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On the relationship between energy and development: A comprehensive note on causation and correlation

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ABSTRACT

[1,2] are two highly cited studies on the relationship between energy and development. These are two seminal empirical papers touching upon the notions of *causation* and *correlation*, respectively, as far as energy economics is concerned. This study is a comprehensive note on these notions' interconnectedness by revisiting both studies thoroughly and globally. None of these studies has ever been revisited at a global scale to the best of our knowledge. To this end, we first review deeper conceptual and philosophical concerns towards *causation* and *correlation* for making a clear distinction between *true* and *spurious causation/correlation*. We then develop a novel method to exclude *spurious* measures from the true ones. We also statistically test several hypotheses regarding the relationship between energy use and wealth creation as captured by income groups. We could not confirm a definite consistency in pair-wise *causation* between energy and welfare variables at the country levels and across distinct estimation periods. Nor could we denote any strong *correlation* between energy variables and wealth creation. Causation results are not surprising as previous studies asserted similar remarks. However, this study firmly says that these are mainly due to *the circularity* and *non-linearity* of the inter-relationships between energy and welfare variables over time, as new institutions might influence development processes.

1. Introduction

Understanding the nature of the inter-relationship between energy use and economic development (nations' affluence or welfare) is of great importance with significant country-specific policy implications. This is about an empirical and contextual investigation of the complex nature of the *energy-welfare nexus*. In most cases, though, it is practically reduced to studying *energy-output*, *energy-economy,* or *energy-growth nexus*. The policy implications may vary from country to country, motivating each country's development strategies differently.

Since the energy crises of the 1970s, such *nexus* analysis has gained increasing attention among economists, environmentalists, and policy-makers alike. [3] is a comprehensive systematic literature survey on the *energy-output nexus*. Among thousands of papers included in that survey (e.g., [4,5]; to name a few recent ones), two seminal papers stand out and deserve to be revisited thoroughly and globally for the following reasons. These influential papers are [1] (henceforth, **K & K**) and [2] (hereafter, just **Ferguson**), touching on the notions of *causation* and *correlation*, respectively.

These articles stand out because the study of the energy-welfare nexus analyses the causation between energy, output, affluence, and any other significant economic variables. For policy purposes, it is essential to determine the direction of the causation between such variables. If only two variables of energy (E) and output (Y) are concerned, there have been identified four possible causation outcomes against the following hypotheses[1]

i) ***Growth Hypothesis***: implying that energy causes economic growth ($E \rightarrow Y$)
ii) ***Conservation Hypothesis***: implying that economic growth drives the energy use ($E \leftarrow Y$)
iii) ***Feedback Hypothesis***: implying that there is a bidirectional causality ($E \leftrightarrow Y$)

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[1] These hypotheses were best articulated, firstly, in Ref. [6] A literature survey on energy–growth nexus. *Energy Policy,* 38**,** 340–349. And [7] Survey of the international evidence on the causal relationship between energy consumption and growth. *Journal of Economic Studies,* 37**,** 53–95.

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iv) ***Neutrality Hypothesis***: implying that there is no interrelationship (E − Y)

Each hypothesis's policy implications are crucial for countries' strategic and national development in the short, medium, and long run. For example, if the *conservation hypothesis* applies to a country, the energy-saving policy would not harm economic growth or a nation's wealth. Like all other literature reviews on this topic,[2] [3], identify **K & K** is the first empirical study to analyse the *causation* between energy and output variables. It is then followed by thousands of papers using various variables and approaches and in the context of various countries. Using the USA data, the article is titled "On the Relationship Between Energy and GNP", applying [13,14] method in the manner that "causality" is defined by the seminal work of [15]. Being only three pages long, **K & K** has been vastly cited by almost all empirical papers in this area. As of July 2020, this article was cited 2,781 and 1127 times in Google Scholar and Scopus, respectively. The study concludes that, in the context of the post-war period, *causality* is *unidirectional*, running from Y to E, resembling the *conservation hypothesis* (E ← Y) for the USA economy. It was such a crucial finding that energy-saving policies would not harm the USA's economic growth. Although such a finding was soon argued to be *spurious* by Ref. [16]; some papers re-affirm the same finding, while others support alternative hypotheses for the USA. Variation in findings is often associated with differences in data periods or implemented methodologies.

Apart from *causation* analysis, another reason for these two articles being important (i.e., **K & K** and **Ferguson**) is as follows. It is intuitive and handy to consider starting any *nexus* analysis with the analysis of the *correlation* between a pair of key variables in the economy. For instance, it would be helpful to calculate the correlation coefficients between per capita total primary energy (E) and per capita output, which is a measure of affluence (A). One may try other pairs of variables such as per capita electricity use (e) and affluence (A). **Ferguson** is one such study, and to date, it has remained the most comprehensive one. Using the OECD database for 1960–1995, the paper is titled "Electricity use and economic development". Apart from electricity use (e), the article has also used the primary energy use (E) as well as the ratio of electricity over primary energy (e/E) as alternative energy variables against affluence (A). It is worth mentioning that this paper has also been highly cited among scholars interested in studying the *energy-welfare nexus*. As of July 2020, it has been cited 389 and 169 times in Google Scholar and Scopus, respectively. The paper made the following firm conclusions:

> "Wealthy countries have a stronger correlation between electricity use and wealth creation than do poor countries and that, for the global economy as a whole, there is a stronger correlation between electricity use and wealth creation than there is between total energy use and wealth. The study also shows that, in wealthy countries, the increase in wealth over time correlates with an increase in the e/E ratio. The results imply that the energy ratio ($/toe) should be replaced by the electricity ratio ($/kWh) as a development indicator and, more precisely, by the e/E ratio (kWh/toe)".

Table 1
Negative or positive citation counts of ferguson article.

Year	Negative	Positive	Total
2003		2	2
2004		1	1
2005	3	1	4
2006	1	6	7
2007		2	2
2008		3	3
2009		4	4
2010	3	13	16
2011	1	6	7
2012	1	15	16
2013	2	9	11
2014	2	10	12
2015	1	9	10
2016	1	11	12
2017	3	19	22
2018		15	15
2019		13	13
Grand Total	**18 (*%11*)**	**139 (*%89*)**	**157**

In a thorough investigation – undertaken by the authors of this paper – on how **Ferguson** is cited within Scopus-indexed articles, it is revealed that the paper has been chiefly cited ***positively***, implying that no critical argument is raised against its strong concluding remarks. Nevertheless, 18 out of157[3] Scopus-indexed articles (11%) have argued merely against its use of *correlation* analysis. There is no argument against the robustness of its findings or methodology in a broader sense. The main criticism against this paper is a well-known argument. This argument is briefly stated here but will be elaborated on in further detail in the next section. All critiques are the same, just rephrased somewhat differently. Here we quote only one of them. [7] argues that "the presence of a strong correlation does not necessarily imply a causal relationship". Table 1 summarises the Ferguson article's negative and positive citation counts. We have noted that no critic has ever questioned how accurately the article has handled the notion of *spurious correlation*.

Against the above background, we contend both papers (i.e., **K & K** and **Ferguson**) are highly related to one another as pairwise *causation* and *correlation* are interconnected concepts. They deserve to be critically, thoroughly, and globally revisited, particularly in their findings' robustness. Hence, this paper's main objective is to conduct a comprehensive note on the *causation* and *correlation* between energy use (as measured by E, e and e/E) and affluence (A). To this end, the main contribution of this paper is to carefully exclude *spurious* measures from the *true* ones in a novel manner. To address methodological shortcomings applied in **K & K** and **Ferguson**, we use the error correction model (ECM) approach, allowing for short-run and long-run true *causation/correlation*. Because our emphasis is on bi-variate or pairwise *causation/correlation*, the ECM approach is justifiable and adequate. Further justifications and the details of our methodology will be elaborated in Sections 2 and 4. Another significant contribution is to test several hypotheses on whether there are any significant differences in energy-welfare correlation coefficients across income groups. We use the World Bank's income-group classifications for this purpose. On the contrary, such judgment was made in **Ferguson** based on the numerical difference of correlation coefficients across country groups using an ad hoc classification. To the best of our knowledge, these papers have never been revisited on a global scale, considering their interconnectedness.

[2] Being the first systematic literature review of its kind on this topic [3], identifies seven independent traditional literature reviews in this area, namely [6]: A literature survey on energy–growth nexus. *Energy Policy,* 38, 340–349 [8]. Survey of the electricity cunsumption-growth literature. *Applied Energy*, 723–731 [7], Survey of the international evidence on the causal relationship between energy consumption and growth. *Journal of Economic Studies,* 37, 53–95 [9]. An international literature survey on energy-economic growth nexus: Evidence from country-specific studies. *Renewable and sustainable energy reviews,* 38, 951–959 [10]. On energy consumption and GDP studies; A meta-analysis of the last two decades. *Renewable and sustainable energy reviews,* 29, 31–36 [11]. Use renewables to be cleaner: meta-analysis of the renewable energy consumptionâ€"economic growth nexus. *Renewable and sustainable energy reviews,* 42, 657–665. And [12] Literature survey on the relationships between energy, environment and economic growth. *Renewable and sustainable energy reviews,* 69, 1129–1146.

[3] This only counts the citations by the end of 2019.

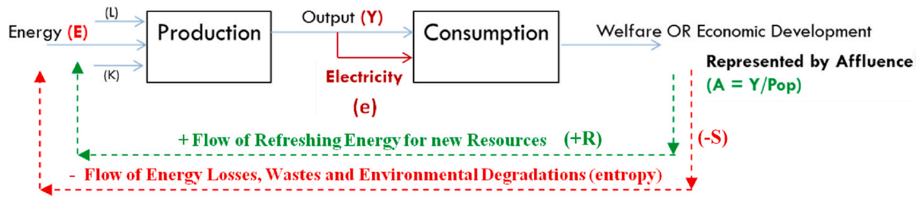


Fig. 1. Schematic flow diagram of *Energy-Welfare Nexus*.

Our main results suggest that due to the *non-stationarity* of energy variables (e, E and e/E) and affluence (A), most pairwise *causation/correlation* indicators, at the level, are *spurious*. We hence argue that the notion of spurious causation/correlation is naïvely addressed in **K & K** and **Ferguson**, creating illusions and falsified conclusions. Overall, our analysis suggests that *causation* and *correlation* indicators are time-dependent and circularly dynamic, depending on each country's technological, institutional, or cultural advancement (i.e., development stages). Therefore, any country-specific development policy should rely on a proper understanding of such dynamics.

The rest of the paper is organised as follows: Section 2 provides a deeper conceptual and philosophical understanding of *causation* and *correlation* notions regarding the *energy-welfare nexus*. Section 3 discusses the data considerations. Section 4 elaborates on this paper's methods and procedures to distinguish between *spurious* and *true causation/correlation* indicators. Section 5 summarises the most intriguing results. Finally, Section 6 concludes and provides some policy implications.

2. Conceptual and philosophical concerns

Fig. 1 is a simplified schematic flow diagram showing the *energy-welfare nexus*. So far, the most relevant variables found in the previous studies are shown in this diagram. These include total primary energy (E), electricity (e), aggregate output (Y as captured by real GDP or real GNP), and affluence (A). The affluence (A) is an indicator of welfare or development, mostly measured by per capita output (Y/Pop).[4] Variable E should include energy and non-energy mineral resources from the natural environment in its broadest sense. In conventional economics textbooks, this is called *Land*. Still, it has all resources beneath the *Land* (minerals, groundwater, etc.) and above it (air and entire atmospheric resources) and freshwater and sea resources. Nonetheless, in most empirical studies on the *energy-welfare nexus*, variable E is merely reduced to primary energy resources such as fossil-based energy carriers (i.e., coal, crude oil, and natural gas) and non-fossil-based renewable energy carriers (e.g., solar, hydro and alike). Other economic resources, namely Labour (L) and Capital (K), are also energy carriers as they encapsulate stock or flow of human-created forces in economic activities (workforce as well as machines and equipment used in the process of consumption and production). Variables L and K are generally paid lesser attention in existing studies, and the emphasis has been mostly on E, e, Y and A variables.

Fig. 1 also shows that *energy-welfare nexus* analysis is a circular and dynamic process. Thus, there are two distinct feedback flows of energy from the affluence variable (A) back to economic resources (E, L and K). These include:

(i) A positive, refreshing/recreating/exploring/recycling/recovering flow of available energy (boosted by desirable outputs – the affluence) for making more resources available to the economy (**+R**)
(ii) A negative flow of unavailable energy related to environmental degradation created from undesirable outputs in various forms of wastes or energy losses (**-S**)

The most frequently used variable for this negative flow (**-S**) is atmospheric wastes known as Green House Gases (GHG), such as CO_2, but solid and liquid wastes and other losses should also be considered. Depending on the *assimilative capacity* of Mother Nature, this negative flow may cause a range of irreversible harm to economies and human welfare from a negligible to immense magnitude. Variable **-S** is the *entropy* of economic systems. According to the second law of thermodynamics, it always exists and cannot be eliminated. The *assimilative capacity* is a natural recycling factory, fixing unavailable energy/matters back into available forms for human use. Typical examples are the natural water cycle, carbon cycles, and alike. The speed of natural assimilation, measured by the *footprints*, does indeed matter. The worst-case scenario may lead to a mass extinction of species (flora and fauna). As long as the positive, refreshing flow is greater than the entropy's flow, the economic development will be globally *sustainable* ($+R \geq -S$).

Like other scientists, economists are interested in "cause and effect" regarding the nature of human behaviour concerning economic actions (production, consumption, and trade) and the allocation of resources. We know that sorting out *causality* from *correlation* turns to become a challenge. Sometimes, this would be misleading because most economic variables are time-dependent, like Fig. 1. A common logical error occurs when you observe that event "A" frequently and consistently happens before event "B". Simply because of this observation, we should not jump to the conclusion that "A caused B". Post *hoc* or *ergo propter hoc* fallacy is a well-known philosophical pitfall. It means "after this (in time), therefore because of this" [17]. We call such falsified reasoning *spurious causation*. This fallacy in human reasoning often occurs simply because A and B's correlation coefficients become close to one. However, such a high *correlation* is *spurious*, too.

Spurious *causation* and *correlation* are like illusions, i.e., wrong or misinterpreted perceptions. Scientists make every effort to avoid illusions by conducting carefully designed experimentation. In reality, there are numerous variables involved in every phenomenon (X, Y, Z, etc.). Under consistent replication processes, scientists aim to keep every other variable constant (known as *laboratory condition*) and only allow the effect of one variable (say X) on another variable (say Y) and vice versa. It is under such replicable experimentation that they can test the

[4] We understand that development is a multi-attribute state of a nation's welfare. Although per capita output is broadly used, it may not be adequate for this purpose. One may consider using Human Development Index (HDI) or other available indicators for this purpose. It should also be mentioned that the terms development, welfare, affluence, and wealth creation are used somewhat equivalent throughout this article.

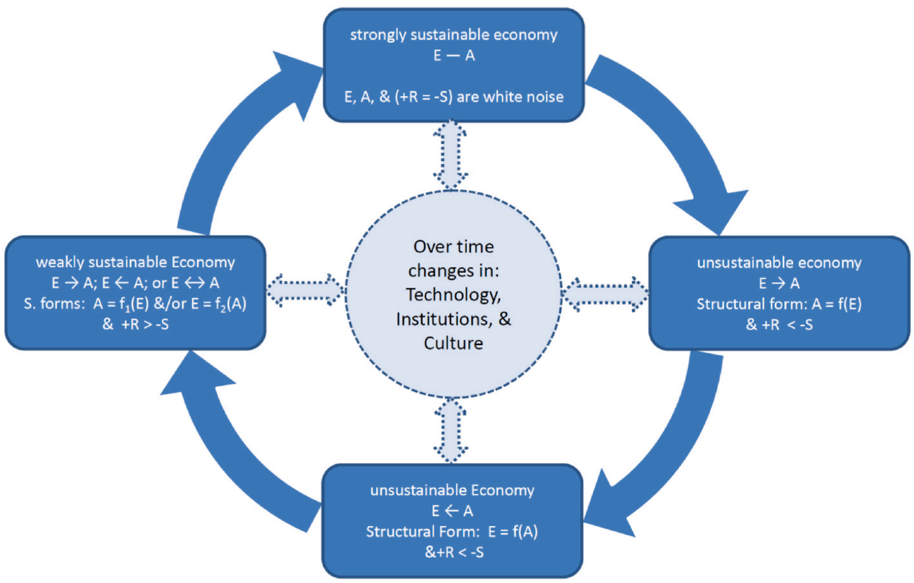


Fig. 2. Circular dynamics of energy-welfare nexus.

above-described quadruplet hypotheses: X → Y; X ← Y; X ↔ Y; and X–Y. Starting from *hypotheses* testing, scientists then can construct *theories* and sometimes discover scientific *Laws*. This is how science evolves. In this process, scientists often test a specific functional relationship between X and Y (be it a linear or non-linear mathematical function) as their *priori hypothesis/theory*. The notion of "true" *causation* can only be realised in such a process of scientific experimentation over natural phenomena.

At first, things appear to be a bit simpler regarding the correlation notion. Calculation of correlation coefficient[5] is a test against whether there is a linear mutual bound between two variables (X and Y), irrespective of the direction of *causation*. Nevertheless, the replication of observations under laboratory conditions must still be held in such a calculation. Otherwise, one may calculate "spurious" *correlations*. It is crucial to understand that non-linear *causation* may push the correlation coefficient away from being perfect (close to −1 or +1) and create a tendency towards zero *correlation*. That is to say that X and Y may hold a "true" non-linear *causation* while having no strong *correlation*.

There is no such luxury as a controlled laboratory condition in economics and social sciences. Observations are often recorded once only as time passes (time-series data). There is no chance of replications like the way that natural scientists do.[6] Therefore, keeping certain variables constant (*ceteris paribus*) is almost impossible while allowing others to change. Thus, economists and statisticians have developed alternative methodologies to overcome this problem. They must implement various statistical tests against collected data to assure that changes in variables are *white noise*, having a normal distribution with a constant mean and constant standard deviation. Otherwise, the time-dependency of variables may lead to spurious *causation/correlation* outcomes. Statisticians have been far ahead of economists working with time-series data in scientific vigilance. Ref. [3] identifies seven distinct generational breakthroughs in the evolution of the methodologies used by economists for *causation* analyses. These are inclusive of those four generations presented by Ref. [19] and comprise:

i) **The 1970s and earlier:** General Equilibrium (*GE*) or Classic Econometrics (CE)
ii) **1972–1978:** Vector Autoregressive (*VAR*)
iii) **1987:** Bi-variate Error Correction Model (*ECM*)
iv) **1990–1991:** Multivariate Vector Error Correction Model (*VECM*)
v) **1995–2001:** Toda-Yamamoto (*TY*) and Autoregressive Distributed Lag (*ARDL*)
vi) **1998–1999:** Panel Analyses (*PA*)[7]
vii) **The 2000s onward:** Structural Vector Autoregressive (*VARX*)

After the emergence of VAR models, the nature of *causality* started to be appropriately and objectively tested against observable economic data. [13,14] developed a mechanical procedure (test) for identifying the *causality* between a pair of variables in the manner that "causality" is defined by Ref. [15]. This method assumes stationarities for all variables (i.e., *white noise*). This is the methodology used in **K & K** for the first time in energy economics (i.e., *energy-welfare nexus* analysis). It is worth mentioning that such *causality* is rather called "*Granger Causality*". Under the notion of *Granger Causality*, there is no *priori theory* under test, like those used by natural scientists. All possible quadruplet causality hypotheses are tested simultaneously. It is often stated that "let rather data talk" and determine the causality relationship as a *posterior theory* known as *Granger Causality*. The methodology for *Granger Causality* is fundamentally revolutionised by Ref. [20]; where the notion of *cointegration* was introduced (the 3rd generation), differentiating between the short-run and long-run causalities.

We should emphasise that it is not entirely correct to equate the *Granger causality* with the *causality* in the general sense (i.e., the scientific pursuit of understanding "cause and effect" in natural phenomena). The jury of the scientific community is still out in this respect. The 1st generation of models in economics started with a *priori theory*. This comprised a specific functional relationship between variables as a predetermined hypothesis, also known as *structural form* (just like natural science). However, the 1st generation models' outcomes mostly became fallacious due to the *post hoc* fallacy as economic data are not white noise in most cases. Throughout the 2nd to 6th generations, there

5 Correlation coefficient is defined as $\rho = \sigma_{XY}/\sigma_X\sigma_Y$, where σ_{XY} is measuring the covariance between X and Y whereas σ_X and σ_Y are measuring the variances of X and Y, respectively. The ρ is a dimensionless quantity and falls between $-1 \leq \rho \leq +1$ (see Ref. [18] Theory and problems of probability and statistics. *Singapore: McGraws-Hill Book and Co.*, p. 82).

6 Recently, there are some extents of scientific experimentation with replication at *micro level* in the new fields of *behavioural* and *experimental economics*.

7 This is coupled with the use of Panel VECM (PVECM), Fully Modified Ordinary Least Square (FMOLS), or Dynamic Ordinary Least Square (DOLS).

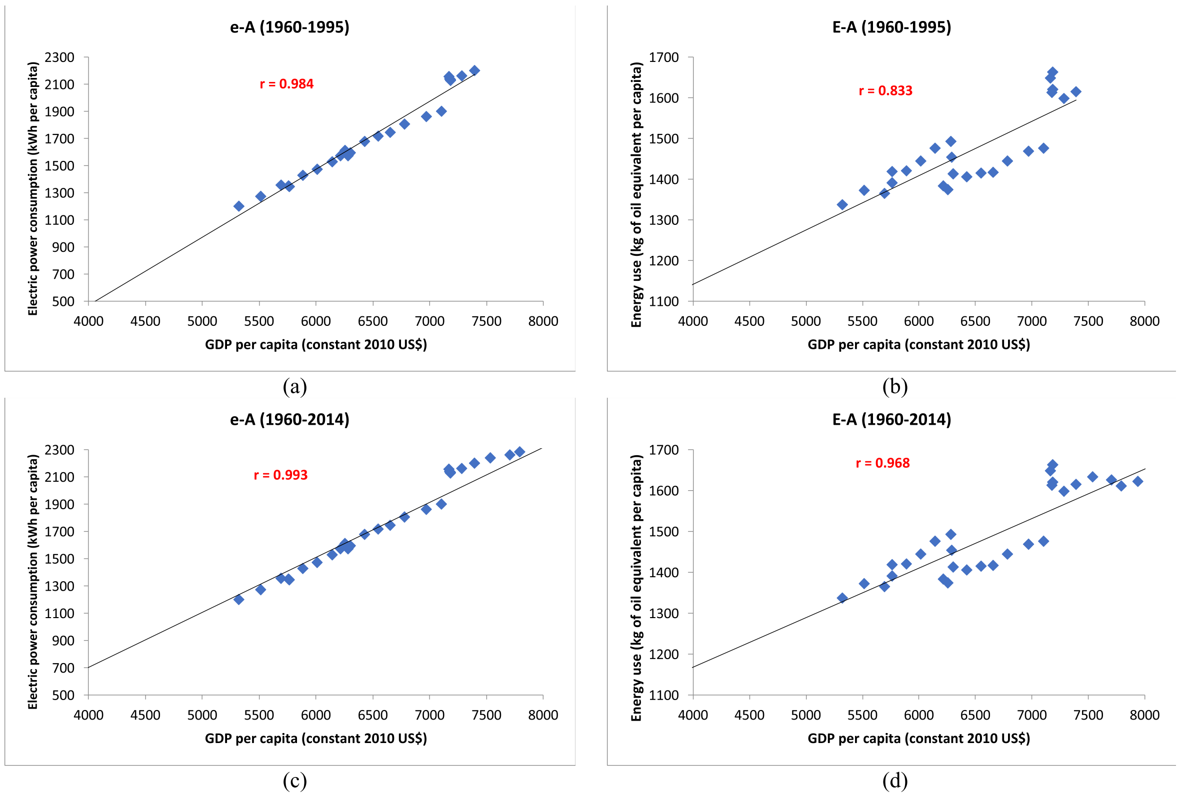


Fig. 3. Correlations between per capita real GDP and energy use (e-A or E-A)– weighted average for the whole world.

has been no *priori theory* under test. The 7th generation (*VARX*) is a fusion, allowing for testing a pre-specified structural form (a *priori theory*) while assuring that all stochastic terms are white noise.

Previous empirical studies on the *energy-welfare nexus* have shown apparent inconsistencies in *Granger causality* tests (e.g. Ref. [3]). Ref. [3] argues that such inconsistencies are mainly due to the dynamic nature of the *energy-welfare nexus* itself rather than being recognised as a problem. It is so because of various likely structural changes imposed on the economic system over time because of a discovery, technological advancement, institutional change, policy or merely an unanticipated external shock. It implies the *variability* or *non-linearity* of the energy-welfare nexus over time in a circular manner. Fig. 2 shows the *circular dynamics* of such *non-linearity* that may cause changes in Granger causality tests, suggesting an overarching testable theory for energy-welfare nexus, incorporating *weak* and *strong sustainability* notions.

In section 1, we mentioned that there had been a serious shortcoming of the use of *correlation* analysis, stated as the main criticism against **Ferguson** (see Table 1). Every economics or statistics student knows that the correlation coefficient is no proof of causation. This is a well-known flaw as early as the article written by Ref. [21] (see also [22, 23]. In his excellent article [22] states that "The very distinction between "true" and "spurious" correlation appears to imply that while correlation, in general, may be no proof of causation, "true" correlation does constitute such proof" [22]. [22] further argues that in order to have a *true correlation*, one needs to identify the nature of the *causal relationship* prior to interpreting the correlation coefficient. According to Ref. [20] approach, as long as two independent stochastic variables, X and Y, are both *stationary* (time-independent or integrated of order zero, I(0)), their causation/correlation is *true* and meaningful. Quite the contrary, the high correlation coefficients for non-stationary variables (i.e., time-dependent) are ***likely*** to be *spurious* unless X and Y are ***cointegrated*** of the same order, e.g., I(1). The interpretation of correlation coefficients of cointegrated variables refers to long-run (linear) mutual bonds.

The discussion presented here in this section substantiates how two notions of *causation* and *correlation* are fundamentally interconnected, both philosophically and practically. It reasserts that the "true" *correlation* suggests that there exists a mutual bound and a genuine (linear) *causation*, but it just does not reveal the direction of *causation*. Fig. 3 shows simple scatter diagrams between per capita energy variables (e or E) and affluence (A) – weighted average for the whole world – for the period of Ferguson's paper (1960–1995) as well as the updated Full Period of 1960–2014. It shows the potential existence of a strong correlation between the energy variables and affluence for the entire world economy. Similar scatter diagrams at country levels for some countries are not as straightforward as Fig. 3, revealing that the correlation coefficients vary significantly over time (as we choose different periods). Figure A1 and A2 in the Appendix show more scatter diagrams for a few hand-picked individual countries in different periods. The fundamental questions that arise here include: Are calculated correlations *spurious*? What is the direction of causalities, if there are any meaningful ones? Answering these questions is indeed prior to any raw interpretation of correlation coefficients.

We argue that **K & K** failed to employ stationarity tests for E and Y variables as the pre-conditions to the VAR model. If both variables are I (1) at level, the VAR model's use is not justifiable and may lead to *spurious causation*. We further argue that the *spurious correlation* in **Ferguson** is naïvely noted and deserves to be addressed appropriately. In **Ferguson**, it is stated that "To check that there have not been any spurious results produced by having two different periods for the data analysis (1960–1995 for the OECD and 1971–1995 for the Non-OECD countries), a further analysis has been undertaken using only 1971–1995 data for all countries and excluding 1960–1970 data for the OECD" [2]. We strongly assert that this is inadequate for addressing the *spuriosity* of *correlation*. Also, for the reasons that are discussed in this section, we firmly believe that the analysis of *true correlation* is inseparable from the analysis of *true causation* in, at least, a pairwise tradition. Section 4 will elaborate on our method's details for excluding spurious *causation/correlation* from the true ones. To address all existing methodological shortcomings, we use the ECM approach of the 3rd generation, allowing for short-run and long-run *causation/correlation*. Because our emphasis is on bi-variate or pairwise *causation/correlation*, the ECM approach is justifiable and adequate. It is because correlation coefficients are always bivariate by their formula. The ECM approach became a popular methodology for *nexus analysis* ever since the publications of [20]. For example, this methodology has been used in Refs. [24–27]. More sophisticated techniques will be needed (4^{th} generation onwards) if multivariate causation analyses are concerned, as implemented in Refs. [4,5]; to name a few.

3. Data considerations

Ferguson has used the *Source OECD* database. We are using the World Development Indicators (WDI) database, which is publicly available and consists of the countries' most comprehensive coverage and variables. Our panel data consists of more than 170 countries from 1960 to2014.[8] However, like **Ferguson** and due to substantive missing data across developing nations, we could only report our calculations for 93 countries, only 4–5 countries more than **Ferguson**. Of course, we are well aware of the differences in the OECD and WDI databases that only exist in monetary variables such as GDP due to the base year's variations, inflation deflators, exchange rates, etc. Other variables, such as energy and electricity data, are precisely the same. We have learned that the OECD database had undergone restructuring in its interface from what used to be called *Source OECD* to what is now called *OECD iLibrary*. We have noticed that in this transition and under the current *OECD iLibrary* database, the maximum number of countries included is reduced to 54 countries, out of which 34 are OECD countries. We also know that many non-OECD countries hold missing observations for older years (some before 1970 and some prior to 1990). That implies that many non-OECD countries are no longer included in the *OECD iLibrary* database used in the *Source OECD* database. This, hence, justifies the use of the WDI database, which holds more country coverage than the *OECD iLibrary* database.

We use the same variables used in **Ferguson**, except the real GDP in constant USA Dollar at constant PPP Exchange rate (GDP-PPP). We found that this variable does not have enough observations in most cases within the WDI database, especially does not cover the Ferguson paper's period (1960–1995). The GDP-PPP in the WDI database starts from the year 1990. We, hence, replaced GDP-PPP with the real GDP in constant US Dollar (GDP-USD). To demonstrate that the results would be similar, we first used the GDP-PPP in our analysis for the available observations and compared the results with those using the GDP-USD with the same period. The entire results were precisely the same for the available period. We also performed a simple correlation analysis between these two variables and found that they are highly correlated (close to 1). Therefore, this is an appealing justification for our decision to use GDP-USD, not compromising the loss of observations in the analysis.

In this paper, in order to classify the level of development or "wealth creation" as expressed in **Ferguson**, we use the standard country classification used in the WDI database according to countries' income groups, namely *High income (HI), Upper middle income (UMI), Lower middle income (LMI),* and *Low income (LI)*.[9] This contrasts with the rather ad hoc regional classification used in Ref. [2] [10] that considers OECD countries as the developed countries. Hence, our approach seems to be a more objective classification according to the state of development of individual countries based on affluence (i.e., per capita income).

4. Methodological considerations

The calculation of the correlation coefficient between X and Y is simple. Perhaps that is why statisticians and economists have a general tendency to use correlation coefficients at first. However, as mentioned in Sections 1 and 2, it is vital to ensure that the estimates are statistically *meaningful* and *non-spurious* (*True*). Due to a large amount of data on a global scale, this task is very calculation intensive. Hence, we have used the ***STATA software package***[11] for most calculations and ***Microsoft Excel*** for Tables, Graphs, and additional data processing. The subsequent steps are developed in this paper to make a firm distinction between "true" and "spurious" *correlation/causation*.

1. Applying the *Augmented Dickey-Fuller* test for every time-series variable to identify if they are *stationary* (*white noise*)
2. If both variables used in the correlation formula are stationary, I(0), then the correlation coefficient at the level is *true* (*meaningful*), otherwise, going to Stage 3
3. Calculating the residual terms of two linear regressions (X on Y and Y on X) and applying the *Augmented Dickey-Fuller* test on both of them to identify whether or not the pair of variables are *cointegrated*
4. Implementing a pairwise *Granger Causality* Test on the same pairs of variables, following [13,14] as is embedded in *STATA*
5. If both residual terms calculated in step 3 are *stationary*, I(0), then the correlation coefficient and Granger causality at the level are undoubtedly *true* (*meaningful*), representing pairwise long-run mutual (linear) bounds
6. If both residual terms calculated in step 3 are *non-stationary*, I(1), then the correlation coefficient and Granger causality at the level are certainly *spurious*
7. If one of the residual terms calculated in step 3 is *stationary*, I(0), and the other one is *non-stationary*, I(1), then the results of the Granger Causality test in Step 4 will give the final verdict.
   - 7.1. If the Granger causality test results suggest the *Neutrality Hypothesis* (X–Y), then the correlation coefficient is *spurious.*
   - 7.2. In all other three cases (i.e., *Growth Hypothesis* (X → Y), *Conservation Hypothesis* (X ← Y), and *Feedback Hypothesis* (X ↔ Y)), then the correlation coefficient is undoubtedly *true*, representing long-run (linear) mutual bounds.
8. Finally, using analysis of variance (ANOVA), appropriate conclusions are made on whether or not correlation coefficients are statistically different (higher/lower) at various income groups (level of affluence).

Following **Ferguson**, steps 1–7 are performed for three pairs of variables: e and A (e-A); E and A (E-A); and e/E and A (e/E-A). We understand that pairwise correlation coefficients and Granger causalities are only suitable to judge linear mutual bounds. The *circularity* and

[8] Note that we have downloaded WDI data for the period of 1960–2018, but many variables are missing after 2014.

[9] For operational and analytical purposes, economies are divided among income groups according to 2017 per capita gross national income (GNI) per capita, calculated using the World Bank Atlas method. The groups are: low income (LI), $995 or less; lower middle income (LMI), $996–3895; upper middle income (UMI), $3896–12,055; and high income (HI), $12,056 or more.

[10] They used the following regional country classification: Middle East, Africa, Non-OECD Europe, Latin America, Asia and OECD.

[11] Our *programming codes* the entire raw and processed data will be available upon request for interested scholars to replicate our work.

Table 2
Summary Results for the USA, Reassessing K & K.

Estimation Period	Energy Variable	r(e-A) [1] Ferguson*	r(e-A) [2] current	Δ = [2] - [1]	A	e	Coint(A-e)	Coint(e-A)	Granger @level	Verdict	r(Δe-ΔA)	Granger @Diff.
1960-1995	E	0.717	0.654	-0.063	I(1)	I(1)	I(1)	I(1)	E — A	Spurious	**0.650**	**E → A**
1996-2014	E		0.979		I(1)	I(1)	I(1)	I(1)	E ↔ A	Spurious	**0.819**	**E ↔ A**
1960-2014	E		0.371		I(1)	I(0)	I(1)	I(1)	E — A	Spurious	**0.648**	**E — A**
1960-1995	e	0.984	0.979	-0.005	I(1)	I(1)	I(1)	I(1)	e — A	Spurious	**0.526**	**e → A**
1996-2014	e		0.369		I(1)	I(1)	I(1)	I(1)	e ↔ A	Spurious	**0.686**	**e ← A**
1960-2014	e		0.946		I(1)	I(0)	I(1)	I(1)	e → A	Spurious	**0.545**	**e — A**
1960-1995	e/E	0.980	**0.986**	0.006	I(1)	I(1)	**I(0)**	**I(0)**	**e/E → Y**	**True**	**-0.342**	**e/E → A**
1996-2014	e/E		**0.810**		I(1)	I(1)	**I(0)**	I(1)	**e/E ↔ Y**	**True**	**-0.044**	**e/E — A**
1960-2014	e/E		0.976		I(1)	I(1)	I(1)	I(1)	e/E → Y	Spurious	**-0.206**	**e/E → A**

Notes: r(x-y) refers to the *correlation coefficient* between x and y; Coint(x-y) refers to *cointegration.*
*This column corresponds to Table 1 in **Ferguson**.

non-linearity of *causation/correlation* are indirectly examined by changing the estimation periods. Therefore, Steps 1–7 are also repeated for three distinctive periods: ***1960–1995*** (Ferguson Period); ***1996–2014*** (Post-Ferguson period); and ***1960–2014*** (Full Period).

The advantages of this novel methodological arrangement will be that, firstly, it excludes any spurious measures from true ones, avoiding misleading policy implications. Secondly, using these distinct periods, we have paid attention to the dynamics of changes in correlation and causation and aimed to assess the robustness of **K & K** and **Ferguson's** findings. In this way, we are implicitly testing for *circularity* and *non-linearity* of pairwise mutual bonds between energy (e, E, e/E) and affluence (A) variables. Thirdly, this is performed at three aggregations levels: country-specific, income-group, and global levels. We have used both weighted and arithmetic means to aggregate the correlation coefficients. Finally, implementing the ANOVA (stage 8) is another advantage of our approach to this topic (a significant contribution). The ANOVA is a prevalent methodology in empirical studies (e.g., Ref. [28]. Of course, this approach is more robust than merely looking at numerical differences as performed in **Ferguson**.

5. Results of analysis of causation and correlation

Summary results of the entire calculations are tabulated in the Appendix Tables. In the Appendix, Table A1.1 represents pairwise correlation and causation between per capita electricity use (e) and affluence (A) in the Ferguson period (1960–1995), both at the level and the first difference. This table corresponds to Table 1 of **Ferguson**. At the level, most variables are non-stationary, I(1), while at their first difference are stationary, I(0). Hence, the verdict on the meaningfulness of *causation/correlation* at the level is presented in the tables. Tables A1.2 and A1.3 show similar results for the same pairs of variables in the Post-Ferguson Period (1996–2014) and Full Period (1960–2014), respectively. Table A2.1 represents pairwise correlation and causation between per capita primary energy use (E) and affluence (A) in the Ferguson Period. This table corresponds to Table 5 of **Ferguson**. Tables A2.2 and A2.3 show similar results for the same pairs of variables in Post-Ferguson and Full Periods, respectively. Finally, Table A3.1 represents pairwise correlation and causation between electricity/energy ratio (e/E) vs affluence (A) in the Ferguson Period. This table corresponds to Table 8 of **Ferguson**. Tables A3.2 and A3.3 show similar results for the same pair of variables in Post-Ferguson and Full Periods, respectively. The most intriguing findings extracted from these Tables in the Appendix are analysed in this section, firstly on *causation*, then *correlation.*

5.1. Causation

Firstly, it is useful to compare our results with those of **K & K,** which tested for causality between E and Y variables[12] for the USA data in the period of 1947–1974. Table 2 shows our extracted results for the USA only. Irrespective of the differences between our sample periods and the pairs of variables with those in **K & K,** our results suggest that, in most cases, Granger causality, as well as correlation coefficients at level, are spurious. As mentioned earlier, Ref. [16] revisited **K & K** and argued that its finding is spurious and sensitive to period selection. Only removing the 1973–74 (the year of the Arab oil embargo – the first oil shock) from the sample would lead to a different outcome, supporting the neutrality hypothesis (E – Y). In our estimates and among the meaningful results at the level, we find inconsistent outcomes for the USA as the estimation period varies. As can be seen, e/E and A are cointegrated in both Ferguson and Post-Ferguson periods but not cointegrated in the full period. Thus, a meaningful Granger causality that is running from e/E → A in the Ferguson Period and that is bidirectional (e/E ↔ A) in the post-Ferguson period. This also confirms how sensitive the direction of causation is to the estimation period, as depicted in Ref. [16].

Interestingly, the Granger causality between this pair of variables (e/E and A) for the Full Period is statistically insignificant. At the same time, its correlation coefficient is high, equal to 0.976, while spurious. It implies that e/E and A are mutually time-dependent and non-cointegrated if the estimation period is extended to the Full period.

At the global level, in the Ferguson period (1960–1995), out of 93 countries, there are 12, 9, and 15 meaningful causality results for e-A, E-A, and e/E-A pairs of variables, respectively. In the Post-Ferguson period (1996–2014), there are 12, 8, and 13 meaningful causality results for e-A, E-A, and e/E-A pairs of variables, respectively. Finally, in the Full-period (1960–2014), there are 8, 5, and 8 meaningful causality results for e-A, E-A, and e/E-A pairs of variables, respectively. Overall, they add up to 93 out of 279. This means that only one-third of all cases at the level are meaningful, representing *true* long-run Granger causality. Further, meaningful outcomes do not necessarily belong to the same countries as the estimation period varies. In the transition from the Ferguson period to Post-Ferguson and Full periods, country-specific Granger causality tests' results vary.

Tables 3 and 4 show the transition matrices of the frequencies of

[12] None of the E and Y variables were divided by population in **K & K**.

Table 3
Transition Matrix of Long Run Granger Causality between e-A at level From 1960-1995 Period to 1996-2014 Period.

		Meaningful (1996-2014)					Spurious (1996-2014)					
		e — A	e → A	e ← A	e ↔ A	Sub-Total	e — A	e → A	e ← A	e ↔ A	Sub-Total	Total
Meaningful			1			1	5	1	1	4	11	12
1960-1995	e — A											
	e → A						1	1			2	2
	e ← A						1			1	2	2
	e ↔ A		1*			1	3		1	3	7	8
Spurious			2	3	6	11	14	6	14	36	70	81
1960-1995	e — A		1	1		2	3	2	4	13	22	24
	e → A		1		4	5	6		4	9	19	24
	e ← A			1	1	2	2	3	3	8	16	18
	e ↔ A			1	1	2	3	1	3	6	13	15
Grand Total			3	3	6	12	19	7	15	40	81	93

Notes:
*Dominican Republic (UMI).

Table 4
Transition Matrix of Long Run Granger Causality between e-A at level From 1960-1995 Period to 1960-2014 Period.

		Meaningful (1960-2014)					Spurious (1960-2014)					
		e — A	e → A	e ← A	e ↔ A	Sub-Total	e — A	e → A	e ← A	e ↔ A	Sub-Total	Total
Meaningful			2	1		3	6		2	1	9	12
1960-1995	e — A											
	e → A						2				2	2
	e ← A		1*			1				1	1	2
	e ↔ A		1**	1***		2	4		2		6	8
Spurious			4	1		5	27	12	21	16	76	81
1960-1995	e — A		1			1	9	4	3	7	23	24
	e → A		1			1	9	6	6	2	23	24
	e ← A		1	1		2	5		8	3	16	18
	e ↔ A		1			1	4	2	4	4	14	15
Grand Total			6	2		8	33	12	23	17	85	93

Notes:
*Ecuador (UMI),
**Gabon (UMI),
***Albania (UMI).

meaningful/spurious long-run Granger causality test outcomes between per capita electricity (e) and affluence (A) across the Ferguson and Post-Ferguson periods. As explained in Section 4, only cointegrated variables will have meaningful long-run causalities. These results show both meaningful and spurious causation outcomes in four quadrants. Consistency of the direction of causation across periods may happen if located on the diagonal of the upper-left quadrant, showing the matrices for the mutually meaningful causalities. As can be seen, there are no diagonal observations in Tables 3 and 4 among the mutually meaningful causalities across both periods. Table 3 shows that only the Dominican Republic has meaningful Granger causality across both Ferguson and post-Ferguson periods. For this country, the Granger causality test suggests bi-directional causality between e and A for the Ferguson period (e ↔ A), while unidirectional runs from e to A for the post-Ferguson period (e → A). Table 4 shows the inconsistency of long-run causality in three countries, as noted beneath the table, in the transition between the Ferguson Period to the Full Period.

Similarly, Tables 5 and 6 summarise the transition matrices of causality outcomes for per capita primary energy (E) and affluence (A). Also, Tables 7 and 8 summarise the transition matrices of causality outcomes for the ratio of electricity over primary energy (e/E) and affluence (A). The tables are self-explanatory. Underneath each table, countries' names are indicated only for the upper-left quadrant of the matrices corresponding to mutually meaningful causalities across the

Table 5
Transition Matrix of Long Run Granger Causality between E-A at Level From 1960-1995 Period to 1996-2014 Period.

		Meaningful (1996-2014)					Spurious (1996-2014)					
		E — A	E → A	E ← A	E ↔ A	Sub-Total	E — A	E → A	E ← A	E ↔ A	Sub-Total	Total
Meaningful					2	2	1	1	2	3	7	9
1960-1995	E — A											
	E → A				1**	1	1	1		1	3	4
	E ← A								1	1	2	2
	E ↔ A				1*	1			1	1	2	3
Spurious			2	2	2	6	18	10	25	25	78	84
1960-1995	E — A		1	2		3	7	3	7	10	27	30
	E → A				1	1	3	3	4	4	14	15
	E ← A				1	1	2	3	7	4	16	17
	E ↔ A		1			1	6	1	7	7	21	22
Grand Total			2	2	4	8	19	11	27	28	85	93

Notes:
*UAE (HI),
**Senegal (LI).

Table 6
Transition Matrix of Long Run Granger Causality between E-A at Level From 1960-1995 Period to 1960-2014 Period.

		Meaningful (1960-2014)					Spurious (1960-2014)					
		E — A	E → A	E ← A	E ↔ A	Sub-Total	E — A	E → A	E ← A	E ↔ A	Sub-Total	Total
Meaningful			1	1		2	2	1	3	1	7	9
1960-1995	E — A											
	E → A						2	1	1		4	4
	E ← A			1*		1			1		1	2
	E ↔ A		1**			1			1	1	2	3
Spurious			1	1	1	3	34	16	26	5	81	84
1960-1995	E — A			1	1	2	16	7	5		28	30
	E → A						8	4	2	1	15	15
	E ← A						5	2	8	2	17	17
	E ↔ A		1			1	5	3	11	2	21	22
Grand Total			2	2	1	5	36	17	29	6	88	93

Notes:
*Panama (HI),
**Gabon (UMI).

estimation periods. Being only a few cases implies that the estimation period plays a crucial role in Granger Causality tests. In Table 8, we observe three countries with consistent outcomes across Ferguson and Full periods. These countries are Malaysia and Bahrain, showing e/E ← Y, and Switzerland with e/E ↔ Y outcome.

As noted from the Appendix tables, almost all variables at their first difference are stationary. That implies that pairwise Granger causality tests are all meaningful at the first difference, representing the short-run causalities. The short-run Granger causalities are interpreted as the direction of *causation* between changes in energy variables and changes in affluence, and vice versa. Table 9 shows the transition matrices of short-run causalities for all three pairs of variables across the three estimation periods. We could firmly conclude that the most dominant, mutually consistent outcome belongs to the *neutrality hypothesis* (e – A, E – A, and e/E – A). This implies that, mostly, there is no cause and effect between (percentage) change of energy variables (e, E, e/E) and affluence (A). In other words, the speed of energy use rarely affects the growth of wealth.

All these findings confirm the frequently raised inconsistency and conflicting cause-and-effect outcomes[13] in the *energy-welfare nexus*. We argue that these inconsistencies are due to the *circular* dynamic nature of the nexus itself rather than being recognised as a severe problem. In this way, we re-affirm that the inter-relationship between energy and affluence (both in the short and long run) is **non-linear** in a ***circular*** manner, indeed. Such inter-relationship is continually transforming over time. Therefore, the direction of Granger causality can naturally flip as the country goes through various phases of its development process.

5.2. Correlation

As noted in Section 2, irrespective of the direction of causation, analysis of "true" correlation provides useful indications of mutually (linear) bounds between pairs of variables. Fig. 4 shows the frequency of

[13] All literature surveys, unanimously, raised this point on the basis of the previous epmerical studies.

Table 7
Transition Matrix of Long Run Granger Causality between e/E-A at level From 1960-1995 Period to 1996-2014 Period.

		Meaningful (1996-2014)					Spurious (1996-2014)					
		e/E — A	e/E → A	e/E ← A	e/E ↔ A	Sub-Total	e/E — A	e/E → A	e/E ← A	e/E ↔ A	Sub-Total	Total
Meaningful				1	1	2	5	2	3	3	13	15
1960-1995	e/E — A											
	e/E → A				1*	1	2	1	1	1	5	6
	e/E ← A						3	1	1	1	6	6
	e/E ↔ A			1**		1			1	1	2	3
Spurious			2	4	5	11	17	14	16	20	67	78
1960-1995	e/E — A			1		1	5	3	4	9	21	22
	e/E → A		1	1	2	4	2	4		3	9	13
	e/E ← A		1	1	3	5	8	5	7	4	24	29
	e/E ↔ A			1		1	2	2	5	4	13	14
Grand Total			2	5	6	13	22	16	19	23	80	93

Notes:
*USA (HI),
**Dominican Republic (UMI).

Table 8
Transition Matrix of Long Run Granger Causality between e/E-A at level From 1960-1995 Period to 1960-2014 Period.

		Meaningful (1960-2014)					Spurious (1960-2014)					
		e/E — A	e/E → A	e/E ← A	e/E ↔ A	Sub-Total	e/E — A	e/E → A	e/E ← A	e/E ↔ A	Sub-Total	Total
Meaningful				2	1	3	4	3	2	3	12	15
1960-1995	e/E — A											
	e/E → A						1	3	1	1	6	6
	e/E ← A			2*		2	2			2	4	6
	e/E ↔ A				1**	1	1		1		2	3
Spurious			2	2	1	5	38	8	19	8	73	78
1960-1995	e/E — A				1	1	13	3	3	2	21	22
	e/E → A		1			1	6		1	5	12	13
	e/E ← A			2		2	11	3	12	1	27	29
	e/E ↔ A		1			1	8	2	3		13	14
Grand Total			2	4	2	8	42	11	21	11	85	93

Notes:
*Malaysia (UMI) and Bahrain (HI),
**Switzerland (HI).

the calculated correlation coefficients between all three pairs of variables. These, in most cases, are spurious within three distinct periods. For instance, in the Ferguson period (1960–1995), only 36 (%13) cases show meaningful correlation, and the rest are spurious. Overall, only 90 out of 837 estimates are meaningful (%11). This is very revealing because **Ferguson's** conclusions are based on spurious correlations.

Table 10 summarises the weighted average correlation coefficients aggregated over income groups and the world. Only figures in **Bold** are statistically meaningful at a 5% level of significance. The rest of the figures (in light grey) are spurious. Due to many missing data, there is no estimate available for the Low-income group. Although most correlation coefficients are close to one, we can draw no conclusion based on these aggregates (see Fig. 2) as most time series are non-stationary.

Alternatively, Table 11 summarises the arithmetic means of true correlation coefficients by income groups and across the periods. The numbers of (true) observations appear as well. As mentioned in Section 3, Stage 8, we use ANOVA to test whether these means at income groups are statistically different. The ***null hypothesis*** is that the means across

Table 9
Transition Matrix of Short Run Granger Causality at 1st difference

e-A at 1st difference
From 1960-1995 Period to 1996-2014 / 1960-2014 Periods

1960-1995	(1996-2014) e — A	e → A	e ← A	e ↔ A	Total	(1960-2014) e — A	e → A	e ← A	e ↔ A	Total
e — A	18	11	13	14	56	39	3	12	2	56
e → A	7	2	1	4	14	7	5	1	1	14
e ← A	6	2	2	1	11	5	1	5		11
e ↔ A	5	1	3	3	12	8		2	2	12
Total	36	16	19	22	**93**	59	9	20	5	**93**

E-A at 1st difference
From 1960-1995 Period to 1996-2014 / 1960-2014 Periods

1960-1995	(1996-2014) E — Y	E → Y	E ← Y	E ↔ Y	Total	(1960-2014) E — Y	E → Y	E ← Y	E ↔ Y	Total
E — Y	25	9	6	10	50	36	1	10	3	50
E → Y	5		1	4	10	3	6		1	10
E ← Y	8	1	3	7	19	10	2	6	1	19
E ↔ Y	7	1	3	3	14	6	2	5	1	14
Total	45	11	13	24	**93**	55	11	21	6	**93**

e/E-A at 1st difference
From 1960-1995 Period to 1996-2014 / 1960-2014 Periods

1960-1995	(1996-2014) e/E — A	e/E → A	e/E ← A	e/E ↔ A	Total	(1960-2014) e/E — A	e/E → A	e/E ← A	e/E ↔ A	Total
e/E — A	27	9	11	14	61	51		9	1	61
e/E → A	7		1	3	11	6	3	2		11
e/E ← A	3	3	3	2	11	8		2	1	11
e/E ↔ A	3	1	2	4	10	5	1	3	1	10
Total	40	13	17	23	**93**	70	4	16	3	**93**

Note: Red figures denote country cases that show no change in the direction of causality across periods (consistent outcomes).

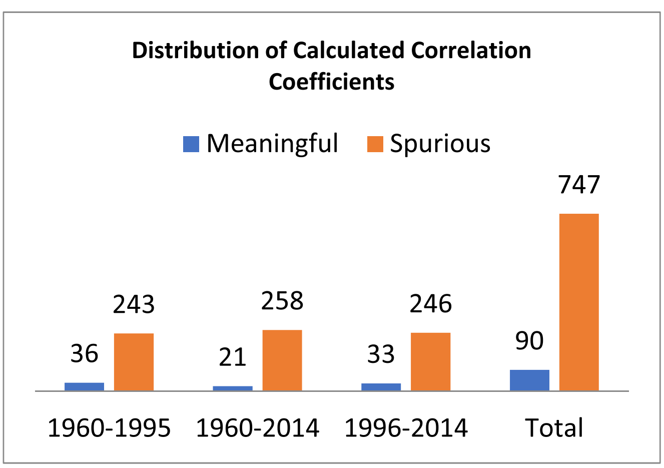


Fig. 4. Distribution of meaningful correlation coefficient by periods.

income groups are equal. Table 13 shows the details of the ANOVA test and F-values. Unlike **Ferguson,** we cannot confirm that wealthy countries (HI/UMI) have a stronger correlation between their energy use (e, E, e/E) and affluence than developing countries (LMI/LI). In all cases, the null hypothesis cannot be rejected either at 1% or at a 5% significance level.

Finally, the correlation coefficients for our three pairs of variables at their first differences are summarised in Table 12 and Table 13 for weighted vs arithmetic averages, respectively. Table 13 shows the ANOVA test results, as well. None of the correlation coefficients at the first differences are spurious. However, the interpretation of these correlation coefficients is that they represent mutual bonds between the changes in energy variables (e, E, ad e/E) and the changes in affluence (A). We notice large disparities between the weighted and arithmetic averages in most income groups globally. As can be noted, at the World level, the arithmetic averaged correlations are generally positive but very low in most cases, implying that there is no strong correlation between the changes in the use of energy and the affluence-change or vice

Table 10
Weighted Average of Correlation Coefficients at the level by Income Groups.

Income	Ferguson, 1960-1995			Post-Ferguson, 1996-2014			Full, 1960-2014		
Group	e-A	E-A	e/E-A	e-A	E-A	e/E-A	e-A	E-A	e/E-A
LI	-	-	-	-	-	-	-	-	-
LMI	0.869	0.869	0.937	0.998	**0.869**	0.997	0.933	0.933	0.909
UMI	0.854	0.854	0.939	**0.999**	0.854	0.988	0.978	0.978	0.908
HI	0.998	0.998	0.990	0.938	0.998	0.945	0.991	0.991	0.987
World	0.984	0.984	0.997	0.992	**0.984**	0.985	0.993	0.993	0.969

Table 11
Arithmetic Average of Correlation Coefficients at level and summary of ANOVA Tests

	Fergusen Period (1960-1995)				Post Ferguson Period (1996-2014)				Full Period (1960-2014)				
	e-A	E-A	e/E-A		e-A	E-A	e/E-A		e-A	E-A	e/E-A		
Means													
Low Income (LI)		0.460	0.284	0.514		-0.720	0.900	0.516	0.943		0.952	0.948	0.675
Lower Middle Income (LMI)	0.501	-0.743	0.319	0.355	0.950	0.333	0.774	0.630	0.608	0.760		0.669	0.499
Upper Middel Income (UMI)	0.582	0.238	0.663	0.484	0.880	0.486	0.379	0.554	0.539	-0.197	0.495	0.645	0.532
High Income (HI)	0.621	-0.602	0.529	0.349	0.898	0.277	0.369	0.579	0.996	0.501	0.823	0.786	0.610
World	**0.568**	**-0.102**	**0.483**	**0.396**	**0.899**	**0.200**	**0.578**	**0.583**	**0.672**	**0.465**	**0.716**	**0.732**	**0.569**
Number of Observations													
Low Income (LI)	0	2	1	2	0	1	2	2	1	0	1	2	5
Lower Middle Income (LMI)	4	1	4	7	2	3	4	8	3	2	0	5	13
Upper Middel Income (UMI)	4	3	3	7	5	1	4	7	3	1	3	5	12
High Income (HI)	4	3	7	12	5	3	3	10	1	2	4	6	21
World	**12**	**9**	**15**	**28**	**12**	**8**	**13**	**27**	**8**	**5**	**8**	**18**	**51**
Variation													
Between Income Groups	0.030	2.142	0.258	0.120	0.007	0.999	0.650	0.032	0.244	0.615	0.248	0.169	0.171
Within Income Groups	2.692	1.625	4.127	10.797	0.061	1.551	2.887	6.560	1.296	0.064	0.652	1.683	12.067
Total	**2.721**	**3.767**	**4.385**	**10.917**	**0.068**	**2.550**	**3.537**	**6.593**	**1.540**	**0.679**	**0.900**	**1.852**	**12.238**
Degree of Freedom													
Between Income Groups	3	3	3	3	3	3	3	3	3	3	3	3	3
Within Income Groups	8	5	11	24	8	4	9	23	4	1	4	14	47
Total	**11**	**8**	**14**	**27**	**11**	**7**	**12**	**26**	**7**	**4**	**7**	**17**	**50**
Mean Square													
Between Income Groups	0.010	0.714	0.086	0.040	0.002	0.333	0.217	0.011	0.081	0.205	0.083	0.056	0.057
Within Income Groups	0.336	0.325	0.375	0.450	0.008	0.388	0.321	0.285	0.324	0.064	0.163	0.120	0.257
F-Value	**0.029**	**2.197**	**0.230**	**0.089**	**0.304**	**0.859**	**0.675**	**0.038**	**0.251**	**3.192**	**0.508**	**0.467**	**0.222**
F Probability	0.993	0.207	0.874	0.965	0.822	0.531	0.589	0.990	0.857	0.385	0.698	0.710	0.881
Critical F Value at 5%	4.066	5.409	3.587	3.009	4.066	6.591	3.863	3.028	6.591	215.707	6.591	3.344	2.802
Critical F A 1%	7.591	12.060	6.217	4.718	7.591	16.694	6.992	4.765	16.694	5403.35	16.694	5.564	4.228
ANOVA Test Result @ %5	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
ANOVA Test Result @ %1	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Table 12
Weighted average of correlation coefficients at 1st differences by income groups.

Income	Ferguson, 1960–1995			Post-Ferguson, 1996–2014			Full, 1960–2014		
Group	e-A	E-A	e/E-A	e-A	E-A	e/E-A	e-A	E-A	e/E-A
LI	–	–	–	–	–	–	–	–	–
LMI	0.064	0.084	0.060	0.875	0.529	0.635	0.239	0.051	0.205
UMI	−0.138	−0.061	−0.286	0.891	0.759	0.400	0.486	0.259	0.153
HI	0.610	0.569	−0.225	0.812	0.821	0.201	0.695	0.575	−0.004
World	0.498	0.519	−0.054	0.823	0.736	0.373	0.640	0.532	0.118

versa. ANOVA results revealed no significant differences in the means of correlation coefficients across income groups in most cases. However, the null hypothesis can be rejected at a 1% level of significance (of course at 5%, too) correlation between e/E and A in the Ferguson and Full period, but not in the post-Ferguson period. For instance, in the Ferguson period, wealthy countries (HI and UMI) have a negative correlation. In contrast, developing countries (LI and LMI) positively correlate between e/E and A. For the post-Ferguson period, the null hypothesis can only be rejected, at a 5% level of significance, for the e-A pair of variables – not for E-A and e/E-A pairs of variables.

Table 13
Arithmetic Average of Correlation Coefficients at 1st first differences and ANOVA

	Fergusen Period (1960-1995)				Post Ferguson Period (1996-2014)				Full Period (1960-2014)				G. Ave.
	e-A	E-A	e/E-A	Ave.	e-A	E-A	e/E-A	Ave.	e-A	E-A	e/E-A	Ave.	
Means													
Low Income (LI)	0.236	0.213	0.170	0.206	0.176	0.106	0.071	0.118	0.249	0.262	0.156	0.222	0.182
Lower Middle Income (LMI)	0.370	0.334	0.136	0.280	0.397	0.310	0.088	0.265	0.419	0.341	0.124	0.295	0.280
Upper Middel Income (UMI)	0.445	0.460	-0.011	0.298	0.441	0.326	0.050	0.272	0.424	0.434	0.020	0.293	0.288
High Income (HI)	0.401	0.356	-0.088	0.223	0.466	0.352	0.022	0.280	0.417	0.334	-0.025	0.242	0.248
World	**0.391**	**0.367**	**0.008**	**0.255**	**0.418**	**0.314**	**0.049**	**0.260**	**0.405**	**0.356**	**0.038**	**0.266**	**0.261**
Number of Observations													
Low Income (LI)	8	8	8	8	8	8	8	8	8	8	8	8	8
Lower Middle Income (LMI)	22	22	22	22	22	22	22	22	22	22	22	22	22
Upper Middel Income (UMI)	25	25	25	25	25	25	25	25	25	25	25	25	25
High Income (HI)	38	38	38	38	38	38	38	38	38	38	38	38	38
World	**93**	**93**	**93**	**93**	**93**	**93**	**93**	**93**	**93**	**93**	**93**	**93**	**93**
Variation													
Between Income Groups	0.279	0.433	0.928	0.118	0.576	0.403	0.065	0.181	0.213	0.247	0.432	0.073	0.082
Within Income Groups	7.093	6.770	5.067	3.009	5.997	7.546	5.531	2.264	4.648	5.164	2.534	1.981	1.775
Total	**7.372**	**7.203**	**5.995**	**3.127**	**6.572**	**7.949**	**5.596**	**2.445**	**4.861**	**5.410**	**2.966**	**2.054**	**1.857**
Degree of Freedom													
Between Income Groups	3	3	3	3	3	3	3	3	3	3	3	3	3
Within Income Groups	89	89	89	89	89	89	89	89	89	89	89	89	89
Total	**92**	**92**	**92**	**92**	**92**	**92**	**92**	**92**	**92**	**92**	**92**	**92**	**92**
Mean Square													
Between Income Groups	0.093	0.144	0.309	0.039	0.192	0.134	0.022	0.060	0.071	0.082	0.144	0.024	0.027
Within Income Groups	0.080	0.076	0.057	0.034	0.067	0.085	0.062	0.025	0.052	0.058	0.028	0.022	0.020
F-Value	**1.168**	**1.898**	**5.431**	**1.161**	**2.848**	**1.585**	**0.348**	**2.372**	**1.359**	**1.417**	**5.059**	**1.094**	**1.362**
F Probability	0.327	0.136	0.002	0.329	0.042	0.199	0.790	0.076	0.260	0.243	0.003	0.356	0.260
Critical F Value at 5%	2.707	2.707	2.707	2.707	2.707	2.707	2.707	2.707	2.707	2.707	2.707	2.707	2.707
Critical F A 1%	4.010	4.010	4.010	4.010	4.010	4.010	4.010	4.010	4.010	4.010	4.010	4.010	4.010
ANOVA Test Result @ %5	NO	NO	**YES**	NO	**YES**	NO	NO	NO	NO	NO	**YES**	NO	NO
ANOVA Test Result @ %1	NO	NO	**YES**	NO	NO	NO	NO	NO	NO	NO	**YES**	NO	NO

6. Conclusions and policy implications

Policy implications of knowing the true nature of the interrelationship between energy use and economic development (nations' affluence or welfare) are of great importance in every country. These may vary from country to country, motivating each country's development strategies differently. This is about an empirical and contextual investigation of the complex nature of the *energy-welfare nexus*. Although there are thousands of empirical studies on this topic, they are not helping to reveal a consistent and overarching explanation of the *circular dynamics* of the *energy-welfare nexus*. In this paper, we critically, thoroughly, and globally revisited **K & K** and **Ferguson** – two highly cited seminal papers on the notions of *causation* and *correlation*, respectively, for analysing the *energy-welfare nexus*. For this, we elaborated on in-depth philosophical and practical interconnectedness between *causation* and *correlation* concepts. We made a novel distinction between "true" and "spurious" pairwise *causation/correlation* indicators. We argued that such a distinction is naïvely addressed in **K & K** and **Ferguson**, creating illusions and falsified conclusions. Our most intriguing findings are as follows.

- Due to the *non-stationarity* of energy variables (e, E and e/E) and affluence (A), most pairwise *causation/correlation* indicators, at the level, are *spurious.* We also used cointegration tests to verify whether or not these measures are meaningful (*true*).
- More specifically, we found that only 13% of our estimates, at the level, in the Ferguson period are non-spurious. Including our Post-Ferguson and Full Periods, only 11% of the total 837 estimates are non-spurious (*true*).
- In most cases, among the meaningful indicators, at the level, the direction of *causation* and the magnitude of *correlation* are not necessarily remaining the same as the estimation periods change.
- The above point reveals that the nature of causation between energy and affluence variables is *non-linear*, causing the direction of *Granger causations* to vary over time.
- *Granger causality* test results are likely to differ across periods because of various institutional changes that take place during society's development processes, as depicted in Fig. 2. This implies that the *energy-welfare nexus* analysis is more challenging than early expectations.
- At the first difference, energy and affluence variables are all *stationary,* and the spuriosity of Granger causality and correlation coefficients are not a concern.
- Granger causality tests against energy and affluence variables, at the first difference, reveals that the *neutrality hypothesis* is the most dominant mutually consistent outcome if we compare them across distinct estimation periods. It implies that the speed of energy use is rarely causing the growth in wealth, and vice versa.
- Apart from the above point, the transition matrices of Granger causality tests across distinct estimation periods still confirm that the nature of causation between energy and affluence variables, at the first difference, is *non-linear*, too.
- Based on ANOVA tests, we could not identify any significant difference in true *correlations* between energy and affluence variables across the income groups that objectively represent the extent of countries' wealth creation. This is in contrast with **Ferguson's** finding.

Overall, our analysis suggests that *causation* and *correlation* indicators are time-dependent, country-specific, and may vary circularly. Thus, it is not unusual that the directions of the Granger causalities in the *energy-welfare nexus* vary, depending on each country's technological, institutional, or cultural advancement (i.e., development stages). Imposing a suitable development policy in each country will rely on a proper understanding of the dynamics of changes in *causation* and *correlation* indicators rather than using a snapshot measure as done in most previous studies. Thus, policymakers of each country should well evaluate the transition matrix of the economy's energy-welfare nexus and make sure they will implement an appropriate policy under the countries' strategic and national development in the short term, medium, and long run. For example, if only the *conservation hypothesis* applies to a country, say, in the long run, the energy-saving policy would have no harm to economic growth or a nation's wealth. Or for example, if the growth hypothesis applies to a country at present, the most appropriate policy recommendation would be to improve the technology and reduce the energy intensity, while reducing the energy consumption would undoubtedly harm the nation's welfare. The feedback hypothesis is more complex, while neutrality refers to the most sustainable state of the energy-welfare nexus. Interestingly, as always, economic policies are not one for all times. They should vary as structural changes take place throughout economic development.

This study implemented a bi-variate *causation* and *correlation* method (i.e., ECM) to demonstrate such a dynamic process. In the future, the idea of this paper can be further tested over more than two distinctive periods, perhaps over continual moving periods. It can also be tested using alternative multivariate methods described in Section 2. If so, they may further enlighten energy policy strategists toward more sustainable development.

Credit author statement

All authors contributed equally to this work.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A

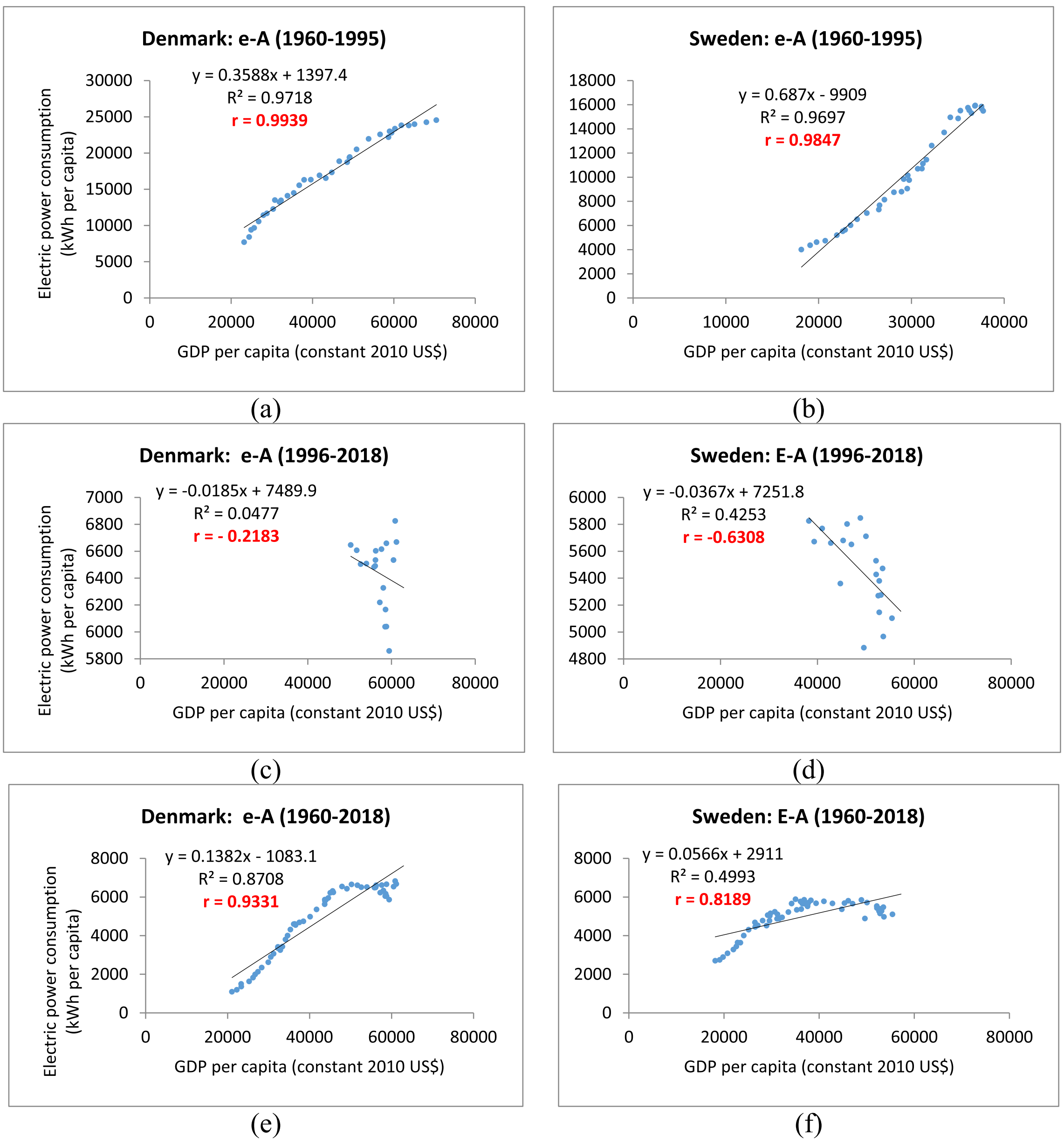
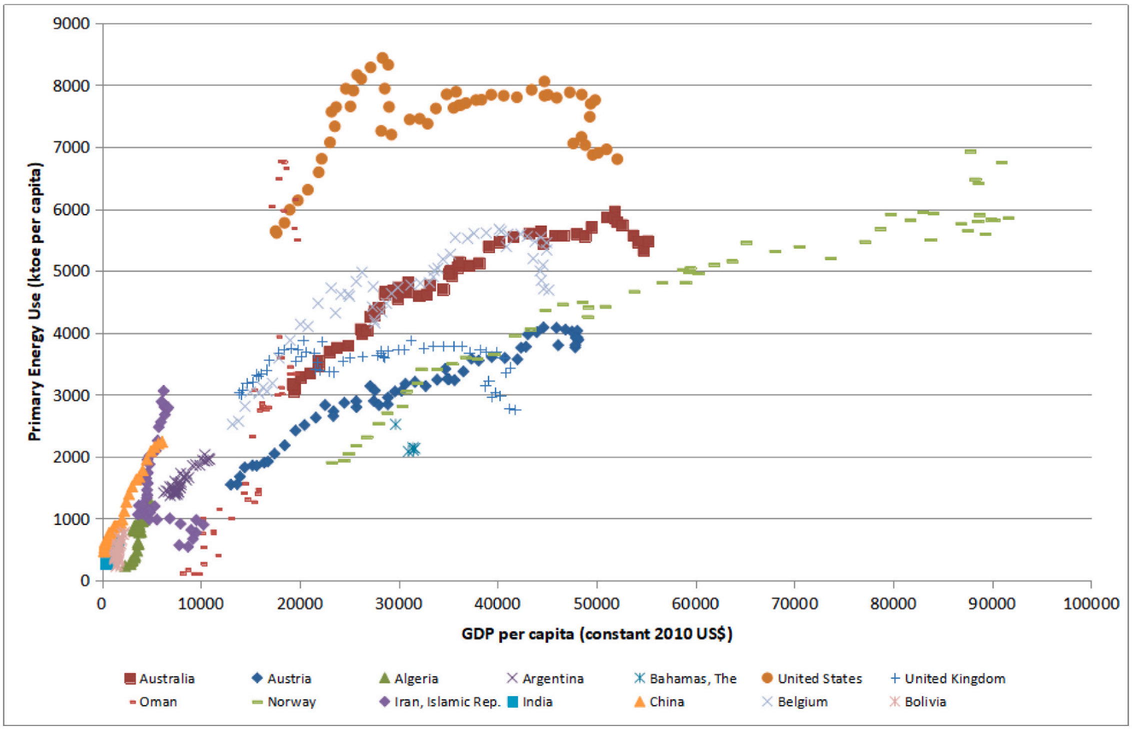
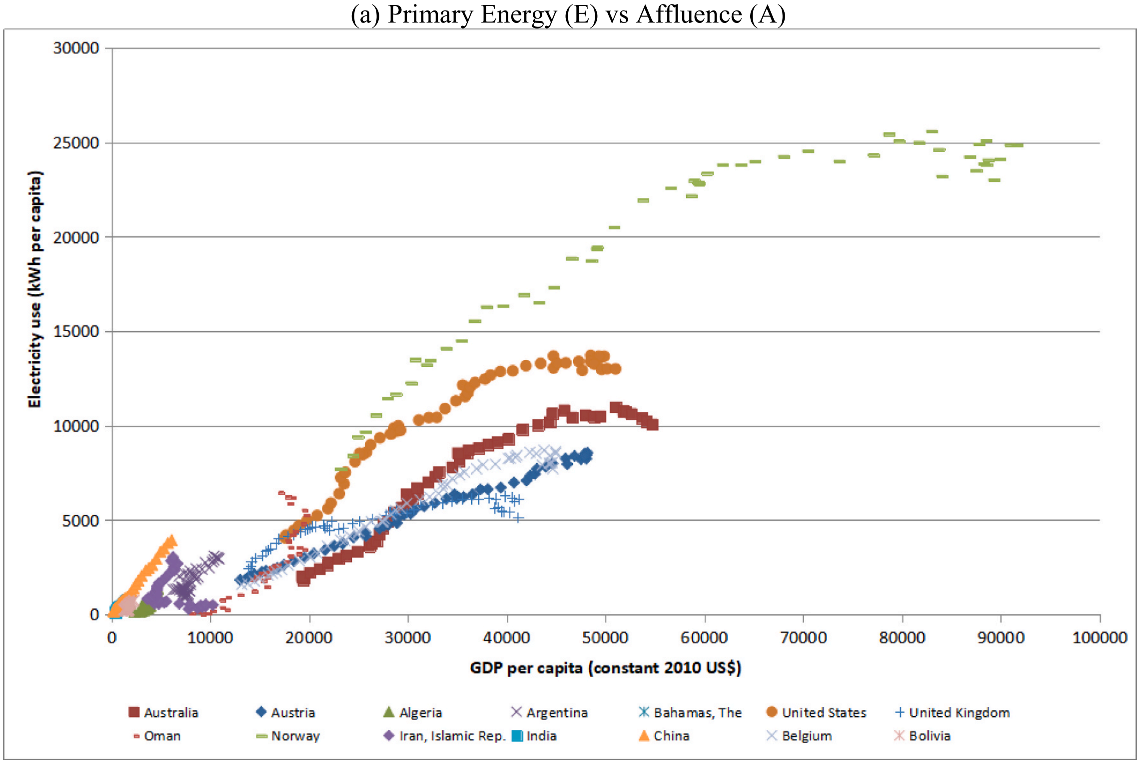


Figure A1. Pair-wise Correlations for e-A and E-A in Denmark & Sweden by periods.



(a) Primary Energy (E) vs Affluence (A)



(b) Electricity (e) vs Affluence (A)

Figure A2. Scatter Diagrams for a Selection of Countries (1960–2018).

Table A1.1
Correlation coefficients: per capita electricity use (e) vs. affluence (A) - 1960–1995

Country	Income Group	r(e-A) [1] Ferguson[1]	r(e-A) [2] current	Δ = [2] - [1]	A	e	Coint (A-e)	Coint (e-A)	Granger @level	Verdict	r(Δe-ΔA)	Granger @Diff.
Albania	UMI	–	0.869	–	I(1)	I(1)	I(1)	I(0)	E ↔ Y	TRUE	0.461	E ↔ Y
Israel	HI	0.981	0.984	0.003	I(1)	I(1)	I(1)	I(0)	E ↔ Y	TRUE	0.376	E – Y
Switzerland	HI	0.968	0.949	−0.019	I(1)	I(1)	I(0)	I(1)	E ↔ Y	TRUE	0.529	E ↔ Y
Oman	HI	0.937	0.952	0.015	I(1)	I(1)	I(0)	I(0)	E ↔ Y	TRUE	0.130	E ← Y
Zambia	LMI	0.882	0.902	0.020	I(1)	I(1)	I(0)	I(1)	E ← Y	TRUE	0.506	E – Y
Kenya	LMI	0.833	0.751	−0.082	I(1)	I(1)	I(0)	I(1)	E → Y	TRUE	0.204	E – Y
Ecuador	UMI	0.776	0.835	0.059	I(0)	I(1)	I(0)	I(1)	E ← Y	TRUE	0.109	E – Y
Angola	LMI	0.718	0.614	−0.104	I(1)	I(1)	I(1)	I(0)	E ↔ Y	TRUE	−0.009	E → Y
Dominican Republic	UMI	0.670	0.615	−0.055	I(1)	I(1)	I(1)	I(0)	E ↔ Y	TRUE	0.101	E ↔ Y
Nicaragua	LMI	0.388	−0.261	−0.649	I(1)	I(1)	I(1)	I(0)	E → Y	TRUE	0.783	E – Y
Trinidad and Tobago	HI	0.017	−0.403	−0.420	I(1)	I(1)	I(1)	I(0)	E ↔ Y	TRUE	0.192	E → Y
Gabon	UMI	−0.274	0.008	0.282	I(0)	I(1)	I(0)	I(1)	E ↔ Y	TRUE	0.129	E – Y
Congo, Rep.	LMI	–	0.684	–	I(1)	I(1)	I(1)	I(1)	E ← Y	Spurious	0.123	E ← Y
Korea, Rep.	HI	–	0.996	–	I(1)	I(1)	I(1)	I(1)	E – Y	Spurious	0.897	E – Y
Mauritius	UMI	–	0.971	–	I(1)	I(1)	I(1)	I(1)	E ← Y	Spurious	0.497	E – Y
Togo	LI	–	−0.031	–	I(1)	I(1)	I(1)	I(1)	E – Y	Spurious	0.456	E – Y
Austria	HI	0.998	0.998	0.000	I(1)	I(1)	I(1)	I(1)	E → Y	Spurious	0.510	E → Y
Canada	HI	0.997	0.994	−0.003	I(1)	I(1)	I(1)	I(1)	E – Y	Spurious	0.710	E – Y
Hong Kong SAR, China	HI	0.997	0.996	−0.001	I(1)	I(1)	I(1)	I(1)	E → Y	Spurious	0.731	E → Y
Italy	HI	0.997	0.998	0.001	I(1)	I(1)	I(1)	I(1)	E – Y	Spurious	0.839	E – Y
Thailand	UMI	0.997	0.997	0.000	I(1)	I(1)	I(1)	I(1)	E ↔ Y	Spurious	0.920	E ↔ Y
Belgium	HI	0.996	0.997	0.001	I(1)	I(1)	I(1)	I(1)	E – Y	Spurious	0.657	E – Y
Netherlands	HI	0.996	0.996	0.000	I(1)	I(1)	I(1)	I(1)	E → Y	Spurious	0.695	E → Y
Japan	HI	0.995	0.991	−0.004	I(1)	I(1)	I(1)	I(1)	E ← Y	Spurious	0.528	E – Y
Denmark	HI	0.994	0.994	0.000	I(1)	I(1)	I(1)	I(1)	E → Y	Spurious	0.488	E → Y
India	LMI	0.993	0.995	0.002	I(1)	I(1)	I(1)	I(1)	E → Y	Spurious	0.574	E ↔ Y
Singapore	HI	0.993	0.994	0.001	I(1)	I(1)	I(1)	I(1)	E ↔ Y	Spurious	0.627	E – Y
Country	**Income Group**	**r(e-A) [1] Ferguson[a]**	**r(e-A) [2] current**	**Δ Dif. = [2] - [1]**	**A**	**e**	**Coint (A-e)**	**Coint (e-A)**	**Granger @level**	**Verdict**	**r(Δe-ΔA)**	**Granger @Diff.**
Colombia	UMI	0.991	0.954	−0.037	I(1)	I(1)	I(1)	I(1)	E – Y	Spurious	0.234	E – Y
Australia	HI	0.990	0.989	−0.001	I(1)	I(1)	I(1)	I(1)	E → Y	Spurious	0.615	E → Y
Sri Lanka	LMI	0.990	0.997	0.007	I(1)	I(1)	I(1)	I(1)	E – Y	Spurious	0.762	E ← Y
Pakistan	LMI	0.989	0.985	−0.004	I(1)	I(1)	I(1)	I(1)	E ← Y	Spurious	0.536	E – Y
China	UMI	0.988	0.995	0.007	I(1)	I(1)	I(1)	I(1)	E ↔ Y	Spurious	0.918	E – Y
Sweden	HI	0.987	0.985	−0.002	I(1)	I(1)	I(1)	I(1)	E ↔ Y	Spurious	0.346	E – Y
Indonesia	LMI	0.986	0.981	−0.005	I(1)	I(1)	I(1)	I(1)	E → Y	Spurious	0.709	E → Y
Malaysia	UMI	0.986	0.991	0.005	I(1)	I(1)	I(1)	I(1)	E ↔ Y	Spurious	0.727	E ↔ Y

(continued on next page)

Table A1.1 (*continued*)

Country	Income Group	r(e-A) [1] Ferguson[1]	r(e-A) [2] current	Δ = [2] - [1]	A	e	Coint (A-e)	Coint (e-A)	Granger @level	Verdict	r(Δe-ΔA)	Granger @Diff.
Spain	HI	0.986	0.987	0.001	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.503	E – Y
Norway	HI	0.985	0.986	0.001	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.112	E – Y
United States	HI	0.984	0.979	−0.005	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.526	E → Y
Ireland	HI	0.983	0.987	0.004	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.249	E – Y
Cyprus	HI	0.980	0.968	−0.012	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	−0.021	E – Y
France	HI	0.979	0.986	0.007	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.227	E ← Y
Greece	HI	0.979	0.924	−0.055	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.501	E – Y
Chile	HI	0.977	0.960	−0.017	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.836	E – Y
Finland	HI	0.977	0.983	0.006	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.423	E ← Y
Portugal	HI	0.976	0.977	0.001	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.575	E – Y
Tunisia	LMI	0.974	0.963	−0.011	I (1)	I (1)	I(1)	I(1)	E → Y	Spurious	0.263	E – Y
Turkey	UMI	0.970	0.975	0.005	I (1)	I (1)	I(1)	I(1)	E → Y	Spurious	0.520	E → Y
New Zealand	HI	0.969	0.846	−0.123	I (1)	I (1)	I(0)	I(1)	E – Y	Spurious	0.239	E – Y
Nepal	LI	0.967	0.975	0.008	I (1)	I (1)	I(1)	I(1)	E → Y	Spurious	0.448	E – Y
Bangladesh	LMI	0.961	0.938	−0.023	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.339	E – Y
Malta	HI	0.958	0.945	−0.013	I (1)	I (1)	I(1)	I(1)	E → Y	Spurious	0.055	E ← Y
Germany	HI	0.956	0.877	−0.079	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.333	E – Y
Morocco	LMI	0.950	0.968	0.018	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.206	E ↔ Y
United Kingdom	HI	0.942	0.934	−0.008	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.487	E – Y
Egypt, Arab Rep.	LMI	0.889	0.992	0.103	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.202	E – Y
Country	**Income Group**	**r(e-A) [1] Ferguson[1]**	**r(e-A) [2] current**	**Δ Dif. = [2] - [1]**	**A**	**e**	**Coint (A-e)**	**Coint (e-A)**	**Granger @level**	**Verdict**	**r(Δe-ΔA)**	**Granger @Diff.**
Luxembourg	HI	0.876	0.801	−0.075	I (1)	I (1)	I(1)	I(0)	E – Y	Spurious	0.337	E – Y
Bulgaria	UMI	0.872	0.711	−0.161	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.695	E ↔ Y
Panama	HI	0.870	0.809	−0.061	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.239	E ← Y
Cuba	UMI	0.858	0.908	0.050	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.776	E – Y
Brazil	UMI	0.822	0.848	0.026	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.565	E – Y
Uruguay	HI	0.818	0.829	0.011	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.306	E ↔ Y
Mexico	UMI	0.773	0.813	0.040	I (1)	I (1)	I(1)	I(1)	E → Y	Spurious	0.233	E → Y
Paraguay	UMI	0.733	0.896	0.163	I (1)	I (1)	I(1)	I(1)	E → Y	Spurious	0.302	E ↔ Y
Myanmar	LMI	0.694	0.720	0.026	I (1)	I (1)	I(1)	I(1)	E → Y	Spurious	0.550	E – Y
Cameroon	LMI	0.693	0.790	0.097	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.364	E – Y
Philippines	LMI	0.684	0.572	−0.112	I (1)	I (0)	I(1)	I(1)	E – Y	Spurious	0.425	E ↔ Y
Congo, Dem. Rep.	LI	0.677	0.918	0.241	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.489	E ← Y
Costa Rica	UMI	0.659	0.757	0.098	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.292	E – Y
Jamaica	UMI	0.615	0.676	0.061	I (1)	I (1)	I(1)	I(1)	E → Y	Spurious	0.189	E → Y
Ghana	LMI	0.483	0.562	0.079	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.175	E – Y
Algeria	UMI	0.444	0.557	0.113	I (1)	I (1)	I(1)	I(1)	E → Y	Spurious	0.350	E – Y

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Table A1.1 (*continued*)

Country	Income Group	r(e-A) [1] Ferguson[1]	r(e-A) [2] current	Δ = [2] - [1]	A	e	Coint (A-e)	Coint (e-A)	Granger @level	Verdict	r(Δe-ΔA)	Granger @Diff.
Honduras	LMI	0.356	0.605	0.249	I (0)	I (1)	I(1)	I(1)	E → Y	Spurious	0.379	E → Y
Jordan	UMI	0.275	0.333	0.058	I (1)	I (1)	I(1)	I(1)	E → Y	Spurious	0.240	E – Y
Haiti	LI	0.273	0.314	0.041	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.435	E – Y
Mozambique	LI	0.169	0.406	0.237	I (0)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.218	E ↔ Y
Guatemala	UMI	0.121	0.712	0.591	I (0)	I (1)	I(1)	I(1)	E – Y	Spurious	0.514	E – Y
Benin	LI	0.097	0.403	0.306	I (1)	I (1)	I(1)	I(1)	E → Y	Spurious	−0.244	E – Y
Sudan	LMI	0.075	−0.003	−0.078	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	−0.259	E – Y
Zimbabwe	LI	−0.008	0.001	0.009	I (1)	I (1)	I(1)	I(1)	E → Y	Spurious	0.504	E – Y
Argentina	HI	−0.077	−0.073	0.004	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.753	E – Y
Bolivia	LMI	−0.208	−0.290	−0.082	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.555	E – Y
El Salvador	LMI	−0.313	−0.333	−0.020	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.740	E ← Y
Peru	UMI	−0.430	−0.345	0.085	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.487	E – Y
Country	**Income Group**	**r(e-A) [1] Ferguson[1]**	**r(e-A) [2] current**	**Δ Dif. = [2] - [1]**	**A**	**e**	**Coint (A-e)**	**Coint (e-A)**	**Granger @level**	**Verdict**	**r(Δe-ΔA)**	**Granger @Diff.**
Bahrain	HI	−0.463	0.313	0.776	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.171	E – Y
South Africa	UMI	−0.489	−0.439	0.050	I (1)	I (1)	I(1)	I(1)	E → Y	Spurious	0.632	E – Y
Senegal	LI	−0.565	−0.720	−0.155	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	−0.418	E – Y
Nigeria	LMI	−0.635	−0.799	−0.164	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.008	E – Y
Brunei Darussalam	HI	−0.658	−0.819	−0.161	I (0)	I (1)	I(1)	I(1)	E → Y	Spurious	−0.367	E – Y
Iraq	UMI	−0.704	0.486	1.190	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.476	E ← Y
Iran, Islamic Rep.	UMI	−0.706	−0.734	−0.028	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.648	E – Y
Venezuela, RB	UMI	−0.842	−0.773	0.069	I (1)	I (1)	I(1)	I(1)	E → Y	Spurious	0.116	E → Y
Saudi Arabia	HI	−0.881	−0.821	0.060	I (1)	I (1)	I(1)	I(1)	E → Y	Spurious	−0.205	E – Y
United Arab Emirates	HI	−0.908	−0.816	0.092	I (1)	I (0)	I(1)	I(1)	E ↔ Y	Spurious	0.081	E ← Y
By Income Groups	**Income Group**	**r(e-A) [1] Ferguson[1]**	**r(e-A) [2] current**	**Δ Dif. = [2] - [1]**	**A**	**e**	**Coint (A-e)**	**Coint (e-A)**	**Granger @level**	**Verdict**	**r(Δe-ΔA)**	**Granger @Diff.**
Low Income	LI	–	–	–	–	–	–	–	–	–	–	
Lower Middle Income	LMI	–	0.869	–	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.064	E → Y
Upper Middle Income	UMI	–	0.854	–	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	−0.138	E – Y
High Income	HI	–	0.998	–	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.610	E ← Y
World	–	–	0.984	–	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.498	E – Y

Notes: r(x-y) refers to *correlation coefficient* between x and y; Coint(x-y) refers to *cointegration.*

[1] This column is corresponding Table 1 in **Ferguson**

Table A1.2
Correlation coefficients: per capita electricity use (e) vs. affluence (A) – 1996–2014

Country	Income Group	r(e-A) [1] Ferguson	r(e-A) [2] current	Δ Dif. = [2] - [1]	A	e	Coint (A-e)	Coint (e-A)	Granger @level	Verdict	r(Δe-ΔA)	Granger @Diff.
Korea, Rep.	HI	–	0.997	–	I (1)	I (1)	I(0)	I(1)	E ← Y	TRUE	0.765	E – Y
Hong Kong SAR, China	HI	0.997	0.845	−0.152	I (1)	I (1)	I(1)	I(0)	E ↔ Y	TRUE	−0.463	E – Y
Indonesia	LMI	0.986	0.960	−0.026	I (1)	I (1)	I(0)	I(0)	E → Y	TRUE	0.631	E ↔ Y

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Table A1.2 (*continued*)

Country	Income Group	r(e-A) [1] Ferguson	r(e-A) [2] current	Δ Dif. = [2] - [1]	A	e	Coint (A-e)	Coint (e-A)	Granger @level	Verdict	r(Δe-ΔA)	Granger @Diff.
Bulgaria	UMI	0.872	0.902	0.030	I (1)	I (1)	I(0)	I(0)	E ↔ Y	TRUE	0.752	E – Y
Panama	HI	0.870	0.987	0.117	I (1)	I (1)	I(1)	I(0)	E ↔ Y	TRUE	0.630	E ↔ Y
Brazil	UMI	0.822	0.987	0.165	I (1)	I (1)	I(0)	I(0)	E ← Y	TRUE	0.621	E – Y
Paraguay	UMI	0.733	0.922	0.189	I (1)	I (1)	I(1)	I(0)	E ↔ Y	TRUE	0.505	E ← Y
Dominican Republic	UMI	0.670	0.767	0.097	I (1)	I (0)	I(1)	I(0)	E → Y	TRUE	0.348	E – Y
Argentina	HI	−0.077	0.861	0.938	I (1)	I (1)	I(1)	I(0)	E → Y	TRUE	0.501	E ↔ Y
Nigeria	LMI	−0.635	0.939	1.574	I (1)	I (1)	I(1)	I(0)	E ← Y	TRUE	0.435	E – Y
Venezuela, RB	UMI	−0.842	0.821	1.663	I (1)	I (1)	I(0)	I(0)	E ↔ Y	TRUE	0.712	E → Y
Saudi Arabia	HI	−0.881	0.803	1.684	I (1)	I (1)	I(1)	I(0)	E ↔ Y	TRUE	0.050	E ↔ Y
Albania	UMI	–	0.857	–	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.294	E ↔ Y
Congo, Rep.	LMI	–	0.877	–	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.417	E ← Y
Mauritius	UMI	–	0.980	–	I (1)	I (1)	I(1)	I(1)	E → Y	Spurious	0.242	E ← Y
Togo	LI	–	0.720	–	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.382	E – Y
Austria	HI	0.998	0.978	−0.020	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.524	E – Y
Canada	HI	0.997	−0.436	−1.433	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.684	E – Y
Italy	HI	0.997	0.934	−0.063	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.909	E – Y
Thailand	UMI	0.997	0.993	−0.004	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.861	E ↔ Y
Belgium	HI	0.996	0.486	−0.510	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.683	E → Y
Netherlands	HI	0.996	0.953	−0.043	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.828	E ↔ Y
Japan	HI	0.995	0.235	−0.760	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.591	E ← Y
Denmark	HI	0.994	−0.218	−1.212	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.665	E – Y
India	LMI	0.993	0.996	0.003	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.785	E – Y
Singapore	HI	0.993	0.876	−0.117	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.682	E ↔ Y
Colombia	UMI	0.991	0.977	−0.014	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.551	E – Y
Country	**Income Group**	**r(e-A) [1] Ferguson**	**r(e-A) [2] current**	**Δ Dif. = [2] - [1]**	**A**	**e**	**Coint (A-e)**	**Coint (e-A)**	**Granger @level**	**Verdict**	**r(Δe-ΔA)**	**Granger @Diff.**
Australia	HI	0.990	0.651	−0.339	I (1)	I (0)	I(1)	I(1)	E – Y	Spurious	0.413	E – Y
Sri Lanka	LMI	0.990	0.971	−0.019	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.441	E – Y
Pakistan	LMI	0.989	0.936	−0.053	I (1)	I (1)	I(1)	I(1)	E → Y	Spurious	0.556	E – Y
China	UMI	0.988	0.998	0.010	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.847	E – Y
Sweden	HI	0.987	−0.631	−1.618	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.521	E – Y
Malaysia	UMI	0.986	0.945	−0.041	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	−0.186	E – Y
Spain	HI	0.986	0.982	−0.004	I (1)	I (1)	I(1)	I(1)	E → Y	Spurious	0.828	E ↔ Y
Norway	HI	0.985	−0.206	−1.191	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.466	E → Y
United States	HI	0.984	0.369	−0.615	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.686	E ← Y
Ireland	HI	0.983	0.843	−0.140	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.525	E ↔ Y
Israel	HI	0.981	0.751	−0.230	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.276	E – Y
Cyprus	HI	0.980	0.962	−0.018	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.787	E ← Y

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Table A1.2 (*continued*)

Country	Income Group	r(e-A) [1] Ferguson	r(e-A) [2] current	Δ Dif. = [2] - [1]	A	e	Coint (A-e)	Coint (e-A)	Granger @level	Verdict	r(Δe-ΔA)	Granger @Diff.
France	HI	0.979	0.666	−0.313	I (0)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.281	E – Y
Greece	HI	0.979	0.809	−0.170	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.537	E ← Y
Chile	HI	0.977	0.972	−0.005	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.353	E – Y
Finland	HI	0.977	0.789	−0.188	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.586	E → Y
Portugal	HI	0.976	0.898	−0.078	I (0)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.756	E ↔ Y
Tunisia	LMI	0.974	0.967	−0.007	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.371	E → Y
Turkey	UMI	0.970	0.969	−0.001	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.740	E ↔ Y
New Zealand	HI	0.969	0.362	−0.607	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.010	E → Y
Switzerland	HI	0.968	0.497	−0.471	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.325	E – Y
Nepal	LI	0.967	0.991	0.024	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.110	E ← Y
Bangladesh	LMI	0.961	0.992	0.031	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.415	E ↔ Y
Malta	HI	0.958	0.871	−0.087	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.455	E – Y
Germany	HI	0.956	0.830	−0.126	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.593	E ← Y
Morocco	LMI	0.950	0.996	0.046	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.453	E → Y
United Kingdom	HI	0.942	−0.169	−1.111	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.677	E → Y
Oman	HI	0.937	0.173	−0.764	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.198	E – Y
Country	**Income Group**	**r(e-A) [1] Ferguson**	**r(e-A) [2] current**	**Δ Dif. = [2] - [1]**	**A**	**e**	**Coint (A-e)**	**Coint (e-A)**	**Granger @level**	**Verdict**	**r(Δe-ΔA)**	**Granger @Diff.**
Egypt, Arab Rep.	LMI	0.889	0.991	0.102	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.295	E ↔ Y
Zambia	LMI	0.882	0.265	−0.617	I (1)	I (0)	I(1)	I(1)	E ↔ Y	Spurious	0.243	E ↔ Y
Luxembourg	HI	0.876	0.238	−0.638	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.525	E ↔ Y
Cuba	UMI	0.858	0.952	0.094	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.215	E → Y
Kenya	LMI	0.833	0.954	0.121	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.648	E – Y
Uruguay	HI	0.818	0.942	0.124	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.434	E ← Y
Ecuador	UMI	0.776	0.982	0.206	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.683	E – Y
Mexico	UMI	0.773	0.892	0.119	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.392	E – Y
Angola	LMI	0.718	0.925	0.207	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.028	E – Y
Myanmar	LMI	0.694	0.917	0.223	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.382	E ← Y
Cameroon	LMI	0.693	0.854	0.161	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.244	E ↔ Y
Philippines	LMI	0.684	0.953	0.269	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.331	E ↔ Y
Congo, Dem. Rep.	LI	0.677	0.710	0.033	I (1)	I (1)	I(1)	I(1)	E → Y	Spurious	0.181	E – Y
Costa Rica	UMI	0.659	0.951	0.292	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.288	E ← Y
Jamaica	UMI	0.615	0.178	−0.437	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.020	E → Y
Ghana	LMI	0.483	0.171	−0.312	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.385	E ← Y
Algeria	UMI	0.444	0.910	0.466	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.333	E → Y
Nicaragua	LMI	0.388	0.967	0.579	I (1)	I (1)	I(1)	I(1)	E → Y	Spurious	0.223	E – Y
Honduras	LMI	0.356	0.948	0.592	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.507	E – Y
Jordan	UMI	0.275	0.935	0.660	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.590	E ← Y

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Table A1.2 (*continued*)

Country	Income Group	r(e-A) [1] Ferguson	r(e-A) [2] current	Δ Dif. = [2] - [1]	A	e	Coint (A-e)	Coint (e-A)	Granger @level	Verdict	r(Δe-ΔA)	Granger @Diff.
Haiti	LI	0.273	0.381	0.108	I (1)	I (1)	I(1)	I(1)	E → Y	Spurious	0.414	E → Y
Mozambique	LI	0.169	0.855	0.686	I (1)	I (0)	I(1)	I(1)	E ↔ Y	Spurious	−0.073	E ← Y
Guatemala	UMI	0.121	0.928	0.807	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.055	E – Y
Benin	LI	0.097	0.960	0.863	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.274	E → Y
Sudan	LMI	0.075	0.974	0.899	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	−0.019	E ← Y
Trinidad and Tobago	HI	0.017	0.939	0.922	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.264	E ↔ Y
Zimbabwe	LI	−0.008	0.703	0.711	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.256	E ↔ Y
Bolivia	LMI	−0.208	0.993	1.201	I (1)	I (1)	I(1)	I(1)	E → Y	Spurious	0.518	E ← Y
Country	**Income Group**	**r(e-A) [1] Ferguson**	**r(e-A) [2] current**	**Δ Dif. = [2] - [1]**	**A**	**e**	**Coint (A-e)**	**Coint (e-A)**	**Granger @level**	**Verdict**	**r(Δe-ΔA)**	**Granger @Diff.**
Gabon	UMI	−0.274	−0.452	−0.178	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.416	E – Y
El Salvador	LMI	−0.313	0.971	1.284	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.441	E → Y
Peru	UMI	−0.430	0.989	1.419	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.456	E ↔ Y
Bahrain	HI	−0.463	0.752	1.215	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.330	E ↔ Y
South Africa	UMI	−0.489	−0.202	0.287	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.630	E – Y
Senegal	LI	−0.565	0.886	1.451	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	−0.133	E → Y
Brunei Darussalam	HI	−0.658	−0.610	0.048	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	−0.328	E ← Y
Iraq	UMI	−0.704	0.004	0.708	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.323	E – Y
Iran, Islamic Rep.	UMI	−0.706	0.922	1.628	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.330	E → Y
United Arab Emirates	HI	−0.908	0.249	1.157	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.144	E ← Y
By Income Groups	**Income Group**	**r(e-A) [1] Ferguson**	**r(e-A) [2] current**	**Δ Dif. = [2] - [1]**	**A**	**e**	**Coint (A-e)**	**Coint (e-A)**	**Granger @level**	**Verdict**	**r(Δe-ΔA)**	**Granger @Diff.**
Low Income	LI	–	–	–	–	–	–	–	–	–	–	
Lower Middle Income	LMI	–	0.998	–	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.875	E ↔ Y
Upper Middle Income	UMI	–	0.999	–	I (1)	I (1)	I(0)	I(0)	E ↔ Y	TRUE	0.891	E ↔ Y
High Income	HI	–	0.938	–	I (1)	I (0)	I(1)	I(1)	E ↔ Y	Spurious	0.812	E ↔ Y
World	–	–	0.992	–	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.823	E ← Y

Notes: r(x-y) refers to *correlation coefficient* between x and y; Coint(x-y) refers to *cointegration*.
*This column is corresponding Table 1 in **Ferguson**

Table A1.3
Correlation coefficients: per capita electricity use (e) vs. affluence (A) – 1996–2014

Country	Income Group	r(e-A) [1] Ferguson[1]	r(e-A) [2] current	Δ Dif. = [2] - [1]	A	e	Coint (A-e)	Coint (e-A)	Granger @level	Verdict	r(Δe-ΔA)	Granger @Diff.
Albania	UMI	–	0.909	–	I (1)	I (1)	I(1)	I(0)	E ← Y	TRUE	0.418	E – Y
Congo, Rep.	LMI	–	0.691	–	I (1)	I (1)	I(0)	I(1)	E ← Y	TRUE	0.186	E ← Y
Spain	HI	0.986	0.996	0.010	I (1)	I (1)	I(0)	I(0)	E → Y	TRUE	0.738	E – Y
Morocco	LMI	0.950	0.996	0.046	I (1)	I (1)	I(0)	I(0)	E → Y	TRUE	0.314	E ← Y
Ecuador	UMI	0.776	0.949	0.173	I (1)	I (1)	I(0)	I(0)	E → Y	TRUE	0.477	E – Y
Ghana	LMI	0.483	0.135	−0.348	I (1)	I (0)	I(1)	I(0)	E → Y	TRUE	0.198	E – Y
Benin	LI	0.097	0.943	0.846	I (1)	I (1)	I(0)	I(1)	E → Y	TRUE	−0.146	E – Y

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Table A1.3 (*continued*)

Country	Income Group	r(e-A) [1] Ferguson[1]	r(e-A) [2] current	Δ Dif. = [2] - [1]	A	e	Coint (A-e)	Coint (e-A)	Granger @level	Verdict	r(Δe-ΔA)	Granger @Diff.
Gabon	UMI	−0.274	−0.242	0.032	I (0)	I (1)	I(0)	I(0)	E → Y	TRUE	0.153	E – Y
Korea, Rep.	HI	–	0.994	–	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.804	E – Y
Mauritius	UMI	–	0.989	–	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.487	E – Y
Togo	LI	–	−0.190	–	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.443	E – Y
Austria	HI	0.998	0.997	−0.001	I (1)	I (1)	I(1)	I(1)	E → Y	Spurious	0.521	E → Y
Canada	HI	0.997	0.898	−0.099	I (1)	I (0)	I(1)	I(1)	E ← Y	Spurious	0.562	E ← Y
Hong Kong SAR, China	HI	0.997	0.956	−0.041	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.086	E – Y
Italy	HI	0.997	0.995	−0.002	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.899	E – Y
Thailand	UMI	0.997	0.994	−0.003	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.850	E ↔ Y
Belgium	HI	0.996	0.985	−0.011	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.653	E → Y
Netherlands	HI	0.996	0.984	−0.012	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.734	E – Y
Japan	HI	0.995	0.992	−0.003	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.634	E ↔ Y
Denmark	HI	0.994	0.933	−0.061	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.524	E → Y
India	LMI	0.993	0.984	−0.009	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.796	E ↔ Y
Singapore	HI	0.993	0.973	−0.020	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.628	E ← Y
Colombia	UMI	0.991	0.961	−0.030	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.427	E – Y
Australia	HI	0.990	0.951	−0.039	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.277	E – Y
Sri Lanka	LMI	0.990	0.990	0.000	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.624	E – Y
Pakistan	LMI	0.989	0.986	−0.003	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.528	E – Y
China	UMI	0.988	0.998	0.010	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.931	E ← Y
Country	**Income Group**	**r(e-A) [1] Ferguson[1]**	**r(e-A) [2] current**	**Δ Dif. = [2] - [1]**	**A**	**e**	**Coint (A-e)**	**Coint (e-A)**	**Granger @level**	**Verdict**	**r(Δe-ΔA)**	**Granger @Diff.**
Sweden	HI	0.987	0.819	−0.168	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.283	E – Y
Indonesia	LMI	0.986	0.980	−0.006	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.553	E – Y
Malaysia	UMI	0.986	0.988	0.002	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.023	E – Y
Norway	HI	0.985	0.918	−0.067	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.321	E – Y
United States	HI	0.984	0.946	−0.038	I (1)	I (0)	I(1)	I(1)	E → Y	Spurious	0.545	E – Y
Ireland	HI	0.983	0.972	−0.011	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.405	E ← Y
Israel	HI	0.981	0.979	−0.002	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.317	E – Y
Cyprus	HI	0.980	0.984	0.004	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.556	E ← Y
France	HI	0.979	0.987	0.008	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.311	E – Y
Greece	HI	0.979	0.954	−0.025	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.527	E ← Y
Chile	HI	0.977	0.993	0.016	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.620	E – Y
Finland	HI	0.977	0.971	−0.006	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.500	E → Y
Portugal	HI	0.976	0.978	0.002	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.618	E – Y
Tunisia	LMI	0.974	0.982	0.008	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.330	E → Y
Turkey	UMI	0.970	0.989	0.019	I (1)	I (1)	I(1)	I(1)	E → Y	Spurious	0.721	E ↔ Y
New Zealand	HI	0.969	0.799	−0.170	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.052	E – Y

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Table A1.3 (*continued*)

Country	Income Group	r(e-A) [1] Ferguson[1]	r(e-A) [2] current	Δ Dif. = [2] - [1]	A	e	Coint (A-e)	Coint (e-A)	Granger @level	Verdict	r(Δe-ΔA)	Granger @Diff.
Switzerland	HI	0.968	0.873	−0.095	I(1)	I(1)	I(1)	I(1)	E ← Y	Spurious	0.331	E – Y
Nepal	LI	0.967	0.995	0.028	I(1)	I(1)	I(1)	I(1)	E ↔ Y	Spurious	0.368	E ← Y
Bangladesh	LMI	0.961	0.996	0.035	I(1)	I(1)	I(1)	I(1)	E → Y	Spurious	0.602	E → Y
Malta	HI	0.958	0.975	0.017	I(1)	I(1)	I(1)	I(1)	E – Y	Spurious	0.254	E – Y
Germany	HI	0.956	0.895	−0.061	I(1)	I(0)	I(1)	I(1)	E ← Y	Spurious	0.456	E ← Y
United Kingdom	HI	0.942	0.897	−0.045	I(1)	I(1)	I(1)	I(1)	E – Y	Spurious	0.493	E – Y
Oman	HI	0.937	0.868	−0.069	I(1)	I(1)	I(1)	I(1)	E – Y	Spurious	0.047	E – Y
Egypt, Arab Rep.	LMI	0.889	0.991	0.102	I(1)	I(1)	I(1)	I(1)	E ↔ Y	Spurious	0.325	E – Y
Zambia	LMI	0.882	0.537	−0.345	I(1)	I(1)	I(1)	I(1)	E ↔ Y	Spurious	0.440	E – Y
Luxembourg	HI	0.876	0.875	−0.001	I(1)	I(0)	I(1)	I(0)	E – Y	Spurious	0.392	E – Y
Bulgaria	UMI	0.872	0.437	−0.435	I(1)	I(1)	I(1)	I(1)	E → Y	Spurious	0.657	E – Y
Panama	HI	0.870	0.963	0.093	I(1)	I(1)	I(1)	I(1)	E ← Y	Spurious	0.498	E ← Y
Country	**Income Group**	**r(e-A) [1] Ferguson[1]**	**r(e-A) [2] current**	**Δ Dif. = [2] - [1]**	**A**	**e**	**Coint (A-e)**	**Coint (e-A)**	**Granger @level**	**Verdict**	**r(Δe-ΔA)**	**Granger @Diff.**
Cuba	UMI	0.858	0.874	0.016	I(1)	I(1)	I(1)	I(1)	E – Y	Spurious	0.673	E – Y
Kenya	LMI	0.833	0.846	0.013	I(1)	I(1)	I(1)	I(1)	E – Y	Spurious	0.400	E – Y
Brazil	UMI	0.822	0.946	0.124	I(1)	I(1)	I(1)	I(1)	E – Y	Spurious	0.494	E – Y
Uruguay	HI	0.818	0.964	0.146	I(1)	I(1)	I(1)	I(1)	E ↔ Y	Spurious	0.435	E ← Y
Mexico	UMI	0.773	0.936	0.163	I(1)	I(1)	I(1)	I(1)	E → Y	Spurious	0.274	E – Y
Paraguay	UMI	0.733	0.909	0.176	I(1)	I(1)	I(1)	I(1)	E → Y	Spurious	0.404	E – Y
Angola	LMI	0.718	0.818	0.100	I(1)	I(1)	I(1)	I(1)	E – Y	Spurious	0.239	E ← Y
Myanmar	LMI	0.694	0.953	0.259	I(1)	I(1)	I(1)	I(1)	E ↔ Y	Spurious	0.544	E ← Y
Cameroon	LMI	0.693	0.477	−0.216	I(1)	I(1)	I(1)	I(1)	E – Y	Spurious	0.279	E – Y
Philippines	LMI	0.684	0.887	0.203	I(1)	I(1)	I(1)	I(1)	E → Y	Spurious	0.442	E – Y
Congo, Dem. Rep.	LI	0.677	0.962	0.285	I(1)	I(1)	I(1)	I(1)	E ← Y	Spurious	0.460	E ← Y
Dominican Republic	UMI	0.670	0.940	0.270	I(1)	I(1)	I(1)	I(1)	E ← Y	Spurious	0.333	E – Y
Costa Rica	UMI	0.659	0.945	0.286	I(1)	I(1)	I(1)	I(1)	E – Y	Spurious	0.318	E – Y
Jamaica	UMI	0.615	0.657	0.042	I(1)	I(1)	I(1)	I(1)	E → Y	Spurious	0.146	E → Y
Algeria	UMI	0.444	0.849	0.405	I(1)	I(1)	I(1)	I(1)	E – Y	Spurious	0.256	E – Y
Nicaragua	LMI	0.388	−0.095	−0.483	I(1)	I(1)	I(1)	I(1)	E – Y	Spurious	0.704	E – Y
Honduras	LMI	0.356	0.903	0.547	I(1)	I(1)	I(1)	I(1)	E → Y	Spurious	0.386	E → Y
Jordan	UMI	0.275	0.721	0.446	I(1)	I(1)	I(1)	I(1)	E – Y	Spurious	0.317	E – Y
Haiti	LI	0.273	0.319	0.046	I(1)	I(1)	I(1)	I(1)	E → Y	Spurious	0.377	E – Y
Mozambique	LI	0.169	0.936	0.767	I(1)	I(1)	I(1)	I(1)	E – Y	Spurious	0.173	E – Y
Guatemala	UMI	0.121	0.945	0.824	I(1)	I(1)	I(1)	I(1)	E → Y	Spurious	0.340	E – Y
Sudan	LMI	0.075	0.954	0.879	I(1)	I(1)	I(1)	I(1)	E ↔ Y	Spurious	0.122	E ↔ Y
Trinidad and Tobago	HI	0.017	0.861	0.844	I(1)	I(1)	I(1)	I(1)	E – Y	Spurious	0.370	E – Y
Zimbabwe	LI	−0.008	0.685	0.693	I(1)	I(1)	I(1)	I(1)	E ← Y	Spurious	0.412	E – Y

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Table A1.3 (*continued*)

Country	Income Group	r(e-A) [1] Ferguson[1]	r(e-A) [2] current	Δ Dif. = [2] - [1]	A	e	Coint (A-e)	Coint (e-A)	Granger @level	Verdict	r(Δe-ΔA)	Granger @Diff.
Argentina	HI	−0.077	0.854	0.931	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.592	E ← Y
Bolivia	LMI	−0.208	0.805	1.013	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.578	E ← Y
El Salvador	LMI	−0.313	0.578	0.891	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.510	E ← Y
Country	**Income Group**	**r(e-A) [1] Ferguson[1]**	**r(e-A) [2] current**	**Δ Dif. = [2] - [1]**	**A**	**e**	**Coint (A-e)**	**Coint (e-A)**	**Granger @level**	**Verdict**	**r(Δe-ΔA)**	**Granger @Diff.**
Peru	UMI	−0.430	0.833	1.263	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.547	E ← Y
Bahrain	HI	−0.463	0.623	1.086	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.187	E – Y
South Africa	UMI	−0.489	0.177	0.666	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.310	E – Y
Senegal	LI	−0.565	0.530	1.095	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	−0.093	E – Y
Nigeria	LMI	−0.635	0.300	0.935	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.111	E – Y
Brunei Darussalam	HI	−0.658	−0.800	−0.142	I (0)	I (1)	I(1)	I(1)	E – Y	Spurious	−0.271	E – Y
Iraq	UMI	−0.704	0.432	1.136	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.324	E ← Y
Iran, Islamic Rep.	UMI	−0.706	−0.183	0.523	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.437	E – Y
Venezuela, RB	UMI	−0.842	−0.401	0.441	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.282	E → Y
Saudi Arabia	HI	−0.881	−0.682	0.199	I (0)	I (1)	I(1)	I(1)	E ← Y	Spurious	−0.105	E – Y
United Arab Emirates	HI	−0.908	−0.824	0.084	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.059	E – Y
By Income Groups	**Income Group**	**r(e-A) [1] Ferguson[1]**	**r(e-A) [2] current**	**Δ Dif. = [2] - [1]**	**A**	**e**	**Coint (A-e)**	**Coint (e-A)**	**Granger @level**	**Verdict**	**r(Δe-ΔA)**	**Granger @Diff.**
Low Income	LI	–	–	–	–	–	–	–	–		–	
Lower Middle Income	LMI	–	0.933	–	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.239	E – Y
Upper Middle Income	UMI	–	0.978	–	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.486	E – Y
High Income	HI	–	0.991	–	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.695	E – Y
World	–	–	0.993	–	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.640	E – Y

Notes: r(x-y) refers to *correlation coefficient* between x and y; Coint(x-y) refers to *cointegration.*

[1] This column is corresponding Table 1 in **Ferguson**

Table A2.1

Correlation coefficients: per capita primary energy use (E) vs. affluence (A) – 1960-1995

Country	Income Group	r(E-A) [1] Ferguson[1]>	r(E-A) [2] current	Δ Dif. = [2] - [1]	A	E	Coint (A-E)	Coint (E-A)	Granger @level	Verdict	r(Δe-ΔA)	Granger @Diff.
Malaysia	UMI	0.972	0.984	0.012	I (1)	I (1)	I(0)	I(0)	E ← Y	TRUE	0.251	E – Y
Mozambique	LI	0.859	0.069	−0.790	I (0)	I (1)	I(0)	I(1)	E ↔ Y	TRUE	0.298	E ↔ Y
Gabon	UMI	0.528	0.283	−0.245	I (0)	I (1)	I(0)	I(1)	E ↔ Y	TRUE	−0.176	E → Y
Senegal	LI	0.487	0.851	0.364	I (1)	I (1)	I(0)	I(1)	E → Y	TRUE	0.098	E – Y
Venezuela, RB	UMI	−0.070	−0.552	−0.482	I (1)	I (1)	I(1)	I(0)	E → Y	TRUE	−0.114	E – Y
Panama	HI	−0.523	−0.592	−0.069	I (1)	I (0)	I(0)	I(1)	E ← Y	TRUE	0.056	E ← Y
Nigeria	LMI	−0.556	−0.743	−0.187	I (1)	I (1)	I(1)	I(0)	E → Y	TRUE	0.091	E – Y
Brunei Darussalam	HI	−0.706	−0.346	0.360	I (0)	I (1)	I(1)	I(0)	E → Y	TRUE	0.107	E – Y
United Arab Emirates	HI	−0.910	−0.869	0.041	I (1)	I (1)	I(1)	I(0)	E ↔ Y	TRUE	0.189	E ↔ Y
Albania	UMI	–	0.904	–	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.624	E ↔ Y

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Table A2.1 (*continued*)

Country	Income Group	r(E-A) [1] Ferguson[1]>	r(E-A) [2] current	Δ Dif. = [2] - [1]	A	E	Coint (A-E)	Coint (E-A)	Granger @level	Verdict	r(Δe-ΔA)	Granger @Diff.
Congo, Rep.	LMI	–	−0.084	–	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.396	E ← Y
Mauritius	UMI	–	0.968	–	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.561	E ← Y
Togo	LI	–	−0.307	–	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.304	E – Y
Pakistan	LMI	0.995	0.991	−0.004	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.296	E – Y
India	LMI	0.995	0.992	−0.003	I (1)	I (1)	I(1)	I(1)	E → Y	Spurious	0.298	E ↔ Y
Indonesia	LMI	0.994	0.982	−0.012	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.477	E ← Y
Spain	HI	0.993	0.994	0.001	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.577	E ← Y
Korea, Rep.	HI	0.993	0.995	–	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.724	E ← Y
Greece	HI	0.991	0.961	−0.030	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.623	E – Y
Cyprus	HI	0.990	0.962	−0.028	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	−0.030	E – Y
Thailand	UMI	0.989	0.983	−0.006	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.830	E ← Y
France	HI	0.987	0.972	−0.015	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.388	E – Y
Hong Kong SAR, China	HI	0.987	0.978	−0.009	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.356	E ← Y
Portugal	HI	0.983	0.979	−0.004	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.411	E – Y
Tunisia	LMI	0.982	0.987	0.005	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.568	E → Y
Switzerland	HI	0.981	0.859	−0.122	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.403	E ↔ Y
Zambia	LMI	0.980	0.983	0.003	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.592	E ← Y
Country	**Income Group**	**r(E-A) [1] Ferguson[1]**	**r(E-A) [2] current**	**Δ Dif. = [2] - [1]**	**A**	**E**	**Coint (A-E)**	**Coint (E-A)**	**Granger @level**	**Verdict**	**r(Δe-ΔA)**	**Granger @Diff.**
Colombia	UMI	0.977	0.917	−0.060	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	−0.010	E – Y
Egypt, Arab Rep.	LMI	0.976	0.990	0.014	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.455	E ← Y
Turkey	UMI	0.975	0.994	0.019	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.723	E – Y
Finland	HI	0.974	0.973	−0.001	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.276	E → Y
Australia	HI	0.972	0.967	−0.005	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.441	E – Y
Sweden	HI	0.968	0.962	−0.006	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.383	E – Y
Norway	HI	0.966	0.972	0.006	I (1)	I (0)	I(1)	I(1)	E – Y	Spurious	0.261	E – Y
Japan	HI	0.958	0.941	−0.017	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.432	E ← Y
Austria	HI	0.958	0.961	0.003	I (1)	I (1)	I(1)	I(1)	E → Y	Spurious	0.405	E → Y
Mexico	UMI	0.955	0.971	0.016	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.858	E – Y
Bangladesh	LMI	0.955	0.903	−0.052	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.064	E – Y
Oman	HI	0.954	0.872	−0.082	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	−0.084	E – Y
China	UMI	0.954	0.945	−0.009	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.322	E – Y
Singapore	HI	0.951	0.942	−0.009	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.439	E ↔ Y
Chile	HI	0.941	0.967	0.026	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.802	E – Y
Ireland	HI	0.938	0.951	0.013	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.101	E – Y
Costa Rica	UMI	0.936	0.919	−0.017	I (1)	I (1)	I(1)	I(1)	E → Y	Spurious	0.610	E – Y
Peru	UMI	0.932	0.897	−0.035	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.786	E ← Y
Italy	HI	0.928	0.933	0.005	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.661	E ↔ Y

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Table A2.1 (*continued*)

Country	Income Group	r(E-A) [1] Ferguson[1]>	r(E-A) [2] current	Δ Dif. = [2] - [1]	A	E	Coint (A-E)	Coint (E-A)	Granger @level	Verdict	r(Δe-ΔA)	Granger @Diff.
Ecuador	UMI	0.926	0.926	0.000	I (0)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.261	E ← Y
Nepal	LI	0.926	0.825	−0.101	I (1)	I (1)	I(1)	I(1)	E → Y	Spurious	−0.225	E – Y
New Zealand	HI	0.925	0.816	−0.109	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.276	E – Y
Morocco	LMI	0.923	0.946	0.023	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.392	E – Y
Belgium	HI	0.922	0.911	−0.011	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.546	E ↔ Y
Canada	HI	0.922	0.941	0.019	I (1)	I (1)	I(1)	I(1)	E → Y	Spurious	0.655	E → Y
Malta	HI	0.905	0.877	−0.028	I (1)	I (1)	I(1)	I(1)	E → Y	Spurious	−0.066	E – Y
Netherlands	HI	0.879	0.877	−0.002	I (1)	I (1)	I(1)	I(1)	E → Y	Spurious	0.614	E – Y
Brazil	UMI	0.877	0.971	0.094	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.797	E ↔ Y
Country	**Income Group**	**r(E-A) [1] Ferguson[1]**	**r(E-A) [2] current**	**Δ Dif. = [2] - [1]**	**A**	**E**	**Coint (A-E)**	**Coint (E-A)**	**Granger @level**	**Verdict**	**r(Δe-ΔA)**	**Granger @Diff.**
Dominican Republic	UMI	0.867	0.344	−0.523	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.375	E – Y
Germany	HI	0.828	0.288	−0.540	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.471	E – Y
Angola	LMI	0.824	0.462	−0.362	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	−0.080	E ↔ Y
Jamaica	UMI	0.814	0.808	−0.006	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.601	E ← Y
Cuba	UMI	0.810	0.814	0.004	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.663	E – Y
Israel	HI	0.769	0.855	0.086	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.021	E ← Y
Paraguay	UMI	0.765	0.916	0.151	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.419	E ← Y
Guatemala	UMI	0.740	0.705	−0.035	I (0)	I (1)	I(1)	I(1)	E → Y	Spurious	0.456	E → Y
United States	HI	0.717	0.654	−0.063	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.650	E → Y
Denmark	HI	0.696	0.674	−0.022	I (1)	I (0)	I(1)	I(1)	E – Y	Spurious	0.492	E – Y
Bulgaria	UMI	0.693	0.328	−0.365	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.634	E ← Y
Algeria	UMI	0.686	0.663	−0.023	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.318	E – Y
Cameroon	LMI	0.656	0.941	0.285	I (1)	I (1)	I(1)	I(1)	E → Y	Spurious	0.529	E → Y
Sri Lanka	LMI	0.642	0.828	0.186	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	−0.002	E – Y
United Kingdom	HI	0.638	0.633	−0.005	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.526	E – Y
Ghana	LMI	0.594	0.276	−0.318	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.244	E – Y
Philippines	LMI	0.585	0.757	0.172	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.579	E ↔ Y
Jordan	UMI	0.560	0.675	0.115	I (1)	I (1)	I(1)	I(1)	E → Y	Spurious	0.652	E – Y
Argentina	HI	0.535	0.366	−0.169	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.679	E – Y
Congo, Dem. Rep.	LI	0.454	0.377	−0.077	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.431	E ← Y
Myanmar	LMI	0.423	−0.115	−0.538	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.570	E ↔ Y
Honduras	LMI	0.407	−0.036	−0.443	I (0)	I (1)	I(0)	I(1)	E – Y	Spurious	0.238	E – Y
Nicaragua	LMI	0.397	0.572	0.175	I (1)	I (0)	I(1)	I(1)	E → Y	Spurious	0.836	E – Y
Benin	LI	0.331	−0.520	−0.851	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.113	E – Y
Zimbabwe	LI	0.280	0.487	0.207	I (1)	I (1)	I(0)	I(1)	E – Y	Spurious	0.205	E – Y
Haiti	LI	0.249	0.756	0.507	I (1)	I (1)	I(1)	I(1)	E → Y	Spurious	0.484	E – Y
Kenya	LMI	−0.028	0.165	0.193	I (1)	I (1)	I(0)	I(1)	E – Y	Spurious	0.385	E → Y

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Table A2.1 (*continued*)

Country	Income Group	r(E-A) [1] Ferguson[1]>	r(E-A) [2] current	Δ Dif. = [2] - [1]	A	E	Coint (A-E)	Coint (E-A)	Granger @level	Verdict	r(Δe-ΔA)	Granger @Diff.
Trinidad and Tobago	HI	−0.085	−0.523	−0.438	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.075	E – Y
Country	**Income Group**	**r(E-A) [1] Ferguson[1]**	**r(E-A) [2] current**	**Δ Dif. = [2] - [1]**	**A**	**E**	**Coint (A-E)**	**Coint (E-A)**	**Granger @level**	**Verdict**	**r(Δe-ΔA)**	**Granger @Diff.**
South Africa	UMI	−0.090	−0.203	−0.113	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.441	E – Y
Uruguay	HI	−0.119	0.066	0.185	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.563	E – Y
El Salvador	LMI	−0.155	0.497	0.652	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.392	E ↔ Y
Bahrain	HI	−0.170	0.330	0.500	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	−0.470	E – Y
Bolivia	LMI	−0.250	−0.155	0.095	I (1)	I (1)	I(1)	I(1)	E → Y	Spurious	0.370	E ← Y
Iran, Islamic Rep.	UMI	−0.487	−0.699	−0.212	I (1)	I (1)	I(1)	I(1)	E → Y	Spurious	0.233	E – Y
Luxembourg	HI	−0.511	−0.586	−0.075	I (1)	I (1)	I(1)	I(1)	E → Y	Spurious	0.680	E – Y
Sudan	LMI	−0.545	−0.179	0.366	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	−0.344	E – Y
Iraq	UMI	−0.586	0.273	0.859	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.386	E ↔ Y
Saudi Arabia	HI	−0.654	−0.729	−0.075	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	−0.091	E → Y
By Income Groups	**Income Group**	**r(E-A) [1] Ferguson[1]**	**r(E-A) [2] current**	**Δ Dif. = [2] - [1]**	**A**	**E**	**Coint (A-E)**	**Coint (E-A)**	**Granger @level**	**Verdict**	**r(Δe-ΔA)**	**Granger @Diff.**
Low Income	LI	–	–	–	–	–	–	–	–	–	–	
Lower Middle Income	LMI	–	0.869	–	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.084	E → Y
Upper Middle Income	UMI	–	0.854	–	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	−0.061	E – Y
High Income	HI	–	0.998	–	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.569	E – Y
World	–	–	0.984	–	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.519	E – Y

Notes: r(x-y) refers to *correlation coefficient* between x and y; Coint(x-y) refers to *cointegration*.

[1] This column is corresponding Table 5 in **Ferguson**

Table A2.2
Correlation coefficients: per capita primary energy use (E) vs. affluence (A) – 1996-2014

Country	Income Group	r(E-A) [1] Ferguson[1]	r(E-A) [2] current	Δ Dif. = [2] - [1]	A	E	Coint (A-E)	Coint (E-A)	Granger @level	Verdict	r(Δe-ΔA)	Granger @Diff.
Congo, Rep.	LMI	–	0.684	–	I (1)	I (1)	I(0)	I(1)	E ↔ Y	TRUE	0.303	E ← Y
France	HI	0.987	0.986	−0.001	I (0)	I (1)	I(0)	I(1)	E ← Y	TRUE	0.363	E – Y
Senegal	LI	0.487	−0.720	−1.207	I (1)	I (1)	I(0)	I(1)	E ↔ Y	TRUE	−0.051	E → Y
Honduras	LMI	0.407	0.605	0.198	I (1)	I (1)	I(1)	I(0)	E ← Y	TRUE	0.543	E – Y
Trinidad and Tobago	HI	−0.085	−0.403	−0.318	I (1)	I (1)	I(0)	I(0)	E → Y	TRUE	0.626	E → Y
Bolivia	LMI	−0.250	−0.290	−0.040	I (1)	I (1)	I(1)	I(0)	E ↔ Y	TRUE	0.225	E ↔ Y
Iraq	UMI	−0.586	0.486	1.072	I (1)	I (1)	I(1)	I(0)	E → Y	TRUE	−0.156	E – Y
United Arab Emirates	HI	−0.910	0.249	1.159	I (1)	I (1)	I(1)	I(0)	E ↔ Y	TRUE	0.041	E ↔ Y
Albania	UMI	–	0.869	–	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.363	E – Y
Mauritius	UMI	–	0.971	–	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.346	E – Y
Togo	LI	–	−0.031	–	I (1)	I (1)	I(1)	I(1)	E → Y	Spurious	−0.102	E – Y
Pakistan	LMI	0.995	0.985	−0.010	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.654	E – Y
India	LMI	0.995	0.995	0.000	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.633	E – Y
Indonesia	LMI	0.994	0.981	−0.013	I (1)	I (1)	I(1)	I(1)	E → Y	Spurious	0.252	E ↔ Y

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Table A2.2 (*continued*)

Country	Income Group	r(E-A) [1] Ferguson[1]	r(E-A) [2] current	Δ Dif. = [2] - [1]	A	E	Coint (A-E)	Coint (E-A)	Granger @level	Verdict	r(Δe-ΔA)	Granger @Diff.
Spain	HI	0.993	0.987	−0.006	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.791	E ↔ Y
Korea, Rep.	HI	0.993	0.996	–	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.876	E → Y
Greece	HI	0.991	0.924	−0.067	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.611	E ↔ Y
Cyprus	HI	0.990	0.968	−0.022	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.638	E ↔ Y
Thailand	UMI	0.989	0.997	0.008	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.836	E – Y
Hong Kong SAR, China	HI	0.987	0.996	0.009	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	−0.513	E ↔ Y
Portugal	HI	0.983	0.977	−0.006	I (0)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.604	E – Y
Tunisia	LMI	0.982	0.963	−0.019	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.557	E ↔ Y
Switzerland	HI	0.981	0.949	−0.032	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	−0.056	E – Y
Zambia	LMI	0.980	0.902	−0.078	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.177	E ← Y
Colombia	UMI	0.977	0.954	−0.023	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.539	E ↔ Y
Egypt, Arab Rep.	LMI	0.976	0.992	0.016	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.157	E ↔ Y
Turkey	UMI	0.975	0.975	0.000	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.691	E → Y
Country	**Income Group**	**r(E-A) [1] Ferguson[1]**	**r(E-A) [2] current**	**Δ Dif. = [2] - [1]**	**A**	**E**	**Coint (A-E)**	**Coint (E-A)**	**Granger @level**	**Verdict**	**r(Δe-ΔA)**	**Granger @Diff.**
Finland	HI	0.974	0.983	0.009	I (1)	I (1)	I(1)	I(1)	E → Y	Spurious	0.393	E – Y
Malaysia	UMI	0.972	0.991	0.019	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.614	E ← Y
Australia	HI	0.972	0.989	0.017	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.638	E – Y
Sweden	HI	0.968	0.985	0.017	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.476	E – Y
Norway	HI	0.966	0.986	0.020	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.041	E – Y
Japan	HI	0.958	0.991	0.033	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.666	E ← Y
Austria	HI	0.958	0.998	0.040	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.277	E ← Y
Mexico	UMI	0.955	0.813	−0.142	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.137	E ← Y
Bangladesh	LMI	0.955	0.938	−0.017	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.444	E – Y
Oman	HI	0.954	0.952	−0.002	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	−0.046	E → Y
China	UMI	0.954	0.995	0.041	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.575	E ↔ Y
Singapore	HI	0.951	0.994	0.043	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.256	E – Y
Chile	HI	0.941	0.960	0.019	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.585	E – Y
Ireland	HI	0.938	0.987	0.049	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.522	E – Y
Costa Rica	UMI	0.936	0.757	−0.179	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.260	E – Y
Peru	UMI	0.932	−0.345	−1.277	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.171	E ↔ Y
Italy	HI	0.928	0.998	0.070	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.743	E – Y
Ecuador	UMI	0.926	0.835	−0.091	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	−0.020	E – Y
Nepal	LI	0.926	0.975	0.049	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.203	E → Y
New Zealand	HI	0.925	0.846	−0.079	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	−0.024	E ← Y
Morocco	LMI	0.923	0.968	0.045	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.090	E → Y
Belgium	HI	0.922	0.997	0.075	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.272	E ← Y
Canada	HI	0.922	0.994	0.072	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.613	E – Y

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Table A2.2 (*continued*)

Country	Income Group	r(E-A) [1] Ferguson[1]	r(E-A) [2] current	Δ Dif. = [2] - [1]	A	E	Coint (A-E)	Coint (E-A)	Granger @level	Verdict	r(Δe-ΔA)	Granger @Diff.
Malta	HI	0.905	0.945	0.040	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	−0.067	E – Y
Netherlands	HI	0.879	0.996	0.117	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	−0.059	E ↔ Y
Brazil	UMI	0.877	0.848	−0.029	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.753	E – Y
Dominican Republic	UMI	0.867	0.615	−0.252	I (1)	I (1)	I(1)	I(1)	E → Y	Spurious	0.488	E → Y
Mozambique	LI	0.859	0.406	−0.453	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	−0.241	E ← Y
Country	**Income Group**	**r(E-A) [1] Ferguson[1]**	**r(E-A) [2] current**	**Δ Dif. = [2] - [1]**	**A**	**E**	**Coint (A-E)**	**Coint (E-A)**	**Granger @level**	**Verdict**	**r(Δe-ΔA)**	**Granger @Diff.**
Germany	HI	0.828	0.877	0.049	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.341	E – Y
Angola	LMI	0.824	0.614	−0.210	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	−0.051	E ← Y
Jamaica	UMI	0.814	0.676	−0.138	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.571	E – Y
Cuba	UMI	0.810	0.908	0.098	I (1)	I (1)	I(1)	I(1)	E → Y	Spurious	−0.049	E ↔ Y
Israel	HI	0.769	0.984	0.215	I (1)	I (1)	I(1)	I(1)	E → Y	Spurious	0.228	E – Y
Paraguay	UMI	0.765	0.896	0.131	I (1)	I (0)	I(1)	I(1)	E ↔ Y	Spurious	0.622	E ↔ Y
Guatemala	UMI	0.740	0.712	−0.028	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	−0.050	E – Y
United States	HI	0.717	0.979	0.262	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.819	E ↔ Y
Denmark	HI	0.696	0.994	0.298	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.121	E – Y
Bulgaria	UMI	0.693	0.711	0.018	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.619	E – Y
Algeria	UMI	0.686	0.557	−0.129	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	−0.017	E – Y
Cameroon	LMI	0.656	0.790	0.134	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.099	E ↔ Y
Sri Lanka	LMI	0.642	0.997	0.355	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.492	E ↔ Y
United Kingdom	HI	0.638	0.934	0.296	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.378	E → Y
Ghana	LMI	0.594	0.562	−0.032	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.389	E – Y
Philippines	LMI	0.585	0.572	−0.013	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.512	E → Y
Jordan	UMI	0.560	0.333	−0.227	I (1)	I (1)	I(1)	I(1)	E → Y	Spurious	0.525	E – Y
Argentina	HI	0.535	−0.073	−0.608	I (1)	I (1)	I(1)	I(1)	E → Y	Spurious	0.662	E – Y
Gabon	UMI	0.528	0.008	−0.520	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	−0.045	E – Y
Congo, Dem. Rep.	LI	0.454	0.918	0.464	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.367	E – Y
Myanmar	LMI	0.423	0.720	0.297	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.179	E ↔ Y
Nicaragua	LMI	0.397	−0.261	−0.658	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.445	E – Y
Benin	LI	0.331	0.403	0.072	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	−0.035	E ↔ Y
Zimbabwe	LI	0.280	0.001	−0.279	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.632	E ← Y
Haiti	LI	0.249	0.314	0.065	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.078	E ← Y
Kenya	LMI	−0.028	0.751	0.779	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.350	E ↔ Y
Venezuela, RB	UMI	−0.070	−0.773	−0.703	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.160	E ↔ Y
South Africa	UMI	−0.090	−0.439	−0.349	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.325	E → Y
Country	**Income Group**	**r(E-A) [1] Ferguson[1]**	**r(E-A) [2] current**	**Δ Dif. = [2] - [1]**	**A**	**E**	**Coint (A-E)**	**Coint (E-A)**	**Granger @level**	**Verdict**	**r(Δe-ΔA)**	**Granger @Diff.**
Uruguay	HI	−0.119	0.829	0.948	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.443	E ← Y

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Table A2.2 (*continued*)

Country	Income Group	r(E-A) [1] Ferguson[1]	r(E-A) [2] current	Δ Dif. = [2] - [1]	A	E	Coint (A-E)	Coint (E-A)	Granger @level	Verdict	r(Δe-ΔA)	Granger @Diff.
El Salvador	LMI	−0.155	−0.333	−0.178	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.332	E ↔ Y
Bahrain	HI	−0.170	0.313	0.483	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.475	E ↔ Y
Iran, Islamic Rep.	UMI	−0.487	−0.734	−0.247	I (1)	I (1)	I(1)	I(1)	E → Y	Spurious	−0.111	E – Y
Luxembourg	HI	−0.511	0.801	1.312	I (1)	I (1)	I(1)	I(1)	E → Y	Spurious	0.298	E – Y
Panama	HI	−0.523	0.809	1.332	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	−0.032	E – Y
Sudan	LMI	−0.545	−0.003	0.542	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.136	E – Y
Nigeria	LMI	−0.556	−0.799	−0.243	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	−0.093	E – Y
Saudi Arabia	HI	−0.654	−0.821	−0.167	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	−0.096	E – Y
Brunei Darussalam	HI	−0.706	−0.819	−0.113	I (1)	I (1)	I(1)	I(1)	E → Y	Spurious	0.468	E – Y
By Income Groups	**Income Group**	**r(E-A) [1] Ferguson[1]**	**r(E-A) [2] current**	**Δ Dif. = [2] - [1]**	**A**	**E**	**Coint (A-E)**	**Coint (E-A)**	**Granger @level**	**Verdict**	**r(Δe-ΔA)**	**Granger @Diff.**
Low Income	LI	–	–	–	–	–	–	–	–	–	–	
Lower Middle Income	LMI	–	0.869	–	I (1)	I (1)	I(1)	I(0)	E ← Y	TRUE	0.529	E – Y
Upper Middle Income	UMI	–	0.854	–	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.759	E ↔ Y
High Income	HI	–	0.998	–	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.821	E ↔ Y
World	–	–	0.984	–	I (1)	I (1)	I(0)	I(1)	E ↔ Y	TRUE	0.736	E ← Y

Notes: r(x-y) refers to *correlation coefficient* between x and y; Coint(x-y) refers to *cointegration*.

[1] This column is corresponding Table 5 in **Ferguson**

Table A2.3

Correlation coefficients: per capita primary energy use (E) vs. affluence (A) – 1960-2014

Country	Income Group	r(E-A) [1] Ferguson[1]	r(E-A) [2] current	Δ Dif. = [2] - [1]	A	E	Coint (A-E)	Coint (E-A)	Granger @level	Verdict	r(Δe-ΔA)	Granger @Diff.
Gabon	UMI	0.528	−0.197	−0.725	I (0)	I (1)	I(0)	I(1)	E → Y	TRUE	−0.129	E → Y
Honduras	LMI	0.407	0.857	0.450	I (1)	I (1)	I(0)	I(1)	E ← Y	TRUE	0.374	E – Y
Kenya	LMI	−0.028	0.664	0.692	I (1)	I (1)	I(0)	I(1)	E ↔ Y	TRUE	0.361	E → Y
Bahrain	HI	−0.170	0.652	0.822	I (1)	I (1)	I(1)	I(0)	E → Y	TRUE	−0.183	E – Y
Panama	HI	−0.523	0.350	0.873	I (1)	I (1)	I(1)	I(0)	E ← Y	TRUE	0.126	E ← Y
Albania	UMI	–	0.193	–	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.648	E ← Y
Congo, Rep.	LMI	–	0.265	–	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.248	E – Y
Mauritius	UMI	–	0.984	–	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.481	E – Y
Togo	LI	–	−0.405	–	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.127	E – Y
Pakistan	LMI	0.995	0.977	−0.018	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.509	E – Y
India	LMI	0.995	0.991	−0.004	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.697	E ← Y
Indonesia	LMI	0.994	0.964	−0.030	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.262	E – Y
Spain	HI	0.993	0.976	−0.017	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.708	E ← Y
Korea, Rep.	HI	0.993	0.992	–	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.791	E → Y
Greece	HI	0.991	0.967	−0.024	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.616	E ← Y
Cyprus	HI	0.990	0.932	−0.058	I (1)	I (1)	I(1)	I(1)	E → Y	Spurious	0.406	E ← Y
Thailand	UMI	0.989	0.991	0.002	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.810	E ↔ Y

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Table A2.3 (*continued*)

Country	Income Group	r(E-A) [1] Ferguson[1]	r(E-A) [2] current	Δ Dif. = [2] - [1]	A	E	Coint (A-E)	Coint (E-A)	Granger @level	Verdict	r(Δe-ΔA)	Granger @Diff.
France	HI	0.987	0.928	−0.059	I (1)	I (0)	I(1)	I(1)	E → Y	Spurious	0.382	E – Y
Hong Kong SAR, China	HI	0.987	0.892	−0.095	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	−0.280	E – Y
Portugal	HI	0.983	0.987	0.004	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.515	E ↔ Y
Tunisia	LMI	0.982	0.982	0.000	I (1)	I (1)	I(1)	I(1)	E → Y	Spurious	0.537	E → Y
Switzerland	HI	0.981	0.162	−0.819	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.112	E – Y
Zambia	LMI	0.980	0.566	−0.414	I (1)	I (0)	I(1)	I(1)	E ↔ Y	Spurious	0.537	E ← Y
Colombia	UMI	0.977	0.417	−0.560	I (1)	I (1)	I(1)	I(1)	E → Y	Spurious	0.339	E – Y
Egypt, Arab Rep.	LMI	0.976	0.984	0.008	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.240	E → Y
Turkey	UMI	0.975	0.986	0.011	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.692	E – Y
Finland	HI	0.974	0.944	−0.030	I (1)	I (1)	I(1)	I(1)	E → Y	Spurious	0.333	E → Y
Country	**Income Group**	**r(E-A) [1] Ferguson[1]**	**r(E-A) [2] current**	**Δ Dif. = [2] - [1]**	**A**	**E**	**Coint (A-E)**	**Coint (E-A)**	**Granger @level**	**Verdict**	**r(Δe-ΔA)**	**Granger @Diff.**
Malaysia	UMI	0.972	0.993	0.021	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.533	E ↔ Y
Australia	HI	0.972	0.933	−0.039	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.393	E – Y
Sweden	HI	0.968	0.722	−0.246	I (1)	I (0)	I(1)	I(1)	E – Y	Spurious	0.341	E – Y
Norway	HI	0.966	0.957	−0.009	I (1)	I (0)	I(1)	I(1)	E ← Y	Spurious	0.075	E ← Y
Japan	HI	0.958	0.944	80.014	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.606	E – Y
Austria	HI	0.958	0.972	0.014	I (1)	I (1)	I(1)	I(1)	E → Y	Spurious	0.330	E → Y
Mexico	UMI	0.955	0.934	−0.021	I (1)	I (0)	I(1)	I(1)	E ← Y	Spurious	0.590	E ← Y
Bangladesh	LMI	0.955	0.989	0.034	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.403	E ← Y
Oman	HI	0.954	0.834	−0.120	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	−0.070	E – Y
China	UMI	0.954	0.993	0.039	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.736	E – Y
Singapore	HI	0.951	0.821	−0.130	I (1)	I (1)	I(1)	I(1)	E → Y	Spurious	0.255	E – Y
Chile	HI	0.941	0.987	0.046	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.647	E – Y
Ireland	HI	0.938	0.837	−0.101	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.289	E – Y
Costa Rica	UMI	0.936	0.975	0.039	I (1)	I (1)	I(1)	I(1)	E → Y	Spurious	0.495	E – Y
Peru	UMI	0.932	0.626	−0.306	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.565	E ← Y
Italy	HI	0.928	0.958	0.030	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.738	E – Y
Ecuador	UMI	0.926	0.896	−0.030	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.095	E – Y
Nepal	LI	0.926	0.961	0.035	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.217	E ← Y
New Zealand	HI	0.925	0.817	−0.108	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.141	E – Y
Morocco	LMI	0.923	0.989	0.066	I (1)	I (1)	I(1)	I(0)	E – Y	Spurious	0.226	E ← Y
Belgium	HI	0.922	0.879	−0.043	I (1)	I (1)	I(1)	I(1)	E → Y	Spurious	0.419	E → Y
Canada	HI	0.922	0.855	−0.067	I (1)	I (0)	I(1)	I(1)	E – Y	Spurious	0.574	E – Y
Malta	HI	0.905	0.826	−0.079	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	−0.066	E – Y
Netherlands	HI	0.879	0.792	−0.087	I (1)	I (0)	I(1)	I(1)	E – Y	Spurious	0.276	E – Y
Brazil	UMI	0.877	0.985	0.108	I (1)	I (1)	I(1)	I(1)	E → Y	Spurious	0.728	E – Y
Dominican Republic	UMI	0.867	0.801	−0.066	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.375	E – Y

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Table A2.3 (*continued*)

Country	Income Group	r(E-A) [1] Ferguson[1]	r(E-A) [2] current	Δ Dif. = [2] - [1]	A	E	Coint (A-E)	Coint (E-A)	Granger @level	Verdict	r(Δe-ΔA)	Granger @Diff.
Mozambique	LI	0.859	−0.498	−1.357	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.493	E → Y
Germany	HI	0.828	−0.442	−1.270	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.345	E ← Y
Country	**Income Group**	**r(E-A) [1] Ferguson[1]**	**r(E-A) [2] current**	**Δ Dif. = [2] - [1]**	**A**	**E**	**Coint (A-E)**	**Coint (E-A)**	**Granger @level**	**Verdict**	**r(Δe-ΔA)**	**Granger @Diff.**
Angola	LMI	0.824	0.788	−0.036	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.117	E ← Y
Jamaica	UMI	0.814	0.735	−0.079	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.558	E ← Y
Cuba	UMI	0.810	−0.133	−0.943	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.521	E – Y
Israel	HI	0.769	0.910	0.141	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.091	E ← Y
Paraguay	UMI	0.765	0.873	0.108	I (1)	I (1)	I(1)	I(1)	E → Y	Spurious	0.527	E – Y
Guatemala	UMI	0.740	0.916	0.176	I (1)	I (1)	I(1)	I(1)	E → Y	Spurious	0.291	E → Y
United States	HI	0.717	0.371	−0.346	I (1)	I (0)	I(1)	I(1)	E – Y	Spurious	0.648	E – Y
Denmark	HI	0.696	0.395	−0.301	I (1)	I (0)	I(1)	I(1)	E – Y	Spurious	0.357	E – Y
Bulgaria	UMI	0.693	−0.402	−1.095	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.587	E – Y
Algeria	UMI	0.686	0.840	0.154	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.241	E – Y
Cameroon	LMI	0.656	0.227	−0.429	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.232	E – Y
Sri Lanka	LMI	0.642	0.958	0.316	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.417	E – Y
United Kingdom	HI	0.638	0.034	−0.604	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.408	E – Y
Ghana	LMI	0.594	−0.404	−0.998	I (1)	I (1)	I(1)	I(1)	E → Y	Spurious	0.191	E – Y
Philippines	LMI	0.585	0.002	−0.583	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.478	E – Y
Jordan	UMI	0.560	0.743	0.183	I (1)	I (0)	I(1)	I(1)	E – Y	Spurious	0.547	E – Y
Argentina	HI	0.535	0.934	0.399	I (1)	I (1)	I(1)	I(1)	E → Y	Spurious	0.677	E – Y
Senegal	LI	0.487	0.784	0.297	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.106	E – Y
Congo, Dem. Rep.	LI	0.454	0.296	−0.158	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.346	E – Y
Myanmar	LMI	0.423	0.690	0.267	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.367	E – Y
Nicaragua	LMI	0.397	0.425	0.028	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.793	E – Y
Benin	LI	0.331	0.202	−0.129	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.063	E – Y
Zimbabwe	LI	0.280	0.802	0.522	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.394	E ← Y
Haiti	LI	0.249	0.010	−0.239	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.346	E – Y
Venezuela, RB	UMI	−0.070	−0.287	−0.217	I (1)	I (0)	I(1)	I(1)	E – Y	Spurious	0.018	E ← Y
Trinidad and Tobago	HI	−0.085	0.930	1.015	I (1)	I (1)	I(1)	I(1)	E → Y	Spurious	0.565	E → Y
South Africa	UMI	−0.090	0.456	0.546	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.328	E – Y
Uruguay	HI	−0.119	0.876	0.995	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.514	E ↔ Y
Country	**Income Group**	**r(E-A) [1] Ferguson[1]**	**r(E-A) [2] current**	**Δ Dif. = [2] - [1]**	**A**	**E**	**Coint (A-E)**	**Coint (E-A)**	**Granger @level**	**Verdict**	**r(Δe-ΔA)**	**Granger @Diff.**
El Salvador	LMI	−0.155	0.648	0.803	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.351	E ↔ Y
Bolivia	LMI	−0.250	0.730	0.980	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.217	E – Y
Iran, Islamic Rep.	UMI	−0.487	−0.210	0.277	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.159	E – Y
Luxembourg	HI	−0.511	−0.673	−0.162	I (1)	I (1)	I(1)	I(1)	E → Y	Spurious	0.446	E – Y

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Table A2.3 (*continued*)

Country	Income Group	r(E-A) [1] Ferguson[1]	r(E-A) [2] current	Δ Dif. = [2] - [1]	A	E	Coint (A-E)	Coint (E-A)	Granger @level	Verdict	r(Δe-ΔA)	Granger @Diff.
Sudan	LMI	−0.545	−0.626	−0.081	I (1)	I (0)	I(1)	I(1)	E – Y	Spurious	−0.068	E – Y
Nigeria	LMI	−0.556	0.176	0.732	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.020	E – Y
Iraq	UMI	−0.586	0.390	0.976	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.112	E ← Y
Saudi Arabia	HI	−0.654	−0.690	−0.036	I (0)	I (1)	I(1)	I(1)	E ← Y	Spurious	−0.083	E ↔ Y
Brunei Darussalam	HI	−0.706	−0.488	0.218	I (0)	I (1)	I(1)	I(1)	E → Y	Spurious	0.123	E – Y
United Arab Emirates	HI	−0.910	−0.436	0.474	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.106	E ← Y
By Income Groups	**Income Group**	**r(E-A) [1] Ferguson[1]**	**r(E-A) [2] current**	**Δ Dif. = [2] - [1]**	**A**	**E**	**Coint (A-E)**	**Coint (E-A)**	**Granger @level**	**Verdict**	**r(Δe-ΔA)**	**Granger @Diff.**
Low Income	LI	–	–	–	–	–	–	–	–	–	–	
Lower Middle Income	LMI	–	0.933	–	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.051	E – Y
Upper Middle Income	UMI	–	0.978	–	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.259	E – Y
High Income	HI	–	0.991	–	I (1)	I (0)	I(1)	I(1)	E – Y	Spurious	0.575	E – Y
World	–	–	0.993	–	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.532	E – Y

Notes: r(x-y) refers to *correlation coefficient* between x and y; Coint(x-y) refers to *cointegration*.

[1] This column is corresponding Table 5 in **Ferguson**

Table A3.1
Correlation coefficients: electricity/energy use proportion (e/E) vs. affluence (A) – 1960-1995

Country	Income Group	r(e/E-A) [1] Ferguson[1]	r(e/E-A) [2] Current	Δ Dif. = [2] - [1]	A	e/E	Coint (A-e/E)	Coint (e/E-A)	Granger @level	Verdict	r(Δe/E-ΔA)	Granger @Diff.
United States	HI	0.980	0.986	0.006	I (1)	I (1)	I(0)	I(0)	E → Y	TRUE	−0.342	E → Y
Sweden	HI	0.946	0.944	−0.002	I (1)	I (1)	I(0)	I(1)	E ← Y	TRUE	−0.094	E – Y
Italy	HI	0.869	0.919	0.050	I (1)	I (1)	I(0)	I(1)	E ← Y	TRUE	−0.221	E – Y
Bangladesh	LMI	0.809	0.936	0.127	I (1)	I (1)	I(0)	I(0)	E → Y	TRUE	0.331	E – Y
Cyprus	HI	0.730	0.866	0.136	I (1)	I (1)	I(1)	I(0)	E ← Y	TRUE	−0.003	E – Y
Malaysia	UMI	0.723	0.916	0.193	I (1)	I (1)	I(1)	I(0)	E ← Y	TRUE	0.209	E – Y
Brunei Darussalam	HI	0.722	−0.837	−1.559	I (0)	I (1)	I(0)	I(1)	E → Y	TRUE	−0.307	E – Y
Angola	LMI	0.267	0.416	0.149	I (1)	I (1)	I(1)	I(0)	E → Y	TRUE	0.016	E → Y
Honduras	LMI	0.256	0.580	0.324	I (0)	I (1)	I(0)	I(1)	E → Y	TRUE	0.300	E → Y
Switzerland	HI	0.113	0.607	0.494	I (1)	I (1)	I(1)	I(0)	E ↔ Y	TRUE	−0.148	E → Y
Dominican Republic	UMI	0.087	0.485	0.398	I (1)	I (1)	I(1)	I(0)	E ↔ Y	TRUE	−0.103	E ↔ Y
Nicaragua	LMI	−0.028	−0.656	−0.628	I (1)	I (0)	I(1)	I(0)	E ↔ Y	TRUE	0.290	E – Y
Mozambique	LI	−0.206	0.284	0.490	I (0)	I (1)	I(0)	I(1)	E → Y	TRUE	0.194	E ↔ Y
Bahrain	HI	−0.441	0.214	0.655	I (1)	I (1)	I(1)	I(0)	E ← Y	TRUE	0.244	E – Y
Iraq	UMI	−0.690	0.587	1.277	I (1)	I (1)	I(0)	I(1)	E ← Y	TRUE	−0.096	E ← Y
Albania	UMI	–	−0.005	–	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.365	E ↔ Y
Congo, Rep.	LMI	–	0.607	–	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	−0.018	E ← Y
Mauritius	UMI	–	0.964	–	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.318	E – Y
Togo	LI	–	0.039	–	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.423	E – Y

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Table A3.1 (*continued*)

Country	Income Group	r(e/E-A) [1] Ferguson[1]	r(e/E-A) [2] Current	Δ Dif. = [2] - [1]	A	e/E	Coint (A-e/E)	Coint (e/E-A)	Granger @level	Verdict	r(Δe/E-ΔA)	Granger @Diff.
Germany	HI	0.988	0.964	−0.024	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	−0.270	E – Y
Australia	HI	0.987	0.984	−0.003	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.012	E – Y
India	LMI	0.984	0.990	0.006	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.471	E → Y
Belgium	HI	0.984	0.977	−0.007	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	−0.157	E → Y
Pakistan	LMI	0.978	0.992	0.014	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.435	E – Y
Indonesia	LMI	0.973	0.984	0.011	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.138	E – Y
Colombia	UMI	0.970	0.917	−0.053	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.203	E – Y
China	UMI	0.967	0.988	0.021	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.474	E – Y
Country	**Income Group**	**r(e/E-A) [1] Ferguson[1]**	**r(e/E-A) [2] Current**	**Δ Dif. = [2] - [1]**	**A**	**e/E**	**Coint (A-e/E)**	**Coint (e/E-A)**	**Granger @level**	**Verdict**	**r(Δe/E-ΔA)**	**Granger @Diff.**
Austria	HI	0.967	0.968	0.001	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	−0.138	E – Y
Denmark	HI	0.966	0.973	0.007	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	−0.325	E – Y
Japan	HI	0.964	0.963	−0.001	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.035	E ← Y
United Kingdom	HI	0.962	0.954	−0.008	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	−0.127	E ← Y
Finland	HI	0.960	0.973	0.013	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.045	E → Y
Greece	HI	0.953	0.915	−0.038	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	−0.191	E – Y
Tunisia	LMI	0.952	0.945	−0.007	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	−0.362	E – Y
Canada	HI	0.950	0.936	−0.014	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	−0.001	E – Y
Ireland	HI	0.949	0.939	−0.010	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	−0.013	E – Y
Sri Lanka	LMI	0.943	0.997	0.054	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.642	E ↔ Y
France	HI	0.940	0.940	0.000	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	−0.186	E ↔ Y
Morocco	LMI	0.937	0.942	0.005	I (1)	I (1)	I(1)	I(1)	E → Y	Spurious	−0.097	E – Y
Netherlands	HI	0.935	0.911	−0.024	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	−0.441	E – Y
Korea, Rep.	HI	0.925	0.913	−0.012	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	−0.074	E – Y
Portugal	HI	0.909	0.869	−0.040	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	−0.082	E → Y
Spain	HI	0.904	0.909	0.005	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	−0.189	E ← Y
Hong Kong SAR, China	HI	0.901	0.924	0.023	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.110	E ← Y
Oman	HI	0.900	0.705	−0.195	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.068	E – Y
Turkey	UMI	0.878	0.976	0.098	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	−0.303	E – Y
New Zealand	HI	0.847	0.712	−0.135	I (1)	I (1)	I(1)	I(1)	E → Y	Spurious	−0.063	E – Y
Luxembourg	HI	0.846	0.859	0.013	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	−0.259	E – Y
Cuba	UMI	0.813	0.407	−0.406	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.054	E – Y
Israel	HI	0.810	0.676	−0.134	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.118	E ← Y
Thailand	UMI	0.785	0.936	0.151	I (1)	I (1)	I(1)	I(1)	E → Y	Spurious	0.000	E – Y
Brazil	UMI	0.762	0.807	0.045	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	−0.336	E ← Y
Paraguay	UMI	0.735	0.916	0.181	I (1)	I (1)	I(1)	I(1)	E → Y	Spurious	0.070	E – Y

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Table A3.1 (*continued*)

Country	Income Group	r(e/E-A) [1] Ferguson[1]	r(e/E-A) [2] Current	Δ Dif. = [2] - [1]	A	e/E	Coint (A-e/E)	Coint (e/E-A)	Granger @level	Verdict	r(Δe/E-ΔA)	Granger @Diff.
Kenya	LMI	0.707	0.710	0.003	I (1)	I (1)	I(0)	I(1)	E – Y	Spurious	−0.012	E – Y
Egypt, Arab Rep.	LMI	0.692	0.908	0.216	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	−0.099	E ← Y
Country	**Income Group**	**r(e/E-A) [1] Ferguson[1]**	**r(e/E-A) [2] Current**	**Δ Dif. = [2] - [1]**	**A**	**e/E**	**Coint (A-e/E)**	**Coint (e/E-A)**	**Granger @level**	**Verdict**	**r(Δe/E-ΔA)**	**Granger @Diff.**
Bulgaria	UMI	0.689	0.291	−0.398	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	−0.099	E ↔ Y
Malta	HI	0.677	0.542	−0.135	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.067	E – Y
Panama	HI	0.636	0.705	0.069	I (1)	I (1)	I(0)	I(1)	E – Y	Spurious	0.097	E – Y
Chile	HI	0.632	0.665	0.033	I (1)	I (1)	I(1)	I(1)	E → Y	Spurious	−0.154	E – Y
Uruguay	HI	0.624	0.645	0.021	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	−0.327	E → Y
Nepal	LI	0.579	0.974	0.395	I (1)	I (1)	I(1)	I(1)	E → Y	Spurious	0.455	E – Y
Congo, Dem. Rep.	LI	0.559	0.916	0.357	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.384	E – Y
Norway	HI	0.521	0.490	−0.031	I (1)	I (1)	I(1)	I(0)	E – Y	Spurious	−0.135	E – Y
Mexico	UMI	0.495	0.528	0.033	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	−0.667	E – Y
Myanmar	LMI	0.440	0.661	0.221	I (1)	I (1)	I(1)	I(1)	E → Y	Spurious	0.366	E ← Y
Ecuador	UMI	0.436	0.724	0.288	I (0)	I (1)	I(0)	I(1)	E – Y	Spurious	−0.115	E – Y
Jamaica	UMI	0.382	0.398	0.016	I (1)	I (1)	I(1)	I(1)	E → Y	Spurious	−0.054	E → Y
Sudan	LMI	0.360	0.026	−0.334	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	−0.112	E – Y
Singapore	HI	0.289	0.262	−0.027	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	−0.342	E ↔ Y
Trinidad and Tobago	HI	0.212	−0.037	−0.249	I (1)	I (1)	I(1)	I(1)	E → Y	Spurious	0.114	E ← Y
Jordan	UMI	0.206	0.133	−0.073	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	−0.315	E – Y
Philippines	LMI	0.172	0.369	0.197	I (1)	I (0)	I(1)	I(1)	E – Y	Spurious	0.111	E – Y
Ghana	LMI	0.165	0.606	0.441	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.143	E – Y
Bolivia	LMI	0.112	−0.299	−0.411	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	−0.138	E – Y
Nigeria	LMI	0.064	−0.785	−0.849	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	−0.005	E – Y
Haiti	LI	−0.037	−0.075	−0.038	I (1)	I (1)	I(1)	I(1)	E → Y	Spurious	0.236	E – Y
Costa Rica	UMI	−0.047	0.186	0.233	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	−0.397	E – Y
Zimbabwe	LI	−0.154	−0.243	−0.089	I (1)	I (1)	I(0)	I(1)	E – Y	Spurious	0.424	E – Y
Benin	LI	−0.213	0.441	0.654	I (1)	I (1)	I(1)	I(1)	E → Y	Spurious	−0.250	E – Y
Algeria	UMI	−0.289	−0.103	0.186	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	−0.202	E – Y
Argentina	HI	−0.328	−0.188	0.140	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.364	E – Y
Guatemala	UMI	−0.421	0.542	0.963	I (0)	I (1)	I(1)	I(1)	E – Y	Spurious	0.408	E – Y
Gabon	UMI	−0.491	−0.142	0.349	I (0)	I (1)	I(0)	I(1)	E – Y	Spurious	0.129	E – Y
Country	**Income Group**	**r(e/E-A) [1] Ferguson[1]**	**r(e/E-A) [2] Current**	**Δ Dif. = [2] - [1]**	**A**	**e/E**	**Coint (A-e/E)**	**Coint (e/E-A)**	**Granger @level**	**Verdict**	**r(Δe/E-ΔA)**	**Granger @Diff.**
Cameroon	LMI	−0.498	0.676	1.174	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.281	E – Y
El Salvador	LMI	−0.540	−0.515	0.025	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.210	E ↔ Y
South Africa	UMI	−0.651	−0.569	0.082	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	−0.035	E – Y
United Arab Emirates	HI	−0.682	−0.007	0.675	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	−0.171	E ↔ Y

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Table A3.1 (*continued*)

Country	Income Group	r(e/E-A) [1] Ferguson[1]	r(e/E-A) [2] Current	Δ Dif. = [2] - [1]	A	e/E	Coint (A-e/E)	Coint (e/E-A)	Granger @level	Verdict	r(Δe/E-ΔA)	Granger @Diff.
Senegal	LI	−0.708	−0.874	−0.166	I (1)	I (1)	I(1)	I(1)	E → Y	Spurious	−0.507	E – Y
Iran, Islamic Rep.	UMI	−0.759	−0.701	0.058	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.130	E – Y
Peru	UMI	−0.794	−0.794	0.000	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	−0.082	E ↔ Y
Venezuela, RB	UMI	−0.833	−0.782	0.051	I (1)	I (1)	I(1)	I(1)	E → Y	Spurious	0.179	E → Y
Zambia	LMI	−0.858	0.626	1.484	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.093	E – Y
Saudi Arabia	HI	−0.901	−0.771	0.130	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.144	E – Y
By Income Groups	**Income Group**	**r(e/E-A) [1] Ferguson[1]**	**r(e/E-A) [2] Current**	**Δ Dif. = [2] - [1]**	**A**	**e/E**	**Coint (A-e/E)**	**Coint (e/E-A)**	**Granger @level**	**Verdict**	**r(Δe/E-ΔA)**	**Granger @Diff.**
Low Income	LI	–	–	–	–	–	–	–	–	–	–	
Lower Middle Income	LMI	–	0.937	–	I (1)	I (1)	I(1)	I(1)	E ← Y	spurious	0.060	E – Y
Upper Middle Income	UMI	–	0.939	–	I (1)	I (1)	I(1)	I(1)	E – Y	spurious	−0.286	E – Y
High Income	HI	–	0.990	–	I (1)	I (1)	I(1)	I(1)	E → Y	spurious	−0.225	E – Y
World	–	–	0.977	–	I (1)	I (1)	I(1)	I(1)	E → Y	spurious	−0.054	E – Y

Notes: r(x-y) refers to *correlation coefficient* between x and y; Coint(x-y) refers to *cointegration*.

[1] This column is corresponding Table 8 in **Ferguson**

Table A3.2
Correlation coefficients: electricity/energy use proportion (e/E) vs. affluence (A) – 1996-2014

Country	Income Group	r(e/E-A) [1] Ferguson	r(e/E-A) [2] current	Δ Dif. = [2] - [1]	A	e/E	Coint (A-e/E)	Coint (e/E-A)	Granger @level	Verdict	r(Δe/E-ΔA)	Granger @Diff.
India	LMI	0.984	0.985	0.001	I (1)	I (1)	I(1)	I(0)	E ← Y	TRUE	0.250	E – Y
United States	HI	0.980	0.810	−0.170	I (1)	I (1)	I(0)	I(1)	E ↔ Y	TRUE	−0.044	E – Y
Indonesia	LMI	0.973	0.953	−0.020	I (1)	I (1)	I(0)	I(1)	E ↔ Y	TRUE	0.255	E – Y
Morocco	LMI	0.937	0.923	−0.014	I (1)	I (1)	I(1)	I(0)	E ↔ Y	TRUE	0.204	E → Y
Hong Kong SAR, China	HI	0.901	0.437	−0.464	I (1)	I (1)	I(1)	I(0)	E → Y	TRUE	0.479	E ← Y
Brazil	UMI	0.762	0.708	−0.054	I (1)	I (1)	I(1)	I(0)	E ← Y	TRUE	−0.124	E – Y
Paraguay	UMI	0.735	0.810	0.075	I (1)	I (1)	I(1)	I(0)	E ↔ Y	TRUE	−0.007	E ← Y
Uruguay	HI	0.624	−0.141	−0.765	I (1)	I (1)	I(1)	I(0)	E ↔ Y	TRUE	−0.339	E ← Y
Nepal	LI	0.579	0.986	0.407	I (1)	I (1)	I(0)	I(0)	E ← Y	TRUE	−0.081	E – Y
Dominican Republic	UMI	0.087	0.849	0.762	I (1)	I (0)	I(1)	I(0)	E ← Y	TRUE	0.142	E – Y
South Africa	UMI	−0.651	−0.849	−0.198	I (1)	I (1)	I(1)	I(0)	E ← Y	TRUE	0.187	E – Y
Senegal	LI	−0.708	0.813	1.521	I (1)	I (1)	I(0)	I(1)	E → Y	TRUE	−0.129	E → Y
Zambia	LMI	−0.858	0.235	1.093	I (1)	I (0)	I(1)	I(0)	E ↔ Y	TRUE	0.217	E ↔ Y
Albania	UMI	–	0.669	–	I (1)	I (1)	I(1)	I(1)	E → Y	Spurious	0.299	E ↔ Y
Congo, Rep.	LMI	–	−0.364	–	I (1)	I (0)	I(1)	I(1)	E ← Y	Spurious	0.377	E ← Y
Mauritius	UMI	–	0.969	–	I (1)	I (1)	I(1)	I(1)	E → Y	Spurious	−0.265	E ← Y
Togo	LI	–	0.807	–	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.539	E ↔ Y
Germany	HI	0.988	0.938	−0.050	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.167	E ↔ Y
Australia	HI	0.987	0.556	−0.431	I (1)	I (0)	I(1)	I(1)	E – Y	Spurious	−0.086	E – Y

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Table A3.2 (*continued*)

Country	Income Group	r(e/E-A) [1] Ferguson	r(e/E-A) [2] current	Δ Dif. = [2] - [1]	A	e/E	Coint (A-e/E)	Coint (e/E-A)	Granger @level	Verdict	r(Δe/E-ΔA)	Granger @Diff.
Belgium	HI	0.984	0.921	−0.063	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.405	E – Y
Pakistan	LMI	0.978	0.916	−0.062	I (1)	I (1)	I(1)	I(1)	E → Y	Spurious	0.294	E ↔ Y
Colombia	UMI	0.970	0.929	−0.041	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.115	E – Y
China	UMI	0.967	0.980	0.013	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.298	E ↔ Y
Austria	HI	0.967	0.893	−0.074	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.136	E – Y
Denmark	HI	0.966	0.756	−0.210	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.155	E – Y
Japan	HI	0.964	0.839	−0.125	I (1)	I (1)	I(1)	I(1)	E → Y	Spurious	−0.174	E – Y
United Kingdom	HI	0.962	0.898	−0.064	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.201	E ↔ Y
Country	**Income Group**	**r(e/E-A) [1] Ferguson**	**r(e/E-A) [2] current**	**Δ Dif.= [2] - [1]**	**A**	**e/E**	**Coint (A-e/E)**	**Coint (e/E-A)**	**Granger @level**	**Verdict**	**r(Δe/E-ΔA)**	**Granger @Diff.**
Finland	HI	0.960	0.709	−0.251	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.213	E ↔ Y
Greece	HI	0.953	0.191	−0.762	I (1)	I (1)	I(1)	I(1)	E → Y	Spurious	−0.261	E ← Y
Tunisia	LMI	0.952	0.855	−0.097	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	−0.185	E – Y
Canada	HI	0.950	−0.656	−1.606	I (1)	I (1)	I(0)	I(1)	E – Y	Spurious	0.111	E – Y
Ireland	HI	0.949	0.816	−0.133	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	−0.057	E – Y
Sweden	HI	0.946	0.062	−0.884	I (1)	I (1)	I(1)	I(0)	E – Y	Spurious	−0.251	E – Y
Sri Lanka	LMI	0.943	0.945	0.002	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	−0.287	E – Y
France	HI	0.940	0.859	−0.081	I (0)	I (1)	I(1)	I(1)	E – Y	Spurious	−0.017	E – Y
Netherlands	HI	0.935	0.928	−0.007	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.551	E ← Y
Korea, Rep.	HI	0.925	0.973	0.048	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	−0.017	E → Y
Portugal	HI	0.909	0.562	−0.347	I (0)	I (1)	I(1)	I(1)	E ← Y	Spurious	−0.115	E – Y
Spain	HI	0.904	0.636	−0.268	I (1)	I (1)	I(1)	I(1)	E → Y	Spurious	−0.111	E → Y
Oman	HI	0.900	−0.145	−1.045	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.082	E → Y
Turkey	UMI	0.878	0.878	0.000	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	−0.140	E – Y
Italy	HI	0.869	−0.045	−0.914	I (1)	I (1)	I(1)	I(1)	E → Y	Spurious	0.121	E ↔ Y
New Zealand	HI	0.847	0.181	−0.666	I (1)	I (1)	I(1)	I(1)	E → Y	Spurious	0.046	E ↔ Y
Luxembourg	HI	0.846	−0.449	−1.295	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.265	E ↔ Y
Cuba	UMI	0.813	0.893	0.080	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.216	E ← Y
Israel	HI	0.810	0.669	−0.141	I (1)	I (0)	I(1)	I(1)	E – Y	Spurious	−0.037	E ← Y
Bangladesh	LMI	0.809	0.950	0.141	I (1)	I (1)	I(1)	I(1)	E → Y	Spurious	−0.039	E → Y
Thailand	UMI	0.785	0.660	−0.125	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	−0.278	E ← Y
Cyprus	HI	0.730	0.678	−0.052	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.031	E ↔ Y
Malaysia	UMI	0.723	0.611	−0.112	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	−0.527	E ← Y
Brunei Darussalam	HI	0.722	−0.201	−0.923	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	−0.528	E – Y
Kenya	LMI	0.707	0.868	0.161	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.441	E ← Y
Egypt, Arab Rep.	LMI	0.692	0.846	0.154	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.007	E → Y
Bulgaria	UMI	0.689	0.866	0.177	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	−0.127	E ↔ Y

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Table A3.2 (*continued*)

Country	Income Group	r(e/E-A) [1] Ferguson	r(e/E-A) [2] current	Δ Dif. = [2] - [1]	A	e/E	Coint (A-e/E)	Coint (e/E-A)	Granger @level	Verdict	r(Δe/E-ΔA)	Granger @Diff.
Malta	HI	0.677	0.824	0.147	I(1)	I(1)	I(1)	I(1)	E ← Y	Spurious	0.320	E – Y
Country	**Income Group**	**r(e/E-A) [1] Ferguson**	**r(e/E-A) [2] current**	**Δ Dif. = [2] - [1]**	**A**	**e/E**	**Coint (A-e/E)**	**Coint (e/E-A)**	**Granger @level**	**Verdict**	**r(Δe/E-ΔA)**	**Granger @Diff.**
Panama	HI	0.636	0.841	0.205	I(1)	I(1)	I(1)	I(1)	E → Y	Spurious	0.216	E → Y
Chile	HI	0.632	0.809	0.177	I(1)	I(1)	I(1)	I(1)	E ↔ Y	Spurious	−0.580	E – Y
Congo, Dem. Rep.	LI	0.559	−0.069	−0.628	I(1)	I(1)	I(1)	I(1)	E → Y	Spurious	−0.100	E → Y
Norway	HI	0.521	−0.645	−1.166	I(1)	I(1)	I(1)	I(1)	E ← Y	Spurious	0.167	E ← Y
Mexico	UMI	0.495	0.819	0.324	I(1)	I(1)	I(1)	I(1)	E → Y	Spurious	0.365	E – Y
Myanmar	LMI	0.440	0.912	0.472	I(1)	I(1)	I(1)	I(1)	E ↔ Y	Spurious	0.207	E ↔ Y
Ecuador	UMI	0.436	0.930	0.494	I(1)	I(1)	I(1)	I(1)	E – Y	Spurious	0.427	E – Y
Jamaica	UMI	0.382	−0.001	−0.383	I(1)	I(1)	I(1)	I(1)	E ↔ Y	Spurious	−0.329	E ↔ Y
Sudan	LMI	0.360	0.974	0.614	I(1)	I(1)	I(1)	I(1)	E ↔ Y	Spurious	−0.156	E ↔ Y
Singapore	HI	0.289	0.694	0.405	I(1)	I(1)	I(1)	I(1)	E ← Y	Spurious	−0.145	E → Y
Angola	LMI	0.267	0.935	0.668	I(1)	I(1)	I(1)	I(1)	E – Y	Spurious	0.055	E – Y
Honduras	LMI	0.256	0.666	0.410	I(1)	I(0)	I(1)	I(1)	E – Y	Spurious	−0.206	E – Y
Trinidad and Tobago	HI	0.212	−0.771	−0.983	I(1)	I(0)	I(1)	I(1)	E → Y	Spurious	−0.221	E → Y
Jordan	UMI	0.206	0.672	0.466	I(1)	I(1)	I(1)	I(1)	E ← Y	Spurious	−0.295	E – Y
Philippines	LMI	0.172	0.914	0.742	I(1)	I(0)	I(1)	I(1)	E → Y	Spurious	−0.270	E ↔ Y
Ghana	LMI	0.165	0.532	0.367	I(1)	I(1)	I(1)	I(1)	E ← Y	Spurious	0.259	E – Y
Switzerland	HI	0.113	0.900	0.787	I(1)	I(1)	I(1)	I(1)	E ↔ Y	Spurious	0.289	E – Y
Bolivia	LMI	0.112	0.701	0.589	I(1)	I(1)	I(1)	I(1)	E ← Y	Spurious	−0.112	E → Y
Nigeria	LMI	0.064	0.935	0.871	I(1)	I(1)	I(1)	I(1)	E ← Y	Spurious	0.511	E ← Y
Nicaragua	LMI	−0.028	0.910	0.938	I(1)	I(1)	I(1)	I(1)	E ← Y	Spurious	−0.109	E ← Y
Haiti	LI	−0.037	0.853	0.890	I(1)	I(1)	I(1)	I(1)	E → Y	Spurious	0.415	E – Y
Costa Rica	UMI	−0.047	−0.689	−0.642	I(1)	I(1)	I(1)	I(1)	E ← Y	Spurious	−0.045	E – Y
Zimbabwe	LI	−0.154	0.408	0.562	I(1)	I(1)	I(1)	I(1)	E ↔ Y	Spurious	−0.187	E ↔ Y
Mozambique	LI	−0.206	0.845	1.051	I(1)	I(0)	I(1)	I(1)	E ↔ Y	Spurious	−0.081	E ← Y
Benin	LI	−0.213	0.879	1.092	I(1)	I(1)	I(1)	I(1)	E – Y	Spurious	0.190	E – Y
Algeria	UMI	−0.289	0.835	1.124	I(1)	I(1)	I(1)	I(1)	E – Y	Spurious	0.309	E – Y
Argentina	HI	−0.328	0.656	0.984	I(1)	I(1)	I(1)	I(1)	E ↔ Y	Spurious	−0.098	E ↔ Y
Guatemala	UMI	−0.421	0.667	1.088	I(1)	I(1)	I(1)	I(1)	E – Y	Spurious	0.124	E – Y
Country	**Income Group**	**r(e/E-A) [1] Ferguson**	**r(e/E-A) [2] current**	**Δ Dif. = [2] - [1]**	**A**	**e/E**	**Coint (A-e/E)**	**Coint (e/E-A)**	**Granger @level**	**Verdict**	**r(Δe/E-ΔA)**	**Granger @Diff.**
Bahrain	HI	−0.441	−0.192	0.249	I(1)	I(1)	I(1)	I(1)	E – Y	Spurious	−0.137	E → Y
Gabon	UMI	−0.491	0.840	1.331	I(1)	I(1)	I(1)	I(1)	E ← Y	Spurious	0.101	E – Y
Cameroon	LMI	−0.498	0.862	1.360	I(1)	I(1)	I(1)	I(1)	E ← Y	Spurious	0.181	E – Y
El Salvador	LMI	−0.540	0.963	1.503	I(1)	I(1)	I(1)	I(1)	E ↔ Y	Spurious	0.037	E ↔ Y
United Arab Emirates	HI	−0.682	−0.852	−0.170	I(1)	I(1)	I(1)	I(1)	E ↔ Y	Spurious	−0.023	E ↔ Y
Iraq	UMI	−0.690	0.023	0.713			I(1)	I(1)	E – Y	Spurious	0.381	E – Y

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Table A3.2 (*continued*)

Country	Income Group	r(e/E-A) [1] Ferguson	r(e/E-A) [2] current	Δ Dif. = [2] - [1]	A	e/E	Coint (A-e/E)	Coint (e/E-A)	Granger @level	Verdict	r(Δe/E-ΔA)	Granger @Diff.
					I (1)	I (1)						
Iran, Islamic Rep.	UMI	−0.759	0.800	1.559	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.314	E – Y
Peru	UMI	−0.794	0.698	1.492	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.040	E ← Y
Venezuela, RB	UMI	−0.833	0.589	1.422	I (1)	I (1)	I(1)	I(1)	E → Y	Spurious	0.081	E ↔ Y
Saudi Arabia	HI	−0.901	0.472	1.373	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.116	E ↔ Y
By Income Groups	**Income Group**	**r(e/E-A) [1] Ferguson**	**r(e/E-A) [2] current**	**Δ Dif. = [2] - [1]**	**A**	**e/E**	**Coint (A-e/E)**	**Coint (e/E-A)**	**Granger @level**	**Verdict**	**r(Δe/E-ΔA)**	**Granger @Diff.**
Low Income	LI	–	–	–	–	–	–	–	–		–	
Lower Middle Income	LMI	–	0.997	–	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.635	E ← Y
Upper Middle Income	UMI	–	0.988	–	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.400	E ↔ Y
High Income	HI	–	0.945	–	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.201	E – Y
World	–	–	0.985	–	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.373	E – Y

Notes: r(x-y) refers to *correlation coefficient* between x and y; Coint(x-y) refers to *cointegration*.
*This column is corresponding Table 8 in **Ferguson**

Table A3.3
Correlation coefficients: electricity/energy use proportion (e/E) vs. affluence (A) – 1960-2014

Country	Income Group	r(e/E-A) [1] Ferguson	r(e/E-A) [2] current	Δ Dif. = [2] - [1]	A	e/E	Coint (A-e/E)	Coint (e/E-A)	Granger @level	Verdict	r(Δe/E-ΔA)	Granger @Diff.
United Kingdom	HI	0.962	0.975	0.013	I (1)	I (1)	I(1)	I(0)	E ← Y	TRUE	0.031	E – Y
Luxembourg	HI	0.846	0.895	0.049	I (1)	I (1)	I(1)	I(0)	E → Y	TRUE	0.009	E ← Y
Malaysia	UMI	0.723	0.947	0.224	I (1)	I (1)	I(1)	I(0)	E ← Y	TRUE	−0.317	E – Y
Congo, Dem. Rep.	LI	0.559	0.952	0.393	I (1)	I (1)	I(1)	I(0)	E ← Y	TRUE	0.305	E – Y
Jamaica	UMI	0.382	0.580	0.198	I (1)	I (1)	I(0)	I(1)	E → Y	TRUE	−0.087	E → Y
Switzerland	HI	0.113	0.933	0.820	I (1)	I (1)	I(0)	I(0)	E ↔ Y	TRUE	0.099	E – Y
Bahrain	HI	−0.441	0.490	0.931	I (1)	I (1)	I(1)	I(0)	E ← Y	TRUE	0.209	E – Y
Gabon	UMI	−0.491	−0.043	0.448	I (0)	I (1)	I(0)	I(1)	E ↔ Y	TRUE	0.130	E – Y
Albania	UMI	–	0.787	–	I (1)	I (1)	I(1)	I(1)	E → Y	Spurious	0.290	E – Y
Congo, Rep.	LMI	–	0.508	–	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.082	E ← Y
Mauritius	UMI	–	0.953	–	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	−0.011	E – Y
Togo	LI	–	0.060	–	I (1)	I (0)	I(1)	I(0)	E – Y	Spurious	0.415	E – Y
Germany	HI	0.988	0.982	−0.006	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.069	E ← Y
Australia	HI	0.987	0.916	−0.071	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	−0.127	E – Y
India	LMI	0.984	0.899	−0.085	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.122	E – Y
Belgium	HI	0.984	0.982	−0.002	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.166	E – Y
United States	HI	0.980	0.976	−0.004	I (1)	I (1)	I(1)	I(1)	E → Y	Spurious	−0.206	E → Y
Pakistan	LMI	0.978	0.973	−0.005	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.322	E – Y
Indonesia	LMI	0.973	0.987	0.014	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.263	E – Y
Colombia	UMI	0.970	0.961	−0.009	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.167	E – Y
China	UMI	0.967	0.949	−0.018	I (1)	I (1)	I(1)	I(1)	E → Y	Spurious	0.531	E ← Y
Austria	HI	0.967	0.973	0.006			I(1)	I(1)	E ← Y	Spurious	−0.012	E – Y

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Table A3.3 (*continued*)

Country	Income Group	r(e/E-A) [1] Ferguson	r(e/E-A) [2] current	Δ Dif. = [2] - [1]	A	e/E	Coint (A-e/E)	Coint (e/E-A)	Granger @level	Verdict	r(Δe/E-ΔA)	Granger @Diff.
					I (1)	I (1)						
Denmark	HI	0.966	0.958	−0.008	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	−0.082	E – Y
Japan	HI	0.964	0.978	0.014	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	−0.015	E – Y
Finland	HI	0.960	0.942	−0.018	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.069	E – Y
Greece	HI	0.953	0.897	−0.056	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	−0.199	E – Y
Tunisia	LMI	0.952	0.907	−0.045	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	−0.293	E – Y
Country	**Income Group**	**r(e/E-A) [1] Ferguson**	**r(e/E-A) [2] current**	**Δ Dif. = [2] - [1]**	**A**	**e/E**	**Coint (A-e/E)**	**Coint (e/E-A)**	**Granger @level**	**Verdict**	**r(Δe/E-ΔA)**	**Granger @Diff.**
Canada	HI	0.950	0.851	−0.099	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.011	E – Y
Ireland	HI	0.949	0.947	−0.002	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	−0.043	E – Y
Sweden	HI	0.946	0.840	−0.106	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	−0.181	E – Y
Sri Lanka	LMI	0.943	0.968	0.025	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.004	E – Y
France	HI	0.940	0.973	0.033	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	−0.072	E ← Y
Morocco	LMI	0.937	0.939	0.002	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	−0.005	E ← Y
Netherlands	HI	0.935	0.972	0.037	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.121	E ← Y
Korea, Rep.	HI	0.925	0.986	0.061	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.022	E ← Y
Portugal	HI	0.909	0.886	−0.023	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	−0.117	E → Y
Spain	HI	0.904	0.941	0.037	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	−0.158	E – Y
Hong Kong SAR, China	HI	0.901	0.884	−0.017	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.323	E – Y
Oman	HI	0.900	0.567	−0.333	I (1)	I (0)	I(1)	I(1)	E – Y	Spurious	0.082	E – Y
Turkey	UMI	0.878	0.967	0.089	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	−0.148	E ← Y
Italy	HI	0.869	0.940	0.071	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	−0.123	E – Y
New Zealand	HI	0.847	0.349	−0.498	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	−0.082	E – Y
Cuba	UMI	0.813	0.733	−0.080	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.108	E – Y
Israel	HI	0.810	0.922	0.112	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.065	E ← Y
Bangladesh	LMI	0.809	0.968	0.159	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.287	E – Y
Thailand	UMI	0.785	0.915	0.130	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	−0.148	E – Y
Brazil	UMI	0.762	0.803	0.041	I (1)	I (0)	I(1)	I(1)	E – Y	Spurious	−0.213	E – Y
Paraguay	UMI	0.735	0.893	0.158	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	−0.004	E – Y
Cyprus	HI	0.730	0.864	0.134	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	−0.059	E – Y
Brunei Darussalam	HI	0.722	−0.802	−1.524	I (0)	I (1)	I(0)	I(1)	E – Y	Spurious	−0.214	E – Y
Kenya	LMI	0.707	0.759	0.052	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.199	E – Y
Egypt, Arab Rep.	LMI	0.692	0.964	0.272	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.000	E – Y
Bulgaria	UMI	0.689	0.846	0.157	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	−0.109	E ← Y
Malta	HI	0.677	0.902	0.225	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.156	E – Y

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Table A3.3 (*continued*)

Country	Income Group	r(e/E-A) [1] Ferguson	r(e/E-A) [2] current	Δ Dif. = [2] - [1]	A	e/E	Coint (A-e/E)	Coint (e/E-A)	Granger @level	Verdict	r(Δe/E-ΔA)	Granger @Diff.
Panama	HI	0.636	0.790	0.154	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.112	E – Y
Country	**Income Group**	**r(e/E-A) [1] Ferguson**	**r(e/E-A) [2] current**	**Δ Dif. = [2] - [1]**	**A**	**e/E**	**Coint (A-e/E)**	**Coint (e/E-A)**	**Granger @level**	**Verdict**	**r(Δe/E-ΔA)**	**Granger @Diff.**
Chile	HI	0.632	0.941	0.309	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	−0.294	E – Y
Uruguay	HI	0.624	0.710	0.086	I (1)	I (1)	I(1)	I(1)	E → Y	Spurious	−0.346	E ← Y
Nepal	LI	0.579	0.993	0.414	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.229	E ← Y
Norway	HI	0.521	−0.280	−0.801	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.075	E – Y
Mexico	UMI	0.495	0.871	0.376	I (1)	I (1)	I(0)	I(1)	E – Y	Spurious	−0.180	E – Y
Myanmar	LMI	0.440	0.942	0.502	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.347	E ↔ Y
Ecuador	UMI	0.436	0.917	0.481	I (1)	I (1)	I(1)	I(1)	E → Y	Spurious	0.259	E – Y
Sudan	LMI	0.360	0.956	0.596	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.100	E ↔ Y
Singapore	HI	0.289	0.741	0.452	I (1)	I (1)	I(1)	I(1)	E → Y	Spurious	−0.165	E → Y
Angola	LMI	0.267	0.805	0.538	I (1)	I (1)	I(1)	I(1)	E → Y	Spurious	0.220	E ← Y
Honduras	LMI	0.256	0.817	0.561	I (1)	I (1)	I(1)	I(1)	E → Y	Spurious	0.039	E – Y
Trinidad and Tobago	HI	0.212	−0.587	−0.799	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	−0.131	E – Y
Jordan	UMI	0.206	0.632	0.426	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	−0.264	E – Y
Philippines	LMI	0.172	0.896	0.724	I (1)	I (1)	I(1)	I(1)	E → Y	Spurious	0.076	E – Y
Ghana	LMI	0.165	0.432	0.267	I (1)	I (0)	I(1)	I(0)	E – Y	Spurious	0.169	E – Y
Bolivia	LMI	0.112	0.672	0.560	I (1)	I (1)	I(1)	I(1)	E → Y	Spurious	−0.032	E – Y
Dominican Republic	UMI	0.087	0.951	0.864	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.147	E – Y
Nigeria	LMI	0.064	0.256	0.192	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.101	E – Y
Nicaragua	LMI	−0.028	−0.226	−0.198	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.253	E – Y
Haiti	LI	−0.037	0.218	0.255	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.244	E – Y
Costa Rica	UMI	−0.047	0.094	0.141	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	−0.294	E – Y
Zimbabwe	LI	−0.154	0.189	0.343	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.217	E – Y
Mozambique	LI	−0.206	0.935	1.141	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.157	E – Y
Benin	LI	−0.213	0.923	1.136	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	−0.148	E – Y
Algeria	UMI	−0.289	0.729	1.018	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.009	E – Y
Argentina	HI	−0.328	0.752	1.080	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.045	E – Y
Guatemala	UMI	−0.421	0.875	1.296	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.261	E – Y
Cameroon	LMI	−0.498	0.274	0.772	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.186	E – Y
Country	**Income Group**	**r(e/E-A) [1] Ferguson**	**r(e/E-A) [2] current**	**Δ Dif. = [2] - [1]**	**A**	**e/E**	**Coint (A-e/E)**	**Coint (e/E-A)**	**Granger @level**	**Verdict**	**r(Δe/E-ΔA)**	**Granger @Diff.**
El Salvador	LMI	−0.540	0.475	1.015	I (1)	I (1)	I(1)	I(1)	E → Y	Spurious	0.142	E ↔ Y
South Africa	UMI	−0.651	−0.112	0.539	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	−0.018	E – Y
United Arab Emirates	HI	−0.682	−0.717	−0.035	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	−0.109	E ← Y
Iraq	UMI	−0.690	0.192	0.882	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.129	E – Y
Senegal	LI	−0.708	0.283	0.991	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	−0.174	E – Y

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Table A3.3 (*continued*)

Country	Income Group	r(e/E-A) [1] Ferguson	r(e/E-A) [2] current	Δ Dif. = [2] - [1]	A	e/E	Coint (A-e/E)	Coint (e/E-A)	Granger @level	Verdict	r(Δe/E-ΔA)	Granger @Diff.
Iran, Islamic Rep.	UMI	−0.759	−0.374	0.385	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.153	E – Y
Peru	UMI	−0.794	0.479	1.273	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	−0.022	E – Y
Venezuela, RB	UMI	−0.833	−0.468	0.365	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.125	E – Y
Zambia	LMI	−0.858	0.430	1.288	I (1)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.140	E – Y
Saudi Arabia	HI	−0.901	−0.766	0.135	I (0)	I (1)	I(1)	I(1)	E ← Y	Spurious	0.114	E ← Y
By Income Groups	**Income Group**	**r(e/E-A) [1] Ferguson**	**r(e/E-A) [2] current**	**Δ Dif. = [2] - [1]**	**A**	**e/E**	**Coint (A-e/E)**	**Coint (e/E-A)**	**Granger @level**	**Verdict**	**r(Δe/E-ΔA)**	**Granger @Diff.**
Low Income	LI	–	–	–	–	–	–	–	–		–	
Lower Middle Income	LMI	–	0.909	–	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.205	E – Y
Upper Middle Income	UMI	–	0.908	–	I (1)	I (1)	I(1)	I(1)	E ↔ Y	Spurious	0.153	E ↔ Y
High Income	HI	–	0.987	–	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	−0.004	E – Y
World	–	–	0.969	–	I (1)	I (1)	I(1)	I(1)	E – Y	Spurious	0.118	E – Y

Notes: r(x-y) refers to *correlation coefficient* between x and y; Coint(x-y) refers to *cointegration*.
*This column is corresponding Table 8 in **Ferguson**

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