Open Access Library Journal
2024, Volume 11, e12710
ISSN Online: 2333-9721
ISSN Print: 2333-9705

Relationship between Energy Consumption and Economic Growth of Mongolia during the 1981-2016 Years (Cointegration and Causality Analysis)

Ganzorig Shagdarsuren, Sodnomdorj Dari, Gantumur Shagdarsuren*

Department of Electrical Engineering, Power Engineering School, Mongolian University of Science and Technology, Ulaanbaatar, Mongolia
Email: *gantumur2020@must.edu.mn

How to cite this paper: Shagdarsuren, G., Dari, S. and Shagdarsuren, G. (2024) Relationship between Energy Consumption and Economic Growth of Mongolia during the 1981-2016 Years (Cointegration and Causality Analysis). *Open Access Library Journal*, **11**: e12710.
https://doi.org/10.4236/oalib.1112710

Received: November 27, 2024
Accepted: December 28, 2024
Published: December 31, 2024

Abstract

In the contemporary world, energy is a very important factor for economic development, especially when a country is in the process of accelerating its economy into an industrialized one, as in the developing countries like Mongolia. The nexus between energy consumption and economic growth has been widely studied by various researchers from different countries. This study investigated the causal relationships (*i.e.*, the short- and long-term structural associations) between the gross domestic product (GDP) and different energy variables of Mongolia by applying a modeling strategy based on the Granger causality from the vector error correction model, the augmented Dickey-Fuller and Phillips-Perron unit root tests, and the Johansen cointegration test. The model determined a long-term unidirectional causality from electricity consumption to GDP and from GDP to primary energy. Furthermore, short-term unidirectional causalities were discovered from GDP to electricity consumption and from primary energy consumption to GDP. In the case of causality relationship between electricity consumptions and GDP of Mongolia supports "growth hypothesis" in long term. Accordingly, in case of causality relationship between Primary energy consumption and GDP of Mongolia supports "neutrality hypothesis" in long term. Consequently, we may conclude that Mongolia has electricity driving economic growth and more electrical energy is required to encourage sustainable economic development. This also implies that the increase of electricity consumption affects positively the economic growth.

Subject Areas

Electric Engineering

Keywords

Electricity Consumption, Energy Consumption, Granger Causality, Mongolia, Economic Growth, Johansen Test for Cointegration, Vector Error Correction Model

1. Introduction

The relationship between energy consumption and economic growth has been a fascinating question since the occurrence of the energy crisis in the 1970s until today. The nexus between energy consumption and economic growth has been widely studied by various researchers from different countries. There is no doubt that energy is one of the major triggers of national economic growth, which plays an important role in the national production and life. Correspondingly, the Mongolian economy, which is based on the natural resources and livestock farming as well as on the agriculture, is expected to expand substantially over the next few decades. At the same time, the energy demand is expected to increase dramatically and energy can also play a vital role in the Mongolian economy and in the development of the country's society.

As noted by [1], among others, if a causality runs from energy consumption to GDP, then an economy is energy-dependent, and hence, energy is a stimulus to growth and that a shortage of energy may negatively affect the country's economic growth or may cause poor economic performance on the part of the country, leading to a fall in income and employment. In other words, energy is a limiting factor to economic growth [2]. Conversely, if a causality runs from GDP to energy consumption, then the economy is not energy-dependent, and hence, as noted by [3], among others, energy conservation policies may be implemented with no adverse effect on growth and employment.

If, on the other hand, there is no causality in either direction (referred to as the "neutrality hypothesis"), then energy consumption is not correlated with the GDP, and as such, energy conservation policies may be pursued without adversely affecting the economy [1].

The cointegration methodology is applied for many country cases for finding a causality between energy consumption and economic growth.

The main purpose of this study is to identify the existence of a causal relationship between the consumptions of different forms of energy and the economic growth of Mongolia, and if such a causal relationship is found, to determine the direction or directions of such. It aimed to investigate this matter empirically by applying a modeling strategy based on the Granger causality from the vector error correction model, the augmented Dickey-Fuller and Phillips-Perron unit root tests, and the Johansen cointegration test. The data that were used in this study were obtained from the U.S. Energy Information Administration website [4] and from the World Development Indicators from the World Bank statistics [5], and they cover the years 1981 to 2016.

The empirical findings that were obtained in this study regarding the causal relationships between the consumptions of 2 different forms of energy and economic growth can be categorized into five distinct cases, as shown below.

For long-term causality:

- No causality (GDP → Electricity consumption), (Primary energy consumption → GDP) or "neutrality hypothesis", no causality from economic growth to electricity consumption and from primary energy consumption to economic growth.
- Unidirectional causality running from electricity consumption to economic growth (Electricity consumption → GDP) or "conservation hypothesis".
- Unidirectional causality running from electricity consumption to economic growth (GDP → Primary energy consumption) or "growth hypothesis".

For short-term causality:

- No causality (Electricity consumption → GDP, GDP → Primary energy consumption) or "neutrality hypothesis" – no causality from electricity consumption to economic growth and from economic growth to primary energy consumption.
- Unidirectional causality from economic growth to electricity consumption, (GDP → Electricity), or "conservation hypothesis".
- Unidirectional causality from primary energy consumption to economic growth (Primary Energy → GDP) or "growth hypothesis".

Table 1 shows the modes of the causal relationships that were tested in this study between the consumption of different forms of energy and economic growth.

Table 1. Mood of causal relationships.

	Links	Short-run	Long-Run
1	GDP → Electricity	+	—
2	Electricity → GDP	—	+
3	GDP → Primary energy	—	+
4	Primary energy → GDP	+	—

+, − denotes existence of causality.

The discovery of the directions of the causalities between the consumption of different forms of energy and economic growth has important policy implications. For instance, the energy conservation policies cannot decrease the economic growth in the case of a unidirectional causality from economic growth to the consumption of different forms of energy, as with the link between electricity and GDP in the empirical analysis in this study for the long-term condition.

In the case of a unidirectional causality from economic growth to the consumption of different forms of energy, energy conservation policies may have a positive or no effect on economic growth.

1.1. Research Motivation

Many studies have tried to test the relationship between energy consumption and economic growth. The link between these two has been widely studied in the economic literature, but there has been no discussion of the causal relationship between energy consumption and economic growth for Mongolia, mostly due to data limitations and probably Mongolia's transitional economic circumstances.

Actually, in terms of energy deposits, Mongolia has abundant energy resources, including conventional and non-conventional resources, within its boundaries, and supposedly, energy can be one of the major triggers of economic development in Mongolia.

Moreover, understanding the relationship between energy consumption and economic growth in Mongolia can provide insights for policy implementations to achieve sustained economic growth under various energy scenarios in the context of the rising international debate on global warming and the reduction of greenhouse gas emissions. On the other hand, it is very applicable to the successful crafting of appropriate energy policies in the short or long term that will be essential to Mongolia's rapid economic development.

The aspiration of this study was to address the following research questions:

1) Is there any causal relationship between the consumption of different forms of energy and the GDP of Mongolia during the period 1981-2016:

a) In the case of electricity consumption.

b) In the case of primary energy consumption.

2) What are the directions of the long- and short-term causalities between the consumption of different forms of energy and the GDP?

3) What are the policy implications if a causality nexus exists between the consumption of different forms of energy and the GDP?

1.2. The Research Objective and Structure

The main purpose of this study was to determine if causal relationships exist between the consumption of different forms of energy and economic growth in Mongolia, and if so, to determine the directions of such causal relationships. Thus, the study aimed to empirically investigate the causal relationships between different variables.

In this study, an attempt was made to identify proofs of this nexus (no causality, unidirectional causality, or bidirectional causality between the consumption of different forms of energy and the GDP of Mongolia) based on the relevant data from 1981 to 2016. The directions of the causalities between the consumption of different forms of energy and economic growth have important policy implications.

On the other hand, if unidirectional causality is found to run from energy consumption to economic growth, any constraint put on energy consumption could lead to an economic downfall, and if "no causality" is found in either direction, the so-called "neutrality hypothesis" would imply that energy conservation policies would not affect the economic growth [6].

Moreover, by identifying the directions of the causal relationships between the main energy factors and economic growth, energy policies with well-suited tendencies would be encouraged. Moreover, it would be very feasible to base energy policy recommendations on the study results obtained, and to support the rapidly growing economy without any negative or adverse effect.

1.3. Research Structure

The following models are analyzed: model 1, Electricity consumption ↔ GDP; model 2, Primary energy consumption ↔ GDP.

2. Literature Review

This chapter describes the main researches on causality between energy consumption and economic growth among different countries with different energy sources and economic development in the world. For this study, a number of previous literatures are reviewed in terms of nexus between the energy consumption and economic growth.

Various researches on causality between energy consumption and economic growth of the countries depend on the level of economic development and energy sources as well. But mainly differentiations among them consist of the different variables and time period of that history period.

Depending on energy consumption impact on the economic growth, works can be separated to the long-time period issues and short-time issues. Using results of the researches with clear vision: what kind of causality exists between energy consumption and economic growth policy makers can choose applicable policy tools in order to increase positive effects of the energy policy in the area.

These diverse results arise due to the different dataset, alternative econometric methodologies and different countries' characteristics. The actual causality is different in different countries and this might be due to different countries' characteristics such as different indigenous energy supplies, different political and economic histories, different political arrangements, different institutional arrangements, different cultures and different energy policies, etc. [7].

As pointed out also by [1] [6]-[12] many others, the directions that the causal relationship between energy consumption and economic growth could be categorized into four types each of which has important implications for energy policy.

1) No causality: No causality between energy consumption and GDP is referred to as "neutrality hypothesis". It implies that energy consumption is not correlated with GDP, which means that neither conservative nor expansive policies in relation to energy consumption have any effect on economic growth.

Thus, the neutrality hypothesis is supported by the absence of a causal relationship between energy consumption and GDP.

2) The unidirectional causality running from economic growth to energy

consumption. It is also called "conservation hypothesis". It suggests that the policy of conserving energy consumption may be implemented with little or no adverse effect on economic growth, such as in a less energy-dependent economy. The conservation hypothesis is supported if an increase in GDP causes an increase in energy consumption.

3) The unidirectional causality running from energy consumption to economic growth. It is also called "growth hypothesis". It implies that restrictions on the use of energy may adversely affect economic growth while increases in energy may contribute to economic growth. The growth hypothesis suggests that energy consumption plays an important role in economic growth both directly and indirectly in the production process as a complement to labor and capital. Consequently, we may conclude that energy is a limiting factor to economic growth and, hence, shocks to energy supply will have a negative impact on economic growth.

4) Bi-directional causality between energy consumption and economic growth. It is also called "feedback hypothesis". It implies that energy consumption and economic growth are jointly determined and affected at the same time.

In these times, the most popular tools for scholars in this area are Granger causality cointegration, vector error correction model, which is used to analyze the causal relationship between energy consumption and economic growth of the country. But before founding Granger test, scholars used to analyze the causality with simple log-linear model and calculated by the ordinary least square (OLS) method and the variables affinities of time series were not concerned.

However, mostly scholars tried to find a vector of the causal relation between energy consumption and economic growth for selected countries with different economic development using different tools, although we got different results. Main differentiation between these works is the absence or existence of the causality between energy consumption and economic growth.

- Existence of (unidirectional, bidirectional) causal relationship.
- Absence of causal relationship.

2.1. Existence of a (Unidirectional, Bidirectional) Causal Relationship

According to the scholars, there are countries where causality between energy consumption and economic growth exists. Some countries' causality goes from the energy consumption to economic growth, and other countries have the opposite causality between economic growth and energy consumption. This chapter will discuss issues, which consist of the existence of causality between energy consumption and economic growth in different countries.

The causal relationship between energy consumption and GNP in the United States of America in the period 1947-1974 was first found by [13] which showed unidirectional causality running from GNP to energy consumption. According to this issue, was found that energy conservation measures do not affect the economy negatively. Scholars used cointegration and causality methods as an analytical tool to determine the relationship between energy consumption and economic growth of the country, which was offered by [14], this method, become most widespread analytical tool in this kind of research areas.

Later same result, but using monthly data [15] in the period of 1973-1978 in United States also found unidirectional causality between energy consumption and GNP. They estimated the long-run elasticity of total employment with respect to energy consumption. In case of Asian countries, [16] found the causal relationships between energy use and income in four Asian countries. In this issue, scholar include except economic growth and energy consumption price as a third variable. In the result, researcher concludes that unidirectional Granger causality runs from energy use to income for India and Indonesia, when bidirectional Granger causality runs from energy to income for Thailand and the Philippines.

In the long-term perspective for India and Indonesia exist unidirectional Granger causality running from energy consumption and prices to income for India and Indonesia. When for Thailand and Philippines energy consumption, income and price are bidirectional causal. In the casual chain, price affects less significant causal chain. In general issue do not support the aspect that energy and income are neutral with respect to each other, with the exception of Indonesia and India where neutrality is observed in short run.

[17] investigated the relationship between coal consumption and real GDP among different regions of China with the use of panel data and indicated that coal consumption and GDP are both I(1) and cointegrated in all regional groupings. The regional causality tests reveal that the coal consumption-GDP relationship is bidirectional in the Coastal and Central regions whereas causality is unidirectional from GDP to coal consumption in the Western region.

[18] investigated a relationship between electricity consumption and GDP in period of 1970-2011 for India. Applying, two-step Engle-Granger technique and Granger causality/Block exogeneity Wald test, the study suggests that it is the electricity energy consumption that fuels economic growth both in short-run and long run. It rejects the neo-classical hypothesis and empirically proves that electricity consumption is a limiting factor on economic growth.

[19] observed cointegration for India, Indonesia and Pakistan and no cointegration for Singapore, Malaysia and the Philippine between GDP and energy consumption with the vector correction model (VECM). And the unidirectional causality was found in India running from energy consumption to GDP, and opposite causality in Indonesia running from GDP to energy consumption, and finally in case of Pakistan bidirectional causality was found. Philippine, Malaysia and Singapore were tested by VAR method and causality was not found among those countries.

[20] investigated the relationships between coal consumption and economic growth of the six biggest coal consumption countries: with coal price as a third variable using a common source of data from 2000 through 2010. Then 6 main coal consumption countries are chosen as China, the United States of America,

India, Germany, Russia and Japan. The tests show: 1) Bidirectional causal relationships between coal consumption and economic growth exist in Germany, Russia and Japan. 2) Only a unidirectional causality from economic growth to coal consumption exists in China.

[21] issued the causal relationship between economic growth, employment and energy consumption in Pakistan and found unidirectional causality running from economic growth to energy consumption. Later authors checked a relationship between economic growth with several types of energy consumption and found unidirectional causality between economic growth to petroleum consumption, also no causality between economic growth and gas consumption, and discovered unidirectional causality running from electricity consumption to economic growth.

The causality between energy consumption and economic growth in Singapore and South Korea was issued by [22]. Using of VAR model helped to discover unidirectional Granger causality in the case of Singapore running from energy consumption to GDP and no Granger causality in case of South Korea. However, bidirectional causality for both countries was found by adopting cointegration and error corrections models (ECMs).

Later [23] discovered bidirectional causality between energy consumption and economic growth of South Korea in the long term and unidirectional causality running from energy consumption to economic growth in short term for the period 1970-1999. Scholars used the Divisia aggregate instead of the conventional energy aggregate and VECM rather than the VAR model.

The energy and economy relationship issues of the G-7 countries and the top 10 emerging economies were studied by [24]. The results showed the existence of unidirectional causalities running from GDP to energy consumption in Italy and South Korea, and from energy consumption to GDP in Germany, France, Japan and Türkiye and bidirectional causality for Argentina.

China was not included in previous research, but [25] discovered unidirectional causality from electricity consumption to GDP within period of 1978-2001. But [12] researched the period of 1971-2000 and found unidirectional causality running from GDP to electricity consumption.

[1] investigated the causality relationship between GDP, agricultural GDP, nonagricultural GDP and electricity consumption in Malawi in the period of 1970-1999. Error correction model showed a bidirectional Granger causality between electricity consumption and GDP and unidirectional Granger causality between electricity consumption and GDP and an unidirectional Granger causality nonagricultural GDP and electricity consumption.

[26] used panel cointegration and panel-based error correction models to find the causality between the energy consumption of 18 developing countries in period of 1975-2001. The results showed long-term and short-term causalities running from energy consumption and economic growth. It implied that energy conservation policies could damage the economic growth of most of inspected

developing countries.

[27] issues the relationship between energy use and GDP in Taiwan region in the period of 1954-2003. Scholars found that different directions of causality exist between GDP and various kinds of energy consumption. The empirical result shows unanimously that in the long run energy acts as an engine for economic growth, and that energy conservation may harm economic growth.

In case of Turkey, [28] got problems with data providing from the 1970 period, what can be reason of the problems in analyzing part of their work. Therefore, they used different approaches to check causality: the Dolado-Lutkepohl test using the VARs in levels and the Granger causality method for de-trended data. As a result, they obtained unidirectional causality running from electricity consumption to GDP which indicated the importance of electricity supply to contribute to the economic growth in Turkey in the period of 1950-2000.

[29] analyzed the causality between energy consumption and GDP in 19 African countries within the period of 1971-2001. He obtained causal relationships only for 12 countries and long-term connections for 8 countries.

In the case of Bangladesh, the causal connections between the electricity consumption per capita and the GDP per capita were studied by [30], who applied cointegration and VECM approaches, and found unidirectional causality running from GDP per capita to electricity consumption per capita what means necessity of employment of energy conservation policies to sustain economic growth in Bangladesh.

The analysis for the causal relationship between energy consumption per capita and GDP per capita for 11 OPEC countries was researched by [31]. The results obtained the unidirectional and strong causality from GDP to energy consumption for OPEC countries. The governments of most of these countries make the domestic price lower than market price resulting in an increase in energy consumption. Thus, the government's policies on conservation do not harm to the economic growth of these countries.

[32] examined the causal linkage between energy consumption and agricultural and nonagricultural outputs in Tunisia in period of 1971-2003. In their study, they used ADF and PSS [33], Johansen cointegration test and VECM. The findings showed there is only a unidirectional causality running from agricultural and non-agricultural sectors to energy consumption, which implies that sectoral growth leads to increases in energy consumption.

[34] investigated a relationship between energy consumption and economic development based on the VAR model using temporal series of China from 1990 to 2009, then used impulse response function and variance decomposition to portray the correlations between economic growth and energy consumption. The result shows that there exists a unidirectional causality from energy consumption to gross domestic product and energy consumption can observably promote the development of economy.

[35] examined a relationship between the electric power consumption of 3

major industries of the whole society and GDP growth in Hainan Island from 1988 to 2009. And they discovered some causalities between them. Only the secondary industry's GDP and the electric power consumption aren't in the same order integration, there doesn't exist co-integration relationship between them. It isn't clear that the electric power consumption in the secondary industry influences the GDP growth in Hainan Island.

[9] examined the long-run relationship between energy consumption and real GDP, including energy prices, for 25 OECD countries from 1981 to 2007. The results suggest that energy consumption is price-inelastic. Causality tests indicate the presence of a bi-directional causal relationship between energy consumption and economic growth.

2.2. Absence of a (Unidirectional, Bidirectional) Causal Relationship

This part described several cases with no causality between energy consumption and economic growth. Researches about no causality between GNP and different kinds of energy consumption have been issued European countries such as United Kingdom, Germany, Italy, Canada, France as well as by Japan.

[36] discovered no causal linkages for the USA, UK and Poland. But in case of South Korea, they found causality running from GDP to energy consumption and causality for Philippine running from energy consumption to GDP.

Several developed countries were observed by [37] in the period of 1950-1982 and causality between energy and output was obtained, but within the years of 1950-1973 no casual connection was found. By using monthly data, [38] checked the cointegration between energy and GDP and found no long-term connection among them.

[20] investigated the relationships between coal consumption and economic growth of the six biggest coal consumption countries using a common source of data from 2000 through 2010. Then 6 main coal consumption countries are chosen as China, the United States of America, India, Germany, Russia and Japan. The tests show that there are no causal relationships between coal consumption and economic growth in USA and India. These coincident results with previous research further indicate that each country should form their own coal consuming policies according to their own situations.

Using the multivariate approach instead of bivariate was started by [39]. Energy, GDP, capital and labor were used to check the Granger causality between energy and GDP in the post-war United States. Scholars applied a multivariate vector autoregressive analysis and also used weighing measure of energy (by changing low quality-coal to high-quality electricity instead of using the total energy itself). Using the total energy with various causality tests no Granger causality was found but with weighting the Granger causality existed.

After applying the bivariate model no relationship between energy use and income way) in the United States was discovered by [40]. The same result of no relationship occurred by employing the multivariate model.

2.3. Energy and Economic Growth

The direct influence of energy in economic growth still remains an interesting question among researchers. As all economic sectors like industrial, mining, transportation, agro-industrial, residential, commercial and public activities increase, the demand for energy similarly increases.

From an economic point of view, the relationship between energy consumption and economic growth lies in two aspects: the growing dependence of economic growth on energy, and on the other hand, economic growth can promote energy technology advances and large-scale development and utilization of energy. There are different views among economists on the role of energy in the economy.

By reviewing the relationship between consumptions of various energy supply and economic growth it is necessary to explain the causality between them. For this reason, the theoretical literature of neoclassical and of ecological economic world views is examined.

2.4. Neo-Classical Views of Economic Growth

The basic growth model which examines the hypothetical economy is the growth model [41]. In this model, Solow focuses on three variables output (Y), capital (K) and labor (L). The production is $Y = f(K, L)$ which does not include resources at all. Economic growth is achieved by increasing inputs of labor or human capital.

On the other hand, the only cause of continuing economic growth is technological progress. When the level of technological knowledge accumulates the functional relationship between productive inputs and output changes, same quantity and quality of inputs can produce greater quantities and better qualities of output. Intuitively, increases in the state of technological knowledge raise the rate of return to capital, thereby offsetting the diminishing returns to capital that would otherwise apply a brake to growth [42].

However, the Solow model just described does not explain how improvements in technology come about and it treats technological progress as an exogenous variable. In endogenous growth models, the relationship between capital and output can be written in the form $Y = AK$. Where the level of technology that is a positive constant (A) and Capital (K), is defined more broadly than in the neoclassical model. According to endogenous growth models, technological knowledge is thought as a form of capital, where it accumulated through research and development and other knowledge creating processes. The technological knowledge through investment in capital exactly offsets the diminishing returns to manufactured capital and the economy can sustain a constant growth rate [42].

In these models, the contribution of energy to economic activity is only considered relative to its cost within production. Therefore, the model considers energy to be an "intermediate good" rather than a "primary input" into the production process. It argues that there are some mechanisms by which economic growth could remain in spite of limited sources of energy resources. Thus, the government can adopt energy conservation policies without having any harmful effect on economic growth [43].

2.5. Ecological Views of Economic Growth

Ecological economic theory on the contrary states that energy consumption is a limiting factor to economic growth, especially in modern economies. Ecological economists judge that technological progress and other physical inputs could not possibly substitute the vital role of energy in the production process. Most importantly, the ecological economists' worldview attempts to account for the laws of thermodynamics. The first law of thermodynamics, the conservation law, implies that the mass of inputs and output must be equal in the production process.

Therefore, there are minimal material input requirements for any production process producing material outputs. The second law of thermodynamics, the efficiency law, implies that a minimum quantity of energy is required to carry out the transformation or movement of matter. All production involves the transformation or movement of matter in some way and all such transformations require energy, and there must be limits to substitution of others factors of production for energy so that energy is also an essential factor of production [42].

This perspective is the so-called "growth hypothesis" and advises that any shock to energy supply will strongly have a negative impact on economic growth. As a result, they are against energy conservation policies.

Without using energy, it is impossible to operate a factory, grow crops, travel, or deliver goods from producers to consumers. Economic growth almost always leads to increased energy use, at least in the early stages of economic development. Energy is included in the production function via empirical analysis conducted by [44].

This study demonstrates the importance of energy in driving economic growth applied to several developing countries between 1981 and 2000 [44]. This function is described as follows:

$$Y_t = A_t * (K_t)^{\alpha} (L_t)^{1-\beta} (E_t)^{1-\alpha-\beta} \tag{1}$$

where,

Y_t: Output;

A_t: Economy's total factor productivity;

K_t: Stock of capital;

E_t: Energy use;

L_t: Labour.

3. Methodology

This chapter will describe the methodology used in order to find causality between economic growth and energy consumptions in Mongolia, using the unit root test, co-integration test, VECM and Granger causality test.

According to [45], a linear combination of two or more non-stationary series, which have the same order of integration, may be stationary. If such a stationary linear combination exists, the series are considered to be cointegrated and long-run equilibrium relationships exist.

In regards to causality testing, we must check at first hand the stationary of variables to decide whether we can apply the standard Granger causality test or not. If the data sets prove to be stationary, then we can apply the standard vector autoregressive (VAR) Granger causality test, but if they prove to be non-stationary, we work with the first differences. This step is to convert the non-stationary variables to stationary data.

Next, we can check whether the variables are cointegrated. If it is shown that the variables have a cointegrating equation, then the Granger causality test based on the vector error correction models (VECM) is used to check the causality between variables.

On the other hand, if they are not cointegrated, we examine also the interrelation between them using a VAR framework in the first differences. **Figure 1** describes the process of causality testing we use to analyze the relationship between energy consumption and economic growth in Mongolia.

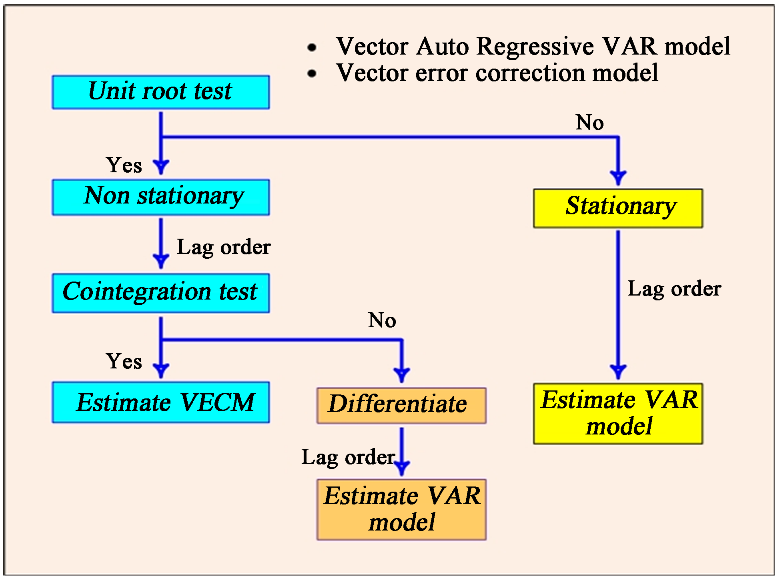

Figure 1. Causality testing steps.

3.1. Data

In our empirical study on cointegration and causality between Mongolia's 2 different energy consumptions and Gross domestic product, we used the time series data of GDP, primary energy, electricity consumptions for the period from 1981 to 2016 of Mongolia. Data set for real Gross domestic product was obtained from the [5]. Data for net energy sector was obtained from [5]. In this paper electricity consumption is expressed in terms of billion kWh, primary energy consumption is expressed in million Btu person and GDP is expressed in constant 2010 US$.

Empirical analysis has been done by using STATA 12.0 statistical package. The choice of the starting period was constrained by the availability of data electricity consumption. The historical trends of GDP and energy consumptions of Mongolia are represented in **Figures 2-4** respectively.

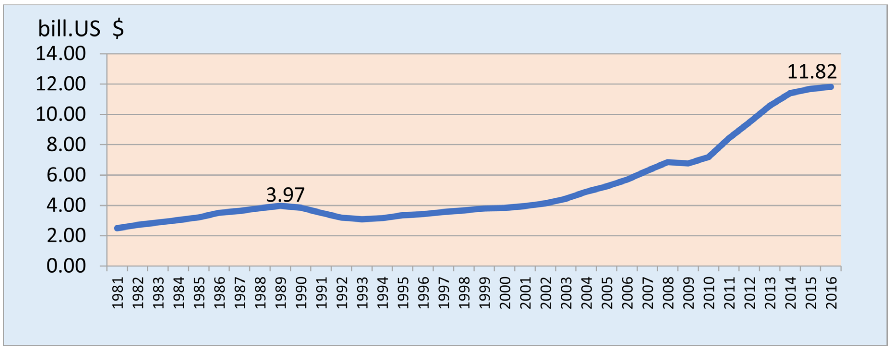

Figure 2. The historical trend of GDP in Mongolia.

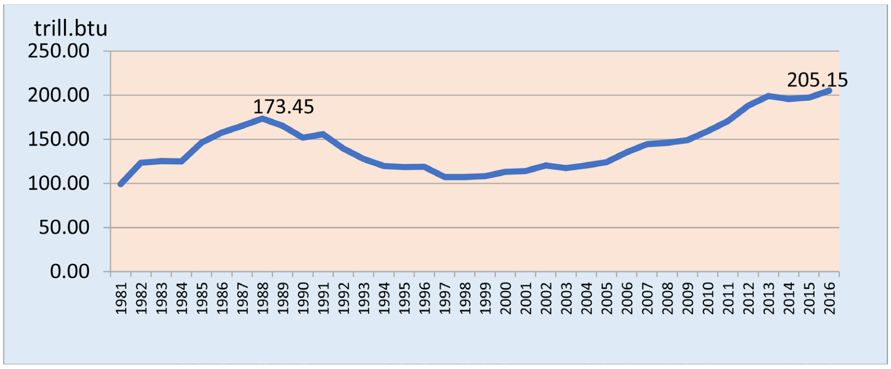

Figure 3. The historical trend of Primary energy consumption in Mongolia.

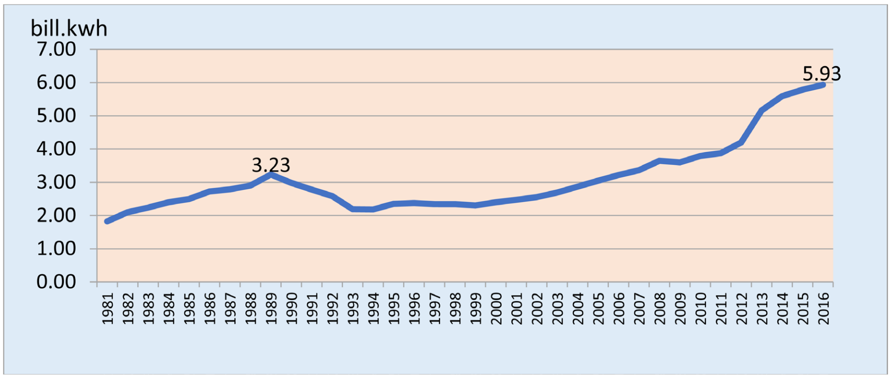

Figure 4. The historical trend of electricity consumption in Mongolia.

Before starting to the analysis, we convert variables of GDP, energy consumption into their natural logarithm for to reduce heteroscedasticity while the second is that the logarithm variables have its economic meaning because they are approximated to be viewed as the growth of the respective differenced variables.

3.2. Stationarity and Integration

Before the 1970s, the models of econometrics were basically built on the assumption of stationary of time series; however, this assumption is obviously too simplistic. But later on [46], identified that most macro-economic time series are non-stationary therefore coefficients may have different distributions, which may result in non reliable regression.

Stationary requires the Mean, Variance and Auto-covariance of a series to be stationary. A series x_t is said to be stationary, if it has a constant mean $E(x_t)$, and its variance $\mathrm{Var}(x_t)$ does not appear to systematically change over time. In this case, it will tend to fluctuate around the mean $E(x_t)$ steadily.

Whereas, a series x_t is said to be non-stationary if it has non-constant mean $E(x_t)$, and variance $\mathrm{Var}(x_t)$ appears to be systematically changed over time. If the difference of a nonstationary series is stationary, the series is said to be integrated, *i.e.* $I(1)$. If a nonstationary series has to be differenced d times to become stationary, then it is said to be integrated of d order: *i.e.* $I(d)$. Only when two series are integrated of the same order, can it be proceeded to test for the presence of cointegration.

Early in 1976, Dickey and Fuller developed the DF method to test the stationarity of time series. In 1979-1980, they improved the DF method to ADF [47]. Because actual series are usually not first-order autoregression series, the augmented Dickey-Fuller (ADF) test is broadly applied to examine the unit root and stationarity of series here.

Firstly, set up the regression equation:

$$\Delta X_t = (\rho - 1) X_{t-1} + \sum_{j=1}^{p} \lambda_j \Delta X_{t-j} + \varepsilon_t \quad (2)$$

where: ε_t is the residual (the same as follows).

Then test the null hypothesis $H0$: $\rho = 1$ that x_t is nonstationary, against $H1$: <1, that x_t is stationary.

3.3. Co-Integration Test

Co-integration - feature several non-stationary (integrated) time series is the existence of a stationary linear combination. The concept of co-integration was first proposed by Granger in 1981. Later this trend developed Engle, Johansen, Phillips and others.

Co-integration is an important feature of many economic variables, which means that, despite the occasional (slightly predictable) behavior of the individual economic variables, there is a long-run relationship between them, which leads to some joint inter-related changes. Actually, it is the correction model (correction) of errors (ECM - Error Correction Model), when the short-term movements are adjusted according to the degree of deviation from the long-term dependence. Such behavior is co-integrated time series. Another method is one presented by [45]. They propose co-integration as non-stationary series, integrated in the same procedure, and linear combination between them may be observed which is stationary. This method includes two steps and means if two series x_t and y_t, are tested to be non-stationary, but both of them are integrated of the same order, the regression equation can be set up as:

$$x_t = \alpha + \beta y_t + \varepsilon_t \tag{3}$$

As authors said the co-integration between x_t and y_t can thereby be tested by examining the stationarity of the residual ε_t. And if x_t and y_t are not co-integrated, all of their linear combinations will be non-stationary, consequently the residual ε_t will be also non-stationary. From the other side, if the ε_t is tested to be stationary, then the co-integration between x_t and y_t can be justified.

3.4. Vector Auto-Regressions (VARs)

Vector auto-regression (VAR) is a dynamics model of multiple time series, in which the current value of the series depends on the past values of a time series. The model proposed by [48] as an alternative system of simultaneous equations involves substantial theoretical limitations. VAR-models are free from the limitations of structural models. However, the problem of VAR-models is a sharp increase in the number of parameters while increasing the number of analyzed time series and the number of lags.

The vector auto-regression is used to analyze the dynamic impact of random disturbances on the system of variables and to predict systems of interrelated time series. This is because VAR approach sidesteps the need for structural modeling by treating endogenous variable in the system as a function of the lagged values of all of the endogenous variables in the system.

Actually VAR, a system of econometric equations, each of which is a model and autoregressive distributed lag (ADL).

The mathematical representation of a VAR is (3) where y_t is a k vector of endogenous variables, x_t is a d vector of exogenous $A_1 \ldots A_p$ variables, and B are matrices of coefficients to be estimated, and is a ε_t vector of innovations.

Since only lagged values of the endogenous variables appear on the right-hand side of the equations, simultaneity is not an issue and OLS yields consistent estimates. Moreover, even though the innovations may be contemporaneously correlated, OLS is efficient and equivalent to GLS since all equations have identical regressors.

Real VAR models have longer lags and more variables. However, compared with the structural models VAR models have fewer options and less stringent restrictions on their values, which makes the VAR model extremely useful when faced with difficulties when collecting baseline information.

For example, suppose that industrial production (IP) and money supply (M1) are jointly determined by a VAR and let a constant be the only exogenous variable. Assuming that the VAR contains two lagged values of the endogenous variables, it may be written as

$$IP_t = a_{11} IP_{t-1} + a_{12} M1_{t-1} + b_{11} IP_{t-2} + b_{12} M1_{t-2} + c_1 + \varepsilon_1 \tag{4}$$

$$M1_t = a_{21}IP_{t-1} + a_{22}M1_{t-1} + b_{21}IP_{t-2} + b_{22}M1_{t-2} + c_1 + \varepsilon_{2t} \quad (5)$$

where a_{ij}, b_{ij}, c_i are the parameters to be estimated.

3.5. Vector Error Correction Model

A Vector Error Correction Model (VECM) can lead to a better understanding of the nature of any non-stationarity among the different component series and can also improve longer term forecasting over an unconstrained model.

Consider a bi-variation vector of integrated order one, and assume that is Y_t cointegrated with cointegrating vector $\beta = (1, -\beta_2)'$ so that $\beta' Y_t = y_{1t} - \beta_2 y_{2t}$ is stationary.

According to [45], cointegration implies the existence of an Error Correction Model (ECM) of the following equation:

$$\Delta y_{1t} = c_1 + \alpha_1 \left(y_{1,t-1} - \beta_2 y_{2,t-1} \right) + \sum_j \gamma_{11}^j \Delta y_{1,t-j} + \sum_j \gamma_{12}^j \Delta y_{2,t-1} + \varepsilon_{1t} \quad (6)$$

$$\Delta y_{2t} = c_2 + \alpha_2 \left(y_{1,t-1} - \beta_2 y_{2,t-1} \right) + \sum_j \gamma_{21}^j \Delta y_{1,t-j} + \sum_j \gamma_{22}^j \Delta y_{2,t-1} + \varepsilon_{2t} \quad (7)$$

The error correction term (ECT, α_2) denotes the long-run equilibrium with the short-run adjustment mechanism that demonstrates how the variables react when they deviate from the equilibrium. Unlike causality analysis using the VAR model which presents only one causal path, the causality analysis using VECM can present three different paths. The first one is "short-run causality tests" the statistical significance on the two types of hypotheses like in the VAR case (test on γ_{12}^j and γ_{22}^j for above equations), the second one is "long-run causality tests" the hypothesis of both short-run and long-run causality (and for above equations) [49].

3.6. Granger Causality Test

In our study, the Granger Causality test was adopted to examine the causality between two series according to [45]. When the past information is collected to forecast variable y_t, we can use only the past information of both x_t and y_t. According to the Granger Causality test, there is causality from x_t to y_t if the past information of x_t can help us to forecast y_t more precisely.

When applying to the Granger Causality test, we first set up the bivariable autoregression model:

$$y_t = \alpha_0 + \sum_{i=1}^{m} \alpha_i y_{t-1} + \sum_{i=1}^{m} \beta_i x_{t-1} + \varepsilon_t \quad (8)$$

$$x_t = \alpha_0 + \sum_{i=1}^{m} \alpha_j x_{t-j} + \sum_{i=1}^{m} \beta_j y_{t-j} + \varepsilon_t \quad (9)$$

Then the F test is carried out to test the null hypothesis H_0: $\beta_i \left(i = 1, 2, \cdots, m \right) = 0$, which is equal to the hypothesis that "x_t has no Granger Causality to y_t". If H_0: $\beta_i \left(i = 1, 2, \cdots, m \right) = 0$, is rejected, then we can also reject the hypothesis "x_t has no Granger Causality to y_t", and thereby conclude that x_t has no Granger causality to y_t. Similarly, the hypothesis H_0: $\beta_j \left(j = 1, 2, \cdots, m \right) = 0$, can be tested to verify whether there is Granger causality from y_t to x_t.

4. Empirical Analysis

In this empirical study on the cointegration and causality between Mongolia's consumption of its two major forms of energy and economic indicators, the time series data of the real GDP and of the consumption of different forms of energy (*i.e.*, primary energy, and electricity) for the period 1981-2016 in Mongolia were used. Before starting the analysis, GDP and electricity consumption were converted into natural logarithms to reduce the heteroscedasticity. Also, the logarithm variables had an economic meaning because they were approximated to represent the growth of the different variables.

4.1. Unit Root Test

Data were obtained from [4] [5]. Moreover, despite the fact that Mongolia's energy industry and industrialization started earlier than those of the USSR, there are insufficient data on such for analysis in this study. In addition, at that time, Mongolia did not have a market economy but a centrally planned economy.

A necessary but insufficient condition for cointegration is that each of the variables should be integrated into the same order (more than zero), or that both series should contain a deterministic trend [50]. To determine if this preliminary condition was fulfilled, times series data on the consumption of electricity, oil, and primary energy and on the GDP of Mongolia were tested for a unit root via various testing procedures, as required by the augmented Dickey-Fuller (ADF) and Phillips Perron tests [47] [51].

Table 2 reports the results of the ADF tests on the integration properties of GDP and of the consumption of different forms of energy (*i.e.*, primary energy, oil, and electricity) for Mongolia. The results of both tests indicate that the four series are non-stationary in their levels and first differences but become stationary in their second differences, or unit roots are discovered.

This indicates that the GDP, Electricity, and Primary Energy variables are individually integrated into order 2 or I (2).

4.2. Cointegration Test

To find a long-term co-integrating relationship between the consumption of different forms of energy and GDP, the Johansen test was adopted in this paper. **Figure 5** & **Figure 6** show the results of the lag selection process, which is required for the next cointegration test.

The cointegration rank r of the time series was tested using two test statistics. The trace test was calculated under H_0: $r_0 \leq r$ and against H_1: $r_0 > r$. By indicating the number of cointegrating vectors as r0, the maximum eigenvalue (λ_{max}) test was calculated under the null hypothesis H_0: $r_0 = r$ and against the alternative hypothesis H_1: $r_0 > r$. **Figure 7** & **Figure 8** show the results of the Johansen maximum likelihood cointegration tests. It was determined that there is a cointegration between the consumption of different forms of energy and GDP.

Table 3 shows the combined results of the trace tests for three links. As a result of the trace test, it can be seen that the null hypothesis of "no cointegration" was also rejected at the 1% significance level because its trace statistic equaled 16.7155,

Table 2. Unit root test. (Energy consumptions and GDP).

Variables		Model	Test statistics	Critical value		
				1%	5%	10%
GDP	Level	ADF	1.571	−3.682	−2.972	−2.688
		PP	0.804	−3.682	−2.972	−2.618
	1st difference	ADF	−2.441	−3.689	−2.975	−2.619
		PP	−2.522	−3.689	−2.975	−2.619
	2nd difference	ADF	−5.187***	−3.696	−2.978	−2.620
		PP	−5.167***	−3.696	−2.978	−2.620
Electricity	Level	ADF	0.534	−3.682	−2.972	−2.618
		PP	−0.046	−3.682	−2.972	−2.6218
	1st difference	ADF	−3.737**	−3.689	−2.975	−2.619
		PP	−3.775**	−3.689	−2.975	−2.6219
	2nd difference	ADF	−7.540***	−3.696	−2.978	−2.620
		PP	−8.089***	−3.696	−2.978	−2.620
Primary energy	Level	ADF	−0.824	−3.682	−2.972	−2.618
		PP	−1.290	−3.682	−2.972	−2.618
	1st difference	ADF	−4.824***	−3.689	−2.975	−2.619
		PP	−4.834***	−3.689	−2.975	−2.619
	2nd difference	ADF	−8.449***	−3.696	−2.978	−2.620
		PP	−10.462***	−3.696	−2.978	−2.620

**, ***Indicates rejection of null hypothesis at the 10%, 5%, 1% level.

```
. varsoc elc gdpconstant2010

   Selection-order criteria
   Sample:  1985 - 2016                         Number of obs      =        32

  lag |    LL       LR      df    p      FPE       AIC       HQIC      SBIC
  ----+---------------------------------------------------------------------
    0 |  15.2781                       .001495  -.829878  -.799513   -.73827
    1 |  111.125  191.69     4  0.000  4.8e-06  -6.57031  -6.47921  -6.29548
    2 |  119.403  16.555     4  0.002  3.7e-06  -6.83766  -6.68583  -6.37962
    3 |   127.22  15.636*    4  0.004  2.9e-06* -7.07628* -6.86372* -6.43502*
    4 |  128.347  2.2537     4  0.689  3.6e-06  -6.89671  -6.62342  -6.07223

   Endogenous:  elc gdpconstant2010
    Exogenous:  _cons
```

* indicates lag order selected by the criterion

Figure 5. Lag selection result for cointegration test of electricity consumption.

```
. varsoc penc gdpconstant2010

   Selection-order criteria
   Sample:  1985 - 2016                          Number of obs      =        32

  +---------------------------------------------------------------------------+
  |lag |    LL      LR      df    p      FPE       AIC       HQIC      SBIC    |
  |----+----------------------------------------------------------------------|
  |  0 |  -.998908                     .004135   .187432   .217797    .27904   |
  |  1 |   101.86  205.72    4  0.000  8.6e-06  -5.99125  -5.90015  -5.71642   |
  |  2 |  113.439  23.159*   4  0.000  5.4e-06  -6.46496  -6.31314* -6.00692*  |
  |  3 |   117.69  8.5011    4  0.075  5.3e-06* -6.48062* -6.26806  -5.83936   |
  |  4 |  121.172  6.9649    4  0.138  5.6e-06  -6.44828  -6.17499   -5.6238   |
  +---------------------------------------------------------------------------+

   Endogenous:  penc gdpconstant2010
    Exogenous:  _cons
```

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
AIC: Akaike information criterion
HQ: Hannan-Quinn information criterion
FPE: Final prediction error
SBIC: Schwarz' Bayesian Information

Figure 6. Lag selection result for cointegration test of Primary energy consumption.

```
. vecrank elc gdpconstant2010, trend(none) lags(3) max levela

                       Johansen tests for cointegration
Trend: none                                              Number of obs =      33
Sample:  1984 - 2016                                              Lags =       3
-------------------------------------------------------------------------------
maximum                                      trace    5% critical  1% critical
  rank    parms       LL       eigenvalue  statistic      value        value
    0       8      121.92893                16.7155      12.53        16.31
    1      11      128.88627     0.34404     2.8008*1*5    3.84         6.51
    2      12      130.28668     0.08137
-------------------------------------------------------------------------------
maximum                                       max     5% critical  1% critical
  rank    parms       LL       eigenvalue  statistic      value        value
    0       8      121.92893                13.9147      11.44        15.69
    1      11      128.88627     0.34404     2.8008       3.84         6.51
    2      12      130.28668     0.08137
```

Figure 7. Cointegration test of electricity with GDP.

```
. vecrank penc gdpconstant2010, trend(trend) lags(3) max levela

                       Johansen tests for cointegration
Trend: trend                                             Number of obs =      33
Sample:  1984 - 2016                                              Lags =       3
-------------------------------------------------------------------------------
maximum                                      trace    5% critical  1% critical
  rank    parms       LL       eigenvalue  statistic      value        value
    0      12      120.44632                18.6056*1    18.17        23.46
    1      15      127.92038     0.36427     3.6575*5     3.74         6.40
    2      16      129.74912     0.10491
-------------------------------------------------------------------------------
maximum                                       max     5% critical  1% critical
  rank    parms       LL       eigenvalue  statistic      value        value
    0      12      120.44632                14.9481      16.87        21.47
    1      15      127.92038     0.36427     3.6575       3.74         6.40
    2      16      129.74912     0.10491
```

Figure 8. Cointegration test of Primary energy with GDP.

which is greater than the 1% critical value of 16.31 for electricity and GDP.

For the maximum eigenvalue test, the null hypothesis of "no cointegration equation" was rejected at the 5% significance level because the maximal eigenvalue

Table 3. Combined cointegration test results of 2 variables.

Variables	Trace statistic	5% critical value	1% critical value	Lags
Electricity - GDP	16.7155	12.53	16.31	3
Primary energy - GDP	18.6056	18.17	23.46	3

statistic was 13.9147, which is greater than the critical value of 11.44.

In the case of Primary energy consumption and GDP, as with the previous H0 hypothesis, such hypothesis was rejected at the 5% significance level. Therefore, it can be concluded that both the Primary energy consumption and GDP series have one co-integrating equation; in other words, there must be a long-term relationship between the two.

4.3. Granger Causality Test

The cointegration test can show the existence only of a long-term causality. To find another study perspective, the Granger causality test was used because the above cointegration that was found does not reveal any information about the direction of causality or the short-term perspective results. To identify all these, there is a need to use VECM-(vector error correction model)-based causality tests.

Table 4. Granger causality test result from VECM model (Energy consumptions and GDP).

№	Null hypothesis	Short term		Long term
		Chi^2	Prob > Chi^2	Prob > z
1.	GDP does not cause Electricity	20.97	0.000***	0.187
	Electricity does not cause GDP	0.09	0.9563	0.038**
2.	GDP does not cause Primary Energy	2.43	0.2969***	0.000***
	Primary Energy does not cause GDP	5.02	0.0813	0.986***

*, **, ***Indicates rejection of null hypothesis at the 10%, 5%, 1% level.

According to Table 4, in the case of electricity consumption and GDP, the causality running from electricity consumption to GDP is less than 5% (0.038); as such, there is a long-term causality between electricity consumption and GDP. Adversely, there is no long-term causality that runs from GDP to electricity consumption. Also, the causality running from GDP to electricity consumption is less than 1% (0.000); as such, there is a short-term causality between GDP and electricity consumption. Conversely, there is no causality running from electricity consumption to GDP, which proves that electricity consumption and GDP have a unidirectional causality in the long term, as in the short term.

In the case of primary energy consumption and GDP, the causality running from GDP to primary energy consumption is less than 1% (0.0000); as such, there is a long-term causality between GDP and primary energy consumption. Also, no long-term causality that runs from Primary Energy consumption to GDP which proves that primary energy consumption and GDP have a unidirectional causality in the long term. Additionally, in the short term, there is no causality running from GDP to primary energy consumption. But, the causality running from Primary energy consumption to GDP is less than 5% (0.0813); as such, there is a short-term unidirectional causality between Primary energy consumption and GDP.

In other words, two unidirectional causalities were indicated in the short term as well as in the long term, running from GDP to energy consumption in Mongolia's main energy nexuses.

5. Conclusions and Policy Implication

Our study examined the causal relationship between different energy consumptions and economic indicator of Mongolia during the period of 1985-2016 through several empirical steps. While testing the relationship we used several methods such as co-integration, Vector error correction model, Granger causality and unit root tests. We started by performing augmented Dickey-Fuller (ADF) and Phillips-Perron tests [48] [51] to check the data to be used in the research for stationary. The test results showed that times series of energy consumptions such as electricity, primary energy and GDP for Mongolia have unit root at their levels and first differences, but become stationary at their second differences, namely I (2).

Then with the application of Johansen cointegration test, we found out that the variables are cointegrated in the long-run. Finally, we used the vector error correction model for Granger causality test and F-test to find out the causality direction and joint significance of the energy consumptions and GDP for Mongolia.

As a result of our model, we indicated a couple of long-run and short-term causal relationships between different energy consumptions and GDP. Understanding the nature of the relationship between energy consumption and economic growth is a key issue that both energy and environmental policy makers have to take into consideration to develop effective policies.

Energy is deeply involved in each economic activity consequently, the results have important policy implications and which can help solve the question as to what extent can economic growth be sustained under various energy availability scenarios.

At first, model determined long-run unidirectional causality from electricity to GDP, long-run unidirectional causality from GDP to primary energy. Furthermore, short-run unidirectional causalities are discovered from GDP to electricity consumption, from Primary energy consumption to GDP; therefore, in case of causality relationship between electricity consumptions and GDP of Mongolia supports "growth hypothesis" in long term.

Accordingly, in case of causality relationship between primary energy consumption and GDP of Mongolia, it supports "neutrality hypothesis" in long-term.

The growth hypothesis suggests that electricity consumption plays an important role in economic growth both directly and indirectly in the production process as a complement to labor and capital. Consequently, we may conclude that Mongolia has an electrical energy dependent economy and more electrical energy is required to encourage economic development. This also implies that the increase of electricity consumption affects positively the economic growth and electricity conservation policies can negatively affect the economic growth so then electrical energy efficiency policies are possible to implement. Also various special programs and policies for the encouragement of efficiency improvement by industries and residential consumers can be implemented.

The initial idea of this study was to investigate the causal relationship between energy use and economic indicator of Mongolia from centrally planned economic period time until present.

Moreover, further comparative or multivariate analysis can be conducted on breakdown level at energy consumption of any specific sectors of Mongolia and as well as the multi-country level, such as energy resources abundant countries.

When energy consumption leads to economic growth in the long term prospective, like our case of electricity, that Mongolia has a electricity driving economy, and more electrical energy is required to encourage economic development. That means, electricity consumption directly affects economic growth and increasing electricity consumption increases economic growth.

The applications of strong energy conservation policies especially in terms of electricity can totally negatively affect the economic growth but energy and electricity efficiency policies are possible to implement. Additionally, the following implications can be revealed from the result:

1) From sustainability point of view in the long run, the growth and development in Mongolia, policy intervention is required to change its economic structure towards a more efficiency-oriented and less resource-depleting one. Also increasing investment in energy technology and research, same time accelerating the transformation of economic structure to the energy intensive mood to further ensure Mongolia's sustainable economic development.

2) Developing capacities with distributed generation based on smart grid system using clean technology can guarantee energy security for the Mongolia, and environmental protection in the region. Moreover, diversification and optimizing of Mongolia's energy supply structure and developing renewable recourses or other clean energies. The country has huge potential of going renewable and certainly the use of renewable energy will play an important role in the future.

3) Conducting energy efficiency policy in all sector, specially power sector industries, mines, communal apartments, households, transportation vehicles, services etc. Actually, the major energy consumer is the sector of industries, communal apartments, buildings and power plants, which was mainly built during the Soviet Union period still apply the costly, outdated technology. There is a significant potential to save energy through employing the energy efficiency policy in this case. This would mean upgrading existing equipment to new energy saving technology, simultaneously increasing efficiency and as well as decreasing all type

of loss. Also improvement of the overall efficiency of energy utilization likewise seasonal efficiency on individual residents and energy consumers. Consequently, low efficiency and high internal use, high T&D loss are the supposedly one of the limiting factors on the economic growth of Mongolia as energy consumption causes economic growth.

4) Economic growth causes expansion in the industry sector which is the most energy-intensive main economic sector. Production in industries such as manufacturing, construction and transportation as well as residential demands a huge amount of energy [52] [53]. This view is supported by recent economic growth in Mongolia which has led to tremendous change in the industry, construction and service sector. With economic growth people's incomes have grown higher, and consequently households have been using higher energy consuming goods and services so then these circumstances stimulate further energy consumption. One possible explanation of the results obtained is that, in the short-run, an increase in GDP leads to expansion of the industrial and commercial sectors, which require energy as a basic input into the production process. Also, higher disposable income increases demand for electronic gadgets for entertainment and comfort for households, likewise for services [54].

5) Continuous implementation of the subsidization policy on the electricity use for the population, industrial and commercial consumers. As well as regarding the electricity consumption, to promote economic growth, the policy should be focused on price level of the electric energy or, directly, on its demand side. In this case, low price level or high demand can promote economic growth [55]. The expansion of industrial and commercial sectors where electricity has been used as basic energy input because of its clean and efficient nature stimulates economic growth. The share of GDP by industrial sector and services sector are the highest and, they consume maximum electricity as compared to others category of consumers. The household sectors use the electricity at the cheapest form of energy. This helps in to add to their financial savings. Since, the household sectors are the major contributor of the total saving of the Mongolian economy; these savings are used to finance capital formation which leads to higher economic growth.

6) Practically, Mongolia reformed its power electric market and legislation but some problems in implementation of the market rules, competitive possibilities, functions and types of energy companies remain unresolved. Therefore, there needs further changes of legislation and regulation as well technical feasibility which is well suited in specific nature of Mongolian power electric system with good fitted to market economy and to meet future energy demand. The legacy of centrally planning economy where artificially inappropriate energy prices encouraged wasteful use of electricity together with inefficient infrastructure, has burdened the transition countries with a weak starting point on the path to sustainable energy. Still in some of these countries, the legacy of central planning economy, with its absence of market signals, reliance on energy intensive industry is still persisting [56].

7) In economic sense, all services, products and goods in a Mongolia are produced (directly or indirectly) with the use of coal and electricity, an increase in GDP (or income) will be associated with an increase in coal consumption, electricity consumption. Our income elasticity estimates support such a relationship. This positive causal relationship does not require a strong and prosperous coal intensive sector in Mongolia. Because economic growth leads to higher coal consumption, if the Mongolian economy keeps growing at a high rate in the future, GHG emissions will follow and the policy makers will continue to face the economic growth-emissions dilemma. As coal is the main contributor to GHG emissions in Mongolia, cutting the consumption of coal seems to be an effective way to curb GHG emissions. On the other hand, the reduction in coal consumption may hinder economic growth. Additionally, adoption of more advanced carbon capture technologies, modern primary energy transformation, transmission technologies, as well revitalization of existing equipment and which may lead to a rise in the cost of coal usage and ultimately a decrease in the attractiveness of the resource. However, the gradual diversification of energy sources may actually be able to enhance energy supply and security in the long-run.

8) In terms of Primary energy consumption of Mongolia supports "neutrality hypothesis" in long term. In other words, energy is assumed to be neutral to growth. If this is not a case, conservative or expansive policies on energy consumption could adversely affect economic growth. Supporters of this view emphasize the role of substitution and technological progress. According to [57], the main reason for the neutral impact of energy on economic growth is that the cost of energy is negligible. It has also been argued that the possible impact of energy consumption on growth will depend on the structure of the economy and the level of economic growth of the country concerned. As the economy grows, its production structure is likely to shift towards service sectors, which are not much dependent on energy [58] and [59].

9) Constructing a smart and secure, unified power electric system and electric grids connected by transmission line capable of providing back-up supply between adjacent grids under conditions of first contingency supply loss. In order to ensure sustainable economic growth, a sufficient amount of energy supply must be ensured. Renew urgently the critical heat and power infrastructure and investment for expansion and modernization of the electricity facilities in central energy system and heating facilities in Ulaanbaatar, where 90% of heat and electricity produced in Mongolia is the top priority to sustain people's life and economic activities, and to reduce urban air pollution in Ulaanbaatar. The formulate and implement energy policy that will take care of energy security also to encourage to create new energy sources are the challenging task for policy makers [60].

Conflicts of Interest

The authors declare no conflicts of interest.

References

[1] Jumbe, C.B.L. (2004) Cointegration and Causality between Electricity Consumption and GDP: Empirical Evidence from Malawi. *Energy Economics*, **26**, 61-68. https://doi.org/10.1016/s0140-9883(03)00058-6

[2] Stern, D.I. (2000) A Multivariate Cointegration Analysis of the Role of Energy in the US Macroeconomy. *Energy Economics*, **22**, 267-283. https://doi.org/10.1016/s0140-9883(99)00028-6

[3] Masih, A.M.M. and Masih, R. (1996) Energy Consumption, Real Income and Temporal Causality: Results from a Multi-Country Study Based on Cointegration and Error-Correction Modelling Techniques. *Energy Economics*, **18**, 165-183. https://doi.org/10.1016/0140-9883(96)00009-6

[4] U.S Energy Information Administration (2016) International Energy Statistics. https://www.eia.gov/beta/international/data/

[5] World Bank (2017) World Development Indicators (WDI). http://data.worldbank.org/country/mongolia

[6] Chontanawat, J., Hunt, L.C. and Pierse R. (2006) Causality between Energy Consumption and GDP: Evidence from 30 OECD and 78 Non-OECD Countries. University of Technology Thonburi, Krung Thep Maha Nakhon.

[7] Chen, S., Kuo, H. and Chen, C. (2007) The Relationship between GDP and Electricity Consumption in 10 Asian Countries. *Energy Policy*, **35**, 2611-2621. https://doi.org/10.1016/j.enpol.2006.10.001

[8] Apergis, N. and Payne, J.E. (2009) Energy Consumption and Economic Growth in Central America: Evidence from a Panel Cointegration and Error Correction Model. *Energy Economics*, **31**, 211-216. https://doi.org/10.1016/j.eneco.2008.09.002

[9] Belke, A.H., Dreger, C. and Dobnik, F. (2010) Energy Consumption and Economic Growth—New Insights into the Cointegration Relationship. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.1635765

[10] Squalli, J. and Wilson, K. (2006) A Bound Analysis of Electricity Consumption and Economic Growth in the GCC. EPRU, Zayed University.

[11] Yoo, S.-H. (2006) The Causal Relationship between Electricity Consumption and Economic Growth in the ASEAN Countries. *Energy Policy*, **34**, 3573-3582. https://doi.org/10.1016/j.enpol.2005.07.011

[12] Shiu, A. and Lam, P. (2004) Electricity Consumption and Economic Growth in China. *Energy Policy*, **32**, 47-54. https://doi.org/10.1016/s0301-4215(02)00250-1

[13] Kraft, J. and Kraft, A. (1978) On the Relationship between Energy and GNP. *Journal of Energy and Development*, **3**, 401-403.

[14] Granger, C.W.J. (1969) Investigating Causal Relations by Econometric Models and Cross-Spectral Methods. *Econometrica*, **37**, Article 424. https://doi.org/10.2307/1912791

[15] Akarca, A.T. and Long, T.V. (1979) Energy and Employment: A Time-Series Analysis of the Causal Relationship. *Resources and Energy*, **2**, 151-162. https://doi.org/10.1016/0165-0572(79)90027-6

[16] Asafu-Adjaye, J. (2000) The Relationship between Energy Consumption, Energy Prices and Economic Growth: Time Series Evidence from Asian Developing Countries. *Energy Economics*, **22**, 615-625. https://doi.org/10.1016/s0140-9883(00)00050-5

[17] Li, R. and Leung, G.C.K. (2012) Coal Consumption and Economic Growth in China.

Energy Policy, **40**, 438-443. https://doi.org/10.1016/j.enpol.2011.10.034

[18] Mohanty, A. and Chaturvedi, D. (2015) Relationship between Electricity Energy Consumption and GDP: Evidence from India. *International Journal of Economics and Finance*, **7**, 186-202. https://doi.org/10.5539/ijef.v7n2p186

[19] Masih, A.M.M. and Masih, R. (1996) Energy Consumption, Real Income and Temporal Causality: Results from a Multi-Country Study Based on Cointegration and Error-Correction Modelling Techniques. *Energy Economics*, **18**, 165-183. https://doi.org/10.1016/0140-9883(96)00009-6

[20] Lei, Y., Li, L. and Pan, D. (2014) Study on the Relationships between Coal Consumption and Economic Growth of the Six Biggest Coal Consumption Countries: With Coal Price as a Third Variable. *Energy Procedia*, **61**, 624-634. https://doi.org/10.1016/j.egypro.2014.11.1185

[21] Aqeel, A. and Butt, M.S. (2001) Relationship between Energy Consumption and Economic Growth in Pakistan. *Asia Pacific Development Journal*, **8**, 101-110.

[22] Glasure, Y.U. and Lee, A. (1998) Cointegration, Error-Correction, and the Relationship between GDP and Energy. *Resource and Energy Economics*, **20**, 17-25. https://doi.org/10.1016/s0928-7655(96)00016-4

[23] Oh, W. and Lee, K. (2004) Causal Relationship between Energy Consumption and GDP Revisited: The Case of Korea 1970-1999. *Energy Economics*, **26**, 51-59. https://doi.org/10.1016/s0140-9883(03)00030-6

[24] Soytas, U. and Sari, R. (2003) Energy Consumption and GDP: Causality Relationship in G-7 Countries and Emerging Markets. *Energy Economics*, **25**, 33-37. https://doi.org/10.1016/s0140-9883(02)00009-9

[25] Lin, B. (2003) Structural Change, Efficiency Improvement and Electricity Demand Forecasting (in Chinese). *Economic Research*, **5**, 57-65.

[26] Lee, C. (2005) Energy Consumption and GDP in Developing Countries: A Cointegrated Panel Analysis. *Energy Economics*, **27**, 415-427. https://doi.org/10.1016/j.eneco.2005.03.003

[27] Lee, C. and Chang, C. (2005) Structural Breaks, Energy Consumption, and Economic Growth Revisited: Evidence from Taiwan Region. *Energy Economics*, **27**, 857-872. https://doi.org/10.1016/j.eneco.2005.08.003

[28] Altinay, G. and Karagol, E. (2005) Electricity Consumption and Economic Growth: Evidence from Turkey. *Energy Economics*, **27**, 849-856. https://doi.org/10.1016/j.eneco.2005.07.002

[29] Wolde-Rufael, Y. (2005) Energy Demand and Economic Growth: The African Experience. *Journal of Policy Modeling*, **27**, 891-903. https://doi.org/10.1016/j.jpolmod.2005.06.003

[30] Mozumder, P. and Marathe, A. (2007) Causality Relationship between Electricity Consumption and GDP in Bangladesh. *Energy Policy*, **35**, 395-402. https://doi.org/10.1016/j.enpol.2005.11.033

[31] Mehrara, M. (2007) Energy Consumption and Economic Growth: The Case of Oil Exporting Countries. *Energy Policy*, **35**, 2939-2945. https://doi.org/10.1016/j.enpol.2006.10.018

[32] Chebbi, H.E. and Boujelbene, Y. (2008) CO_2 Emissions, Energy Consumption and Economic Growth in Tunisia. 2008 *International Congress*, Ghent, 26-29 August 2008, 260-268.

[33] Kwiatkowski, D., Phillips, P.C.B., Schmidt, P. and Shin, Y. (1992) Testing the Null Hypothesis of Stationarity against the Alternative of a Unit Root. *Journal of Econometrics*,

54, 159-178. https://doi.org/10.1016/0304-4076(92)90104-y

[34] Li, Z.-W. and Zheng, X.G. (2012) Study on Relationship of Energy Consumption and Economic Growth in China. *Physics Procedia*, **24**, 313-319. https://doi.org/10.1016/j.phpro.2012.02.047

[35] Hu, X. and Lin, X. (2013) A Study of the Relationship between Electricity Consumption and GDP Growth in Hainan International Tourism Island of China. *Research in World Economy*, **4**, 109-115. https://doi.org/10.5430/rwe.v4n1p109

[36] Yu, E.S.H. and Choi, J.Y. (1985) The Causal Relationship between Energy and GNP: An International Comparison. *Journal of Energy and Development*, **10**, 249-272.

[37] Erol, U. and Yu, E.S.H. (1987) On the Causal Relationship between Energy and Income for Industrializing Countries. *Journal of Energy and Development*, **13**, 113-122.

[38] Yu, E.S.H. and Jin, J.C. (1992) Cointegration Tests of Energy Consumption, Income, and Employment. *Resources and Energy*, **14**, 259-266. https://doi.org/10.1016/0165-0572(92)90010-e

[39] Stern, D.I. (1993) Energy and Economic Growth in the Usa. *Energy Economics*, **15**, 137-150. https://doi.org/10.1016/0140-9883(93)90033-n

[40] Cheng, B. (1995) An Investigation of Cointegration and Causality between Energy Consumption and Economic Growth. *Journal of Energy Development*, **21**, 73-84.

[41] Solow, R.M. (1956) A Contribution to the Theory of Economic Growth. *The Quarterly Journal of Economics*, **70**, 65-94. https://doi.org/10.2307/1884513

[42] Stern, D.I. (2003) Evidence from Panel Unit Root and Cointegration Tests That the Environmental Kuznets Curve Does Not Exist. Department of Economics Energy and Economic Growth, April 2003, Department of Economics, Sage 3208, Rensselaer Polytechnic Institute.

[43] Bartleet, M. and Gounder, R. (2010) Energy Consumption and Economic Growth in New Zealand: Results of Trivariate and Multivariate Models. *Energy Policy*, **38**, 3508-3517. https://doi.org/10.1016/j.enpol.2010.02.025

[44] International Energy Agency (2004) World Energy Outlook 2004.

[45] Engle, R.F. and Granger, C.W.J. (1987) Co-Integration and Error Correction: Representation, Estimation, and Testing. *Econometrica*, **55**, 251-276. https://doi.org/10.2307/1913236

[46] Nelson, C.R. and Plosser, C.R. (1982) Trends and Random Walks in Macroeconmic Time Series. *Journal of Monetary Economics*, **10**, 139-162. https://doi.org/10.1016/0304-3932(82)90012-5

[47] Dickey, D.A. and Fuller, W.A. (1979) Distribution of the Estimators for Autoregressive Time Series with a Unit Root. *Journal of the American Statistical Association*, **74**, 427-431. https://doi.org/10.1080/01621459.1979.10482531

[48] Sims, C.A. (1980) Macroeconomics and Reality. *Econometrica*, **48**, 1-48. https://doi.org/10.2307/1912017

[49] Kim, J. (2010) The Relationship between Energy Consumption and Economic growth: Theoretical and Empirical Issues. College of Engineering. Ph.D. Dissertation, Seoul National University.

[50] Granger, C.W.J. (1988) Some Recent Development in a Concept of Causality. *Journal of Econometrics*, **39**, 199-211. https://doi.org/10.1016/0304-4076(88)90045-0

[51] Cheng, B.S. and Lai, T.W. (1997) An Investigation of Co-Integration and Causality between Energy Consumption and Economic Activity in Taiwan Region. *Energy Economics*, **19**, 435-444. https://doi.org/10.1016/s0140-9883(97)01023-2

[52] Phillips, P.C.B. and Perron, P. (1988) Testing for a Unit Root in Time Series Regression. *Biometrika*, **75**, 335-346. https://doi.org/10.1093/biomet/75.2.335

[53] Ozturk, I. (2010) A Literature Survey on Energy-Growth Nexus. *Energy Policy*, **38**, 340-349. https://doi.org/10.1016/j.enpol.2009.09.024

[54] Mishra, V., Smyth, R. and Sharma, S. (2009) The Energy-GDP Nexus: Evidence from a Panel of Pacific Island Countries. *Resource and Energy Economics*, **31**, 210-220. https://doi.org/10.1016/j.reseneeco.2009.04.002

[55] Shahbaz, M., Mutascu, M., *et al.* (2012) Revisiting the Relationship between Electricity Consumption, Capital and Economic Growth: Cointegration Causality Analysis in Romania. *Romanian Journal of Economic Forecasting*, **3**, 97-120.

[56] European Bank for Reconstruction Development (2010) Securing Sustainable Energy in Transition Economies. http://www.ebrd.com/downloads/research

[57] Belloumi, M. (2009) Energy Consumption and GDP in Tunisia: Cointegration and Causality Analysis. *Energy Policy*, **37**, 2745-2753. https://doi.org/10.1016/j.enpol.2009.03.027

[58] Solow, R.M. (1974) The Economics of Resources or the Resources of Economics. In: *Classic Papers in Natural Resource Economics*, Palgrave Macmillan UK, 257-276. https://doi.org/10.1057/9780230523210_13

[59] Cheng, B.S. (1995) An Investigation of Cointegration and Causality between Energy Consumption and Economic Growth. *Journal of Energy and Development*, **21**, 73-84.

[60] Mohanty, A. and Chaturvedi, D. (2015) Relationship between Electricity Energy Consumption and GDP: Evidence from India. *International Journal of Economics and Finance*, **7**, 186-202. https://doi.org/10.5539/ijef.v7n2p186