated and disaggregated levels. Energy Economics, 30 (6), 3077–3094

Zachariadis, T., 2007. Exploring the relationship between energy use and economic growth with bivariate models: new evidence from G-7 countries. Energy Economics, 29 (6), 1233–1253.

Zachariadis, T., Pashouortidou, N., 2007. An empirical analysis of electricity consumption in Cyprus. Energy Economics, 29, 183–198.

Zamani, M., 2007. Energy consumption and economic activities in Iran. Energy Economics, 29(6), 1135-1140. doi:10.1016/j.eneco.2006.04.008

Zarnikau, J., 1997. A reexamination of the causal relationship between energy consumption and gross national product. Journal of Energy and Development, 21, 229–239.

Zhang, X. P., Cheng, X. M., 2009. Energy consumption, carbon emissions, and economic growth in China. Ecological Economics, 68(10), 2706-2712. doi:10.1016/j.ecolecon.2009.05.011

Zhixin, Z., Xin, R., 2011. Causal Relationships between Energy Consumption and Economic Growth. Energy Procedia, 5, 2065-2071. dx.doi.org/10.1016/j.egypro.2011.03.356

Ziramba, E., 2009. Disaggregate energy consumption and industrial production in South Africa. Energy Policy, 37(6), 2214–2220. dx.doi.org/10.1016/j.enpol.2009.01.048

Zou, G., Chau, K. W., 2006. Short- and long-run effects between oil consumption and economic growth in China. Energy Policy, 34(18), 3644–3655. dx.doi.org/10.1016/j.enpol.2005.08.009

References

Anderson, J. A., 1982. Logistic Regression, in: Handbook of Statistics. North-Holland, New York

Agresti, A., 1996. An Introduction to Categorical Data Analysis. John Wiley, New York.

Beaudreau, B. C., 2010. On the methodology of energy-GDP Granger causality tests. Energy, 35(9), 3535-3539. doi:10.1016/j.energy.2010.03.062

Bithas, K., Nijkamp, P., 1997a. Decisive conditions for an effective and efficient multi-modal freight transport network in Europe: A meta-analytic perspective. Tinbergen Institute, Netherlands.

Bithas, K., Nijkamp, P., 1997b. Critical factors for an effective and efficient multi-modal freight transport network in Europe. Innovation: The European Journal of Social Science Research, 10(3), 243-258. DOI**:** 10.1080/13511610.1997.9968530

Duntsch, I., Gunther, G., 1998. Simple data filtering in rough set systems. International Journal of Approximate Reasoning, 18, 93-106

DeCoster, J., 2004. Meta-analysis Notes. Retrieved <3/15/2012> from http://www.stat-help.com/notes.html

Engle, R. F., Granger, C. W. J., 1987. Co-integration and error correction: Representation, estimation and testing. Econometrica, 55(2), 251-276.

Glass, G. V., 1976. Primary, Secondary and Meta-Analysis of Research. Educational Researcher, 5 (10), 3-8

Granger, C. W. J., 1969. Investigating causal relations by econometric model and cross spectral methods. Econometrica, 37(3), 424-438.

Hawcroft, J. L., Milfont, L. T., 2010. The use (and abuse) of the new environmental paradigm scale over the last 30 years: A meta-analysis. Journal of Environmental Psychology, 30, 143-158

Hsiao, C., 1981. Autoregressive Modeling and Money Income Causality Detection. Journal of Monetary Economics, 7, 85–106.

Johansen, S., Juselius, K., 1990. Maximum Likelihood Estimation and Inferences on Cointegration with Application to the Demand for Money. Oxford Bulletin of Economics and Statistics, 52, 169–210.

Karanfil, F., 2009. How many times again will we examine the energy-income nexus using a limited range of traditional econometric tools? Energy Policy, 37(4), 1191-1194. doi:10.1016/j.enpol.2008.11.029

Kaufmann, R., 1992. A biophysical analysis of the energy/real GDP ratio: implications for substitution and technical change. Ecological Economics, 6(1), 35-56. doi:10.1016/0921-8009(92)90037-S

Komorowski, J., Øhrn, A., Skowron, A., 2002. The ROSETTA Rough Set Software System, In Handbook of Data Mining and Knowledge Discovery, W. Klösgen and J. Zytkow (eds.), ch. D.2.3, Oxford University Press. ISBN 0-19-511831-6.

Kusiak, A., 2001. Rough Set Theory: A Data Mining Tool for Semiconductor Manufacturing. IEEE Transactions on electronics packaging manufacturing, 21 (1), 44-50

Øhrn, A., Komorowski, J., 1997. ROSETTA: A Rough Set Toolkit for Analysis of Data, Proc. Third International Joint Conference on Information Sciences, Fifth International Workshop on Rough Sets and Soft Computing (RSSC'97), Durham, NC, USA, 3, 403-407.

Ozturk, I., 2010. A literature survey on energy–growth nexus. Energy Policy, 38(1), 340-349. Elsevier. doi:10.1016/j.enpol.2009.09.024

Pawlak, Z., 1982. Rough sets. International Journal of Information and Computer sciences, 11 (5), 341-356

Pawlak, Z., 1991. Rough Sets – Theoretical Aspects of Reasoning about Data. Kluwer Academic Publisher

Payne, J. E., 2010. Survey of the international evidence on the causal relationship between energy consumption and growth. Journal of Economic Studies, 37(1), 53-95. doi:10.1108/01443581011012261

Pedroni, P., 1999. Critical values for cointegration tests in heterogeneous panels with multiple regressors, Oxford Bulletin of Economics and Statistics, 61, 653–670.

Pesaran, M. H., Shin, Y., Smith, R. J., 2001. Bounds testing approaches to the analysis of level relationships. Journal of Applied Econometrics, 16(3), 289- 326. doi: 10.1002/jae.616.

Rupp, T., 2005. Rough set methodology in meta-analysis. A comparative and exploratory analysis. Darmstast Discussion Papers in Economics, Nr: 157

Sims, C. A., 1972. Money, income, and causality.American Economic Review, 62, 540-552.

Slowinski, R., 1993. Handbook of Applications and Advances of Rough Sets Theory, Kluwer Academic Publisher

Stern, D., 2011. The role of energy in economic growth. Ann. N.Y. Acad. Sci. 1219, 26-51. doi: 10.1111/j.1749-6632.2010.05921.x

Toda, H. Y., Yamamoto, T., 1995. Statistical inferences in vector autoregressions with possibly integrated processes. Journal of Econometrics, 66, 225-50.

Warr, B., Ayres, R., Eisenmenger, N., Krausmann, F., Schandl, H., 2010. Energy use and economic development: A comparative analysis of useful work supply in Austria, Japan, the United Kingdom and the US during 100 years of economic growth. Ecological Economics, 69 (10), 1904-1917. doi: 10.1016/j.ecolecon.2010.03.021.