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The impact of energy use on the growing economy of Mongolia

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Introduction

In the contemporary world, energy is a very important factor for economic development especially when a country is in process of accelerating its economy into the industrialization stage like Mongolia. The nexus between energy consumption and economic growth has been widely studied by researchers from the different countries.

Main purpose of this study is to identify the existence of a causal relationship and the directions between different energy consumptions and economic growth of Mongolia so it aimed to investigate empirically by applying a modeling strategy based on the Granger causality from vector error correction model, augmented Dickey-Fuller and Phillips-Perron tests, Johansen cointegration test.

Actually, the Mongolian economy based on natural resources and mining sector, is expected to expand substantially over the next few decades. Also at the same time energy demand will increase strongly because, the development of mega projects involving coal, copper, gold, iron ore, and uranium mining can dramatically increase the energy demand in the following decades so energy can also play a vital role in Mongolian economy and social development.

Research questions

1. Is there any causal relationship between energy consumptions and GDP of Mongolia during the period 1985-2012?

   - A. In case of electricity consumption?
   - B. In case of oil consumption?
   - C. In case of primary energy consumption?

2. What are the directions of the long and short term causalities between different energy consumptions and GDP?

   - A. In case of electricity consumption?
   - B. In case of oil consumption?
   - C. In case of primary energy consumption?

Motivation

So far, the causal relationship between energy consumption and economic growth, this topic has not been sufficiently researched for Mongolia mostly due to data limitation and transitional economic circumstances.

Mongolia has a lot of energy resources which includes conventional and non-conventional resource within its boundary and supposedly energy can be major factor in economic development of Mongolia.

Additionally, understanding structural relationship and the directions of causalities is very important to make energy policy which will be appropriate to sustaining Mongolia's economic development and reducing global warming, reduction of greenhouse gas emissions.

Moreover, through identifying relationships between main energy factors and economic growth that we are going to encourage to our energy policy with well suited tendency also to support our rapid increasing economy without any negative effect or adverse.

Research structure

Research structure

•Chapter 1 introduces the study.

•Chapter 2 presents the study background, including an introduction to Mongolia's energy sector and economy.

•Chapter 3 sets forth the literature review.

•Chapter 4 develops the theoretical framework and hypothesis and Methodology.

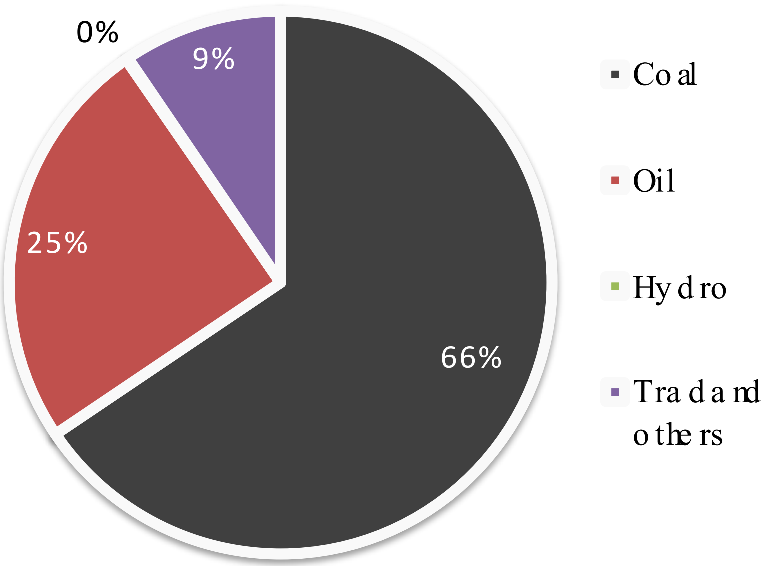
•Chapter 5 examines empirical results as well as the directions of causality and short-term and long-term structural relationships among energy consumptions and GDP during the period 1985-2012. The following models are analyzed:

- Model 1: Electricity consumption-GDP
- Model 2: Oil consumption-GDP
- Model 4: Primary energy consumption-GDP

•Chapter 6 describes the Policy implications which will be used to provide advice for the effective management of Mongolian energy sector and conclusion, limitations of the study.

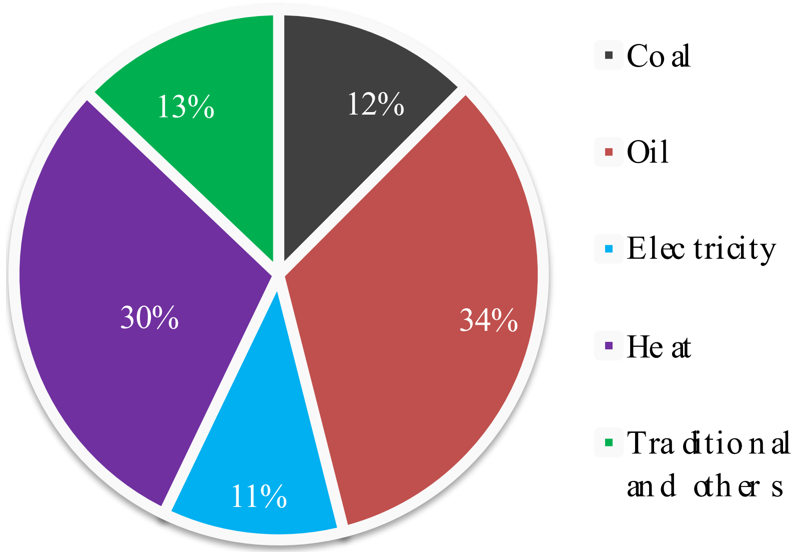
Structure of energy consumption

Primary energy supply by source in Mongolia



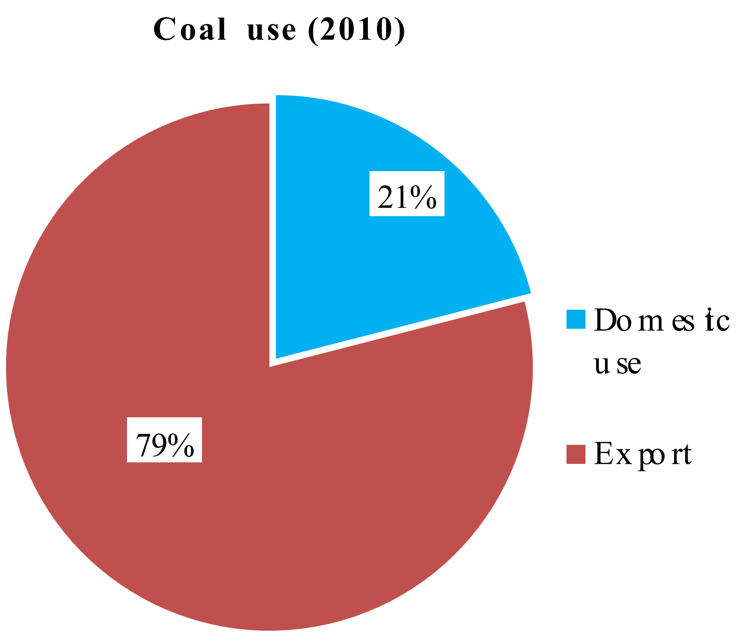
Total-3545 (1000 TOE)

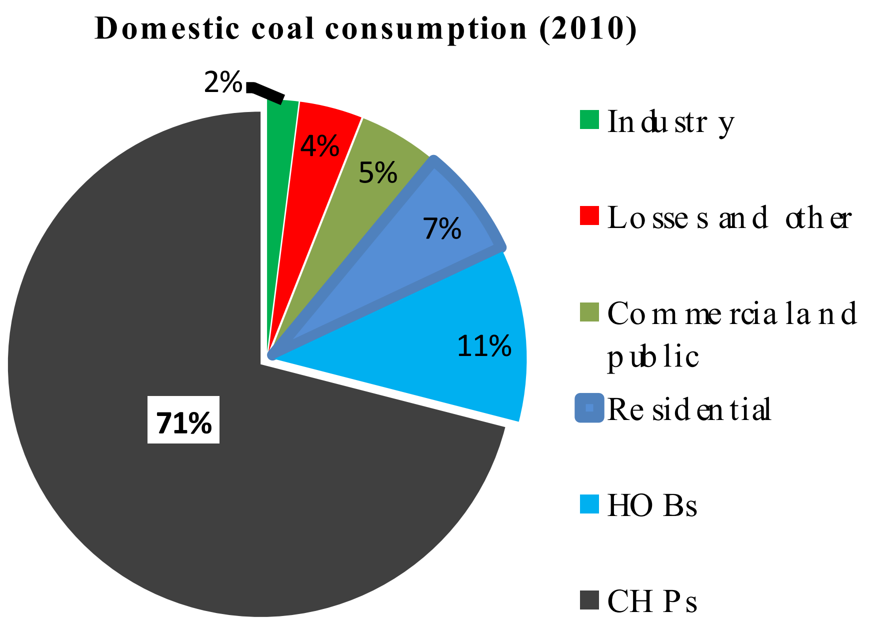
Final energy demand by source in Mongolia



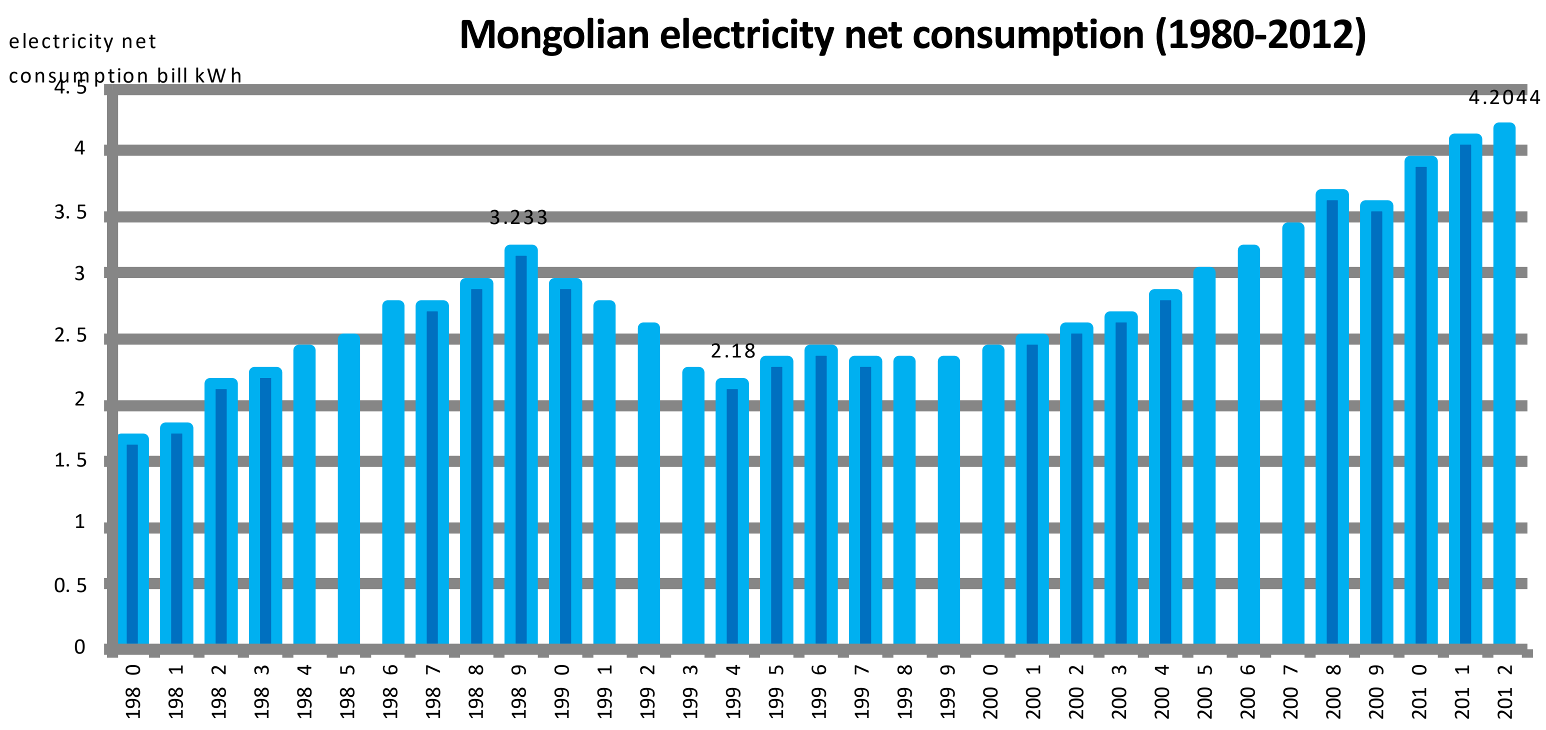
Total-2611 (1000 TOE)

Structure of coal consumption

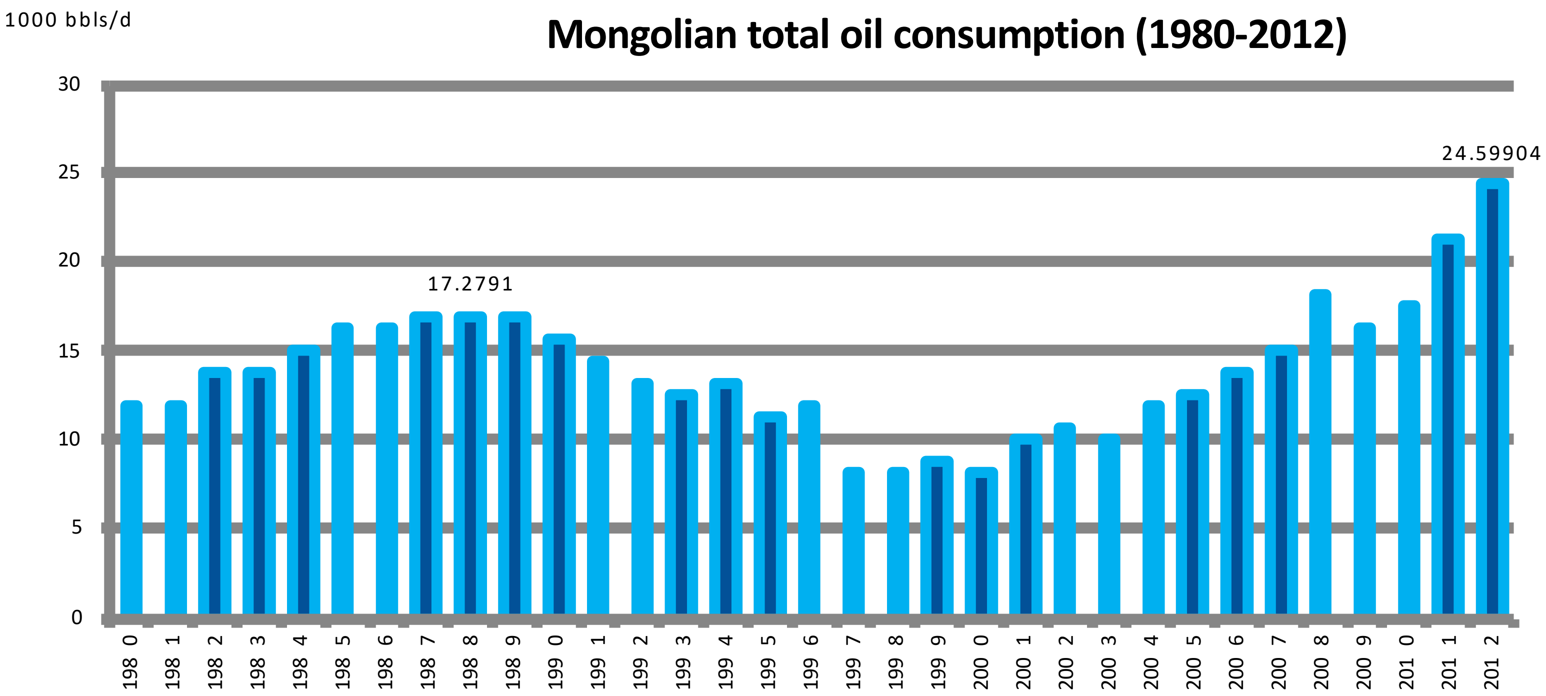




Overview of energy sector



Overview of energy sector



Literature review

This chapter describes main researches on causality between Energy consumption and Economic growth among different countries with different energy sources and economic development in the world.

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.

- No causality: No causality between energy consumption and GDP is referred to as "neutrality hypothesis".
- The unidirectional causality running from economic growth to energy consumption. It is also called "conservation hypothesis".
- The unidirectional causality running from energy consumption to economic growth. It is also called "growth hypothesis".
- Bi-directional causality between energy consumption and economic growth. It is also called "feedback hypothesis".

Literature review

Existence of a (unidirectional, bidirectional) causal relationship.

The causal relationship between energy consumption and GNP in the United States of America in the period 1947-1974 was first found by **Kraft and Kraft** (1978) 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 **Granger** (1969), this method, become most widespread analytical tool in this kind of research areas.

Later same result, but using monthly data **Akarca and Long** (1979) 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, **Asafu-Adjaye** (2000) found the causal relationships between energy use and income in four Asian countries.

Li and Leung 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.

Asit Mohanty and Devtosh Chaturvedi investigated 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.

Literature review

Zhang-wei and Zheng (2012) investigated relationship between energy consumption and economic development based on the VAR model using temporal series of China from 1990 to 2009, then uses 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.

Masih and Masih (1996) 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. The Philippine, Malaysia and Singapore were tested by VAR method and causality was not found among those countries.

Belke and Dreger (2010) 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.

Literature review

Absence of a (unidirectional, bidirectional) causal relationship.

Several developed countries were observed by **Erol and Yu** (1987) 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, **Yu and Jin** (1992) checked the cointegration between energy and GDP and found no long term connection among them.

Yalin Lei and Li (2014), 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 that there are no causal relationships between coal consumption and economic growth in USA and India.

Using the multivariate approach instead of bivariate was started by **Stern** (1993). Energy, GDP, capital and labor was used to check the Granger causality between energy and GDP in the post-war United States. Scholar 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 **Cheng** (1995). The same result of no relationship occurred by employing the multivariate model.

Literature review

Additionally, for this research work many previous studies are reviewed. As below listed are different researches on causality between Energy consumption and Economic Growth of the countries depend on the level of economic development and energy sources as well.

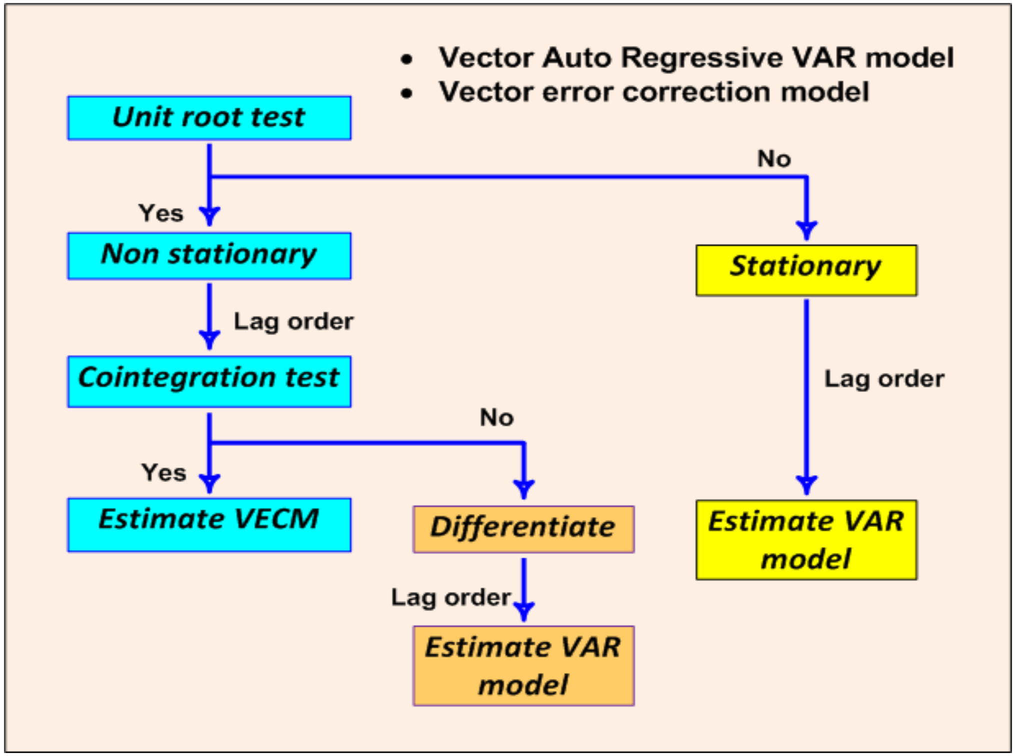
Authors	Period	Country	Methodology	Causality relationship
Kraft and Kraft (1978)	1947–1974	USA	Granger causality	GDP→EC
Akarca and Long (1980)	1950–1970	USA	Sims' technique	No causality
Yu and Hwang (1984)	1947–1979	USA	Sims' technique	No causality
Abosedra and Baghestani (1989)	1947–1987	USA	Cointegration, Granger causality	GDP→EC
Hwang and Gum (1991)	1961–1990	Taiwan	Cointergration, error correction	No causality
Yu and Jin (1992)	1974–1990	USA	Cointegration and Granger causality	No causality
Stern (1993)	1947–1990	USA	Multivariate VAR model	EC→GDP
Cheng (1995)	1947–1990	USA	Cointegration and Granger causality	No causally
Cheng and Lai (1997)	1954–1993	Taiwan	Ganger causality	GDP→EC
Chontanawat et al. (2008)	2008	78 non OECD	Cointegration and Granger causality	EC→GDP
Li Zhang-wei, Zheng (2012)	1990-2009	China	Ganger causality, Var model	EC→GDP
Li Fei et.al., (2011)	1985-2001	China	Cointegration and Granger causality	EC→GDP
Herrerias et.al., (2013)	1995-2009	China	Cointegration and Granger causality	EC→GDP
Xiaohui Hai and Yandong W, (2015)	1991-2012	China	Cointegration, Granger causality	EC→GDP
Xiaohua Hu (2013)	1990-2009	China,Hainan	Cointegration, Granger causality	EC→GDP
Shohrat Baymuradovich Niyazmuradov (2012)	1992-2010	Turkmenistan	Cointegration, Granger causality	EC→GDP, GDP → EC

Hoang Buu Quoc (2012)	1984-2010	Vietnam	Cointegration, Granger causality	GDP→EC
Ularbek Ruslanovich Niizaliev (2013)	1990-2011	Kyrgyz republic	Cointegration, Granger causality	EC→GDP, GDP → EC
Ali Aliabadi (2012)	1991-2008	Iran	Cointegration, Granger causality	GDP → EC
Carlo Mario Franchini Irujo (2014)	1971-2010	Peru	Cointegration, Granger causality, Trivariate Analysis	EC→GDP, GDP → EC
Mercy Abrokwah-Koranteng (2013)	1971-2009	Ghana	Cointegration, Granger causality	GDP → EC
Mergenbayev A Kayirdinovich (2013)	1990-2010	Kazakhstan	Cointegration, Granger causality	EC→GDP
Ali Mohammed Aziz (2013)	1989-2011	Yemen	Cointegration, Granger causality	EC→GDP
Cheng (1998)	1952-1995	Japan	Hsiao's version of Granger causality	GDP→EC
Cheng (1999)	1952-1995	India	Cointegration, Granger causality	GDP→EC
Stern (2000)	1948-1994	USA	Cointegration, Granger causality	EC→GDP
Soytas et al. (2001)	1960-1995	Turkey	Cointegration, Granger causality	EC→GDP
Aqeel and Butt (2001)	1955–1996	Pakistan	Cointegration and Hsiao's version of Granger causality	GDP→EC
Fatai et al. (2002)	1960–1999	New Zealand	Granger causality, Toda and Yamamoto's and autoregressive distributed lag (ARDL) technique	No causality
Glasure (2002)	1961–1990	South Korea	Cointegration, error-correction, variance decomposition	GDP↔EC
Hondroyiannis et al. (2002)	1960–1996	Greece	Error correction model	GDP↔EC
Altinay and Karagol (2004)	1950-2000	Turkey	Hsiao's version of Granger causality	No causality
Ghali and El-Sakka (2004)	1961–1997	Canada	Cointegration, VEC, Granger causality	GDP↔EC
Paul and Bhattacharya (2004)	1950-1996	India	Cointegration, Granger causality	GDP↔EC
Oh and Lee (2004)	1970–1999	Korea	Granger causality and error correction	EC→GDP
Wolde-Rufael (2004)	1952–1999	Shanghai	A modified version of Granger causality	EC→GDP
Lee and Chang (2005)	1954-2003	Taiwan	Johansen-Juselius, Cointegration, VEC	EC→GDP
Ang (2007)	1960-2000	France	Cointegration, VECM	Energy use→GDP (in the short run)
Lee and Chang (2007 a)	1955-2003	Taiwan	Granger causality, Cointegration, VECM	EC→GDP

Glasure (2002)	1961–1990	South Korea	Cointegration, error-correction, variance decomposition	GDP↔EC
Hondroyiannis et al. (2002)	1960–1996	Greece	Error correction model	GDP↔EC
Altinay and Karagol (2004)	1950-2000	Turkey	Hsiao's version of Granger causality	No causality
Ghali and El-Sakka (2004)	1961–1997	Canada	Cointegration, VEC, Granger causality	GDP↔EC
Paul and Bhattacharya (2004)	1950-1996	India	Cointegration, Granger causality	GDP↔EC
Oh and Lee (2004)	1970–1999	Korea	Granger causality and error correction	EC→GDP
Wolde-Rufael (2004)	1952–1999	Shanghai	A modified version of Granger causality	EC→GDP
Lee and Chang (2005)	1954-2003	Taiwan	Johansen-Juselius, Cointegration, VEC	EC→GDP
Ang (2007)	1960-2000	France	Cointegration, VECM	Energy use→GDP (in the short run)
Lee and Chang (2007 a)	1955-2003	Taiwan	Granger causality, Cointegration, VECM	EC→GDP (only where there is a low level of energy consumption in Taiwan)
Jobert and Karanfil (2007)	1960-2003	Turkey	Granger causality test	No causality
Ho and Siu (2007)	1966-2002	Hong Kong	Cointegration, VEC model	EC→GDP
Zamani (2007)	1967-2003	Iran	Granger causality, Cointegration, VECM	GDP → Total energy
Lise and Montfort (2007)	1970-2003	Turkey	Cointegration test	GDP↔EC
Karanfil (2008)	1970-2005	Turkey	Granger causality test, cointegration test	GDP↔EC No causality (when unrecorded economy is taken into account)
Ang (2008)	1971-1999	Malaysia	Johansen cointegration, VEC model	GDP↔EC
Erdal et al. (2008)	1970-2006	Turkey	Pair-wise granger causality, Johansen cointegration	ELC↔GDP
Bowden and Payne (2009)	1949-2006	USA	Toda-Yamamoto causality test	EC→GDP
Halicioglu (2009)	1960-2005	Turkey	Granger causality test, ARDL, cointegration test	No causality
Payne (2009)	1949-2006	USA	Toda-Yamamoto causality test	No causality
Soytas and Sari (2009)	1960-2000	Turkey	Toda-Yamamoto causality test	No causality
Belloumi (2009)	1971-2004	Tunisia	Granger causality, VECM	GDP↔EC (in the long-run)

Methodology

Causality testing steps



The most popular method, tools for students in this area are Granger causality cointegration test, vector error correction model, which is used to analyze the causal relationship between energy consumption and economic growth of any country.

A modeling strategy based on the Granger causality from vector error correction model, augmented Dickey-Fuller and Phillips-Perron tests and Johansen cointegration test.

Methodology

Stationarity and integration

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

Whereas, a series *xt* is said to be non-stationary if it has non-constant mean *E(xt)*, and variance Var(*xt*) 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 (Dickey, Fuller, 1979). 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:

$$\Delta x_t = (\rho - 1)x_{t-1} + \sum_{j=1}^{p} \lambda_j \Delta x_{t-j} + \varepsilon_t$$

Where: ε_t is the residual (the same as follows).Then test the null hypothesis *H*0: ρ= 1 that x_t is nonstationary, against *H*1: < 1, that x_t is stationary.

Methodology

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 Engle and Grange (1987). 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 xt and yt, are tested to be non-stationary, but both of them are integrated of the same order, the regression equation can be set up as:

$$xt = \alpha + \beta yt + \varepsilon t$$

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

Methodology

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 Engle and Granger (1987), cointegration implies the existence of an Error Correction Model (ECM) of the following equation:

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

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

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). Kim, Jinsoo (2010).

Methodology

Granger causality test

In our study, the Granger Causality test was adopted to examine the causality between two series according to Engle and Grange (1987). When the past information is collected to forecast variable *yt*, we can use only the past information of both *xt* and *yt* .

According to the Granger Causality test, there is causality from *xt* to *yt* if the past information of *xt* can help us to forecast *yt* more precisely. When applying to the Granger Causality test, we first set up the bivariable autoregression model:

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

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

Then the F Test is carried out to test the null hypothesis $H0{:}\beta i$ (i = 1, 2,…, m) = 0, which is equal to the hypothesis that "*xt* has no Granger Causality to *yt*". If $\boldsymbol{H0{:}\beta i}$ (i = 1, 2,…, m) = 0, is rejected, then we can also reject the hypothesis "*xt* has no Granger Causality to *yt*", and thereby conclude that *xt* has no Granger causality to *yt*. Similarly, the hypothesis $H0{:}\beta j$ (j = 1, 2,…, m) = 0, can be tested to verify whether there is Granger causality from *yt* to *xt* .

Data

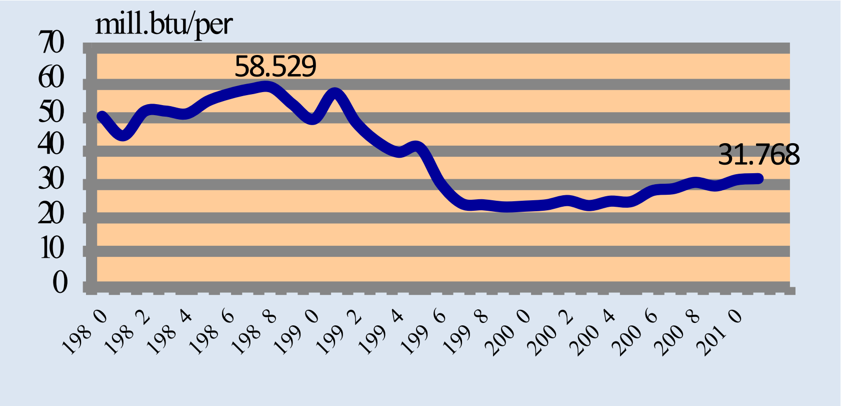
- ➢In our empirical study on cointegration and causality between Mongolia's 3 major energy consumptions and economic indicator, we use the time series data of real GDP, and energy consumptions such as oil, primary energy, electricity for the period from 1985 to to 2012 of Mongolia.

- ➢Before starting to the analysis we convert the values of GDP and electricity consumption into natural logarithms 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.

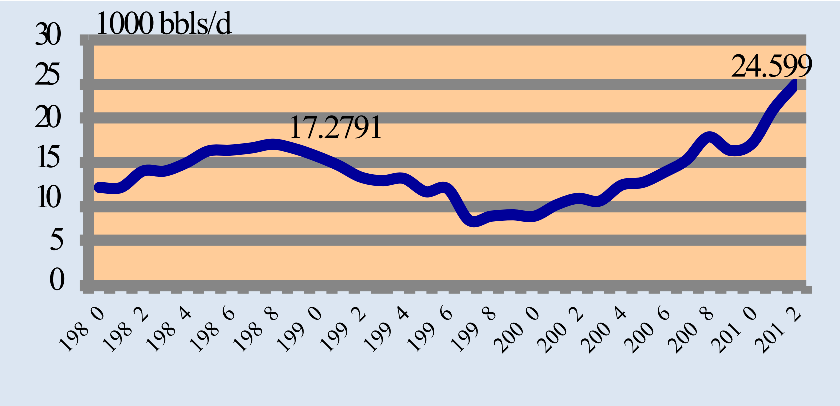
- Data for economic sector as well as energy field have been obtained from the web site U.S. Energy information administration and world development indicator by World bank. *http://www.eia.gov/countries/*, *http://data.worldbank.org/*. Empirical analysis was done by using STATA 12.0statistical package.

Data

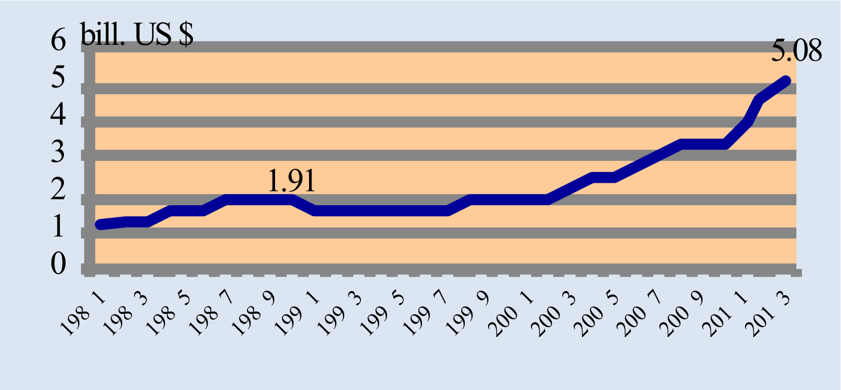
The historical trend of Primary energy consumption



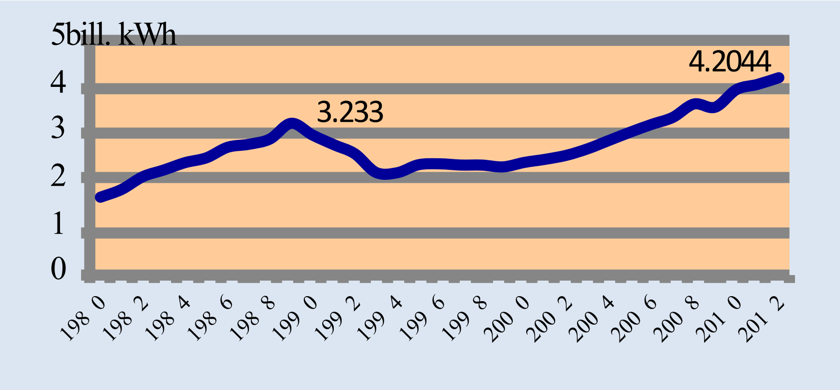
The historical trend of Oil consumption



The historical trend of GDP



The historical trend of Electricity consumption



Empirical Result

As a result, vector error correctional model we indicated couple of long-run and short term causal relationships between different energy consumptions and GDP, so then at first determined long-run unidirectional causality from electricity to GDP, long-run bidirectional causalities between GDP and oil consumption also between primary energy and GDP.

Furthermore, short run unidirectional causalities are discovered from GDP to electricity consumption, from GDP to oil consumption and as well as from GDP to primary energy consumption.

Mood of Causal Relationships

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

Empirical Result

Unit root test. (Electricity, Oil, GDP)

Variables		Model	Test statistics	Critical value		
				1%	5%	10%
GDP	Level	ADF	2.779*	-3.746	-2.994	-2.628
		PP	1.886	-3.736	-2.994	-2.628
	1st difference	ADF	-2.010	-3.743	-2.997	-2.629
		PP	-2.136	-3.743	-2.997	-2.629
	2nd difference	ADF	-4.528***	-3.750	-3.000	-2.630
		PP	-4.511***	-3.750	-3.000	-2.630
Electricity	Level	ADF	0.418	-3.736	-2.994	-2.628
		PP	-0.054	-3.736	-2.997	-2.629
	1st difference	ADF	-3.514**	-3.743	-2.997	-2.629
		PP	-3.512**	-3.743	-2.997	-2.629
	2nd difference	ADF	-7.246***	-3.750	-3.000	-2.630
		PP	-7.762***	-3.750	-3.000	-2.630
Oil	Level	ADF	0.684	-3.736	-2.994	-2.628
		PP	0.249	-3.736	-2.994	-2.628
	1st difference	ADF	-3.591**	-3.743	-2.997	-2.639
		PP	-3.609**	-3.743	-2.997	-2.629
	2nd difference	ADF	-8.703***	-3.750	-3.000	-2.630
		PP	-10.403***	-3.750	-3.000	-2.630

Empirical Result

Unit root test. (Primary energy and GDP.n)

Variables		Model	Test statistics	Critical value		
				1%	5%	10%
Primary energy	Level	ADF	-0.314	-3.736	-2.994	-2.628
		PP	-0.508	-3.736	-2.994	-2.628
	1st difference	ADF	-2.626*	-3.743	-2.997	-2.629
		PP	-2.728*	-3.743	-2.997	-2.639
	2nd difference	ADF	-6.038***	-3.750	-3.000	-2.630
		PP	-6.084***	-3.750	-3.000	-2.630
GDP n	Level	ADF	3.272	-3.736	-2.994	-2.628
		PP	3.311	-3.736	-2.994	-2.628
	1st difference	ADF	-2.791**	-3.743	-2.997	-2.629
		PP	-2.759**	3.743	-2.997	-2.629
	2nd difference	ADF	-7.474***	-3.750	-3.000	-2.630
		PP	-8.588***	-3.750	-3.000	-2.630

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

Lag selection results for cointegration test.

Lag selection result for co-integration test. Oil

```
. varsoc lnoc lngdp

  Selection-order criteria
  Sample:  1989 - 2012                         Number of obs      =        24
```

lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	-64.8301				.898994	5.56918	5.59522	5.66735
1	3.52705	136.71	4	0.000	.004224	.206079	.284214	.500593
2	7.81034	8.5666	4	0.073	.004166	.182472	.312696	.673328
3	18.6551	21.69*	4	0.000	.002408*	-.387929*	-.205615*	.299269*
4	20.876	4.4417	4	0.350	.002913	-.239666	-.005263	.643874

```
  Endogenous:  lnoc lngdp
   Exogenous:  _cons
```

* indicates lag order selected by the criterion

Lag selection result for co-integration test. Electricity

```
. varsoc lnelc lngdp

  Selection-order criteria
  Sample:  1989 - 2012                         Number of obs      =        24
```

lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	21.0043				.000704	-1.58369	-1.55765	-1.48552
1	85.0122	128.02	4	0.000	4.7e-06	-6.58435	-6.50622	-6.28984*
2	87.67	5.3156	4	0.256	5.4e-06	-6.4735	-6.34228	-5.98165
3	96.9102	18.48*	4	0.001	3.5e-06*	-6.90918*	-6.72687*	-6.22198
4	98.4298	3.0393	4	0.551	4.5e-06	[illegible]	-6.46808	-5.81895

```
  Endogenous:  lnelc lngdp
   Exogenous:  _cons
```

* indicates lag order selected by the criterion

Lag selection results for cointegration test.

```
. varsoc penc gdpn

   Selection-order criteria
   Sample:  1989 - 2012                         Number of obs      =        24
```

lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	.293379				.003952	.142218	.168263	.24039
1	46.5596	92.532	4	0.000	.000117*	-3.37996	-3.30183*	-3.08545*
2	47.9231	2.727	4	0.604	.000147	-3.16026	-3.03003	-2.6694
3	51.9451	8.0441	4	0.090	.00015	-3.16209	-2.97978	-2.4749
4	59.057	14.224*	4	0.007	.000121	-3.42142*	-3.18702	-2.53788

```
   Endogenous:  penc gdpn
    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

Lag selection result for cointegration test. Primary energy

Cointegration test result

```
. vecrank lnoc lngdp, lags(3) max levela
```

Johansen tests for cointegration

Trend: constant   Number of obs = 25

Sample: 1988 - 2012   Lags = 3

maximum rank	parms	LL	eigenvalue	trace statistic	5% critical value	1% critical value
0	10	5.2800566		15.6064 1	15.41	20.04
1	13	12.626761	0.44442	0.9130*5	3.76	6.65
2	14	13.083258	0.03586			

maximum rank	parms	LL	eigenvalue	max statistic	5% critical value	1% critical value
0	10	5.2800566		14.6934	14.07	18.63
1	13	12.626761	0.44442	0.9130	3.76	6.65
2	14	13.083258	0.03586			

The Cointegration test of oil with GDP

Vector Error Correction Model estimation

. vecrank lnelc lngdp, trend(none) lags(3) max levela

Johansen tests for cointegration

Trend: none Number of obs = 25

Sample: 1988 - 2012 Lags = 3

maximum rank	parms	LL	eigenvalue	trace statistic	5% critical value	1% critical value
0	8	87.873884		16.6684	12.53	16.31
1	11	95.215941	0.44421	1.9843*1*5	3.84	6.51
2	12	96.208069	0.07630			

maximum rank	parms	LL	eigenvalue	max statistic	5% critical value	1% critical value
0	8	87.873884		14.6841	11.44	15.69
1	11	95.215941	0.44421	1.9843	3.84	6.51
2	12	96.208069	0.07630			

Cointegration test of electricity with GDP

Cointegration test result

```
. vecrank penc gdpn,  lags(4) max levela
```

Johansen tests for cointegration

Trend: constant — Number of obs = 24

Sample: 1989 - 2012 — Lags = 4

maximum rank	parms	LL	eigenvalue	trace statistic	5% critical value	1% critical value
0	14	49.434486		19.2451*1	15.41	20.04
1	17	59.033657	0.55064	0.0468*5	3.76	6.65
2	18	59.057039	0.00195			

maximum rank	parms	LL	eigenvalue	max statistic	5% critical value	1% critical value
0	14	49.434486		19.1983	14.07	18.63
1	17	59.033657	0.55064	0.0468	3.76	6.65
2	18	59.057039	0.00195			

Cointegration test of Primary energy with GDP

Cointegration test result

Combined cointegration test results of 3 variables

Variables	Trace statistic	5% critical value	1% critical value	Lags
Electricity – GDP	16.6684	12.53	16.31	3
Oil –GDP	15.6064	15,41	20.04	3
Primary energy –GDP	19.2451	15.41	16.31	4

Granger Causality test.

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.	Lngdp does not cause Lnoc	7.65	0.0219**	0.000***
	Lnoc does not cause Lngdp	0.89	0.6416	0.044**
2.	Lngdp does not cause Lnelc	9.56	0.0084***	0.267
	Lnelc does not cause Lngdp	0.22	0.8955	0.038**
3.	gdpn does not cause penc	17.87	0.0005***	0.000***
	penc does not cause gdpn	0.21	0.9769	0.008***

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

Policy Implication

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.

Diversification and optimization of Mongolia's energy supply structure and developing renewable 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. Moreover, 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.

- Conducting energy efficiency policies in all sector, specially power sector industries, communal apartments, transportation vehicles, etc. The industries, communal apartments, buildings and power plants, which was mainly built during the Soviet Union period still apply the costly, outdated technology.

- Moreover, **electricity** consumption clearly affect economic growth in long-run case. Then the applications, implications of strong energy conservation policies especially in terms of electricity can totally negatively affect the economic growth. On other side energy and electricity efficiency policies are possible to implement.

Policy Implication

➢When energy consumption leads to economic growth in the long term prospective, like in our case of primary energy, oil, electricity, that means that **Mongolia has a primary energy dependent economy and more primary energy is required to foster economic development.**

➢In the short term, economic growth causes energy consumptions. That implies, 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.

➢In terms of bidirectional causalities in long-run between oil and GDP, primary energy and GDP, policy makers have to think of balancing between energy conservation policies and satisfying increasing oil, coal needs of the rigorously developing country.

Policy Implication

•Continuous implementation of the subsidization policy on the electricity use for the population and commercial consumers. Regarding the electricity consumption, to promote economic growth, the policy should be focused on price level of the electric energy directly, or on its demand side.

•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 modifications to 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.

➢Government should be careful in formulating various energy and environmental policies so as to avoid adverse effects on economic growth.

Population awareness about "Green technology".

Policy Implication

•Renew urgently the critical heat and power infrastructure in central energy system and heating facilities in capital, 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.

Adoption of more advanced carbon capture technologies, modern primary energy transformation, transmission technologies. However, the gradual diversification of energy sources may actually be able to enhance energy supply and security in the long-run.

Constructing a secure, integrated power electric system and electric grids connected by transmission line capable of providing back-up supply between adjacent grids.

Conclusion

- As a result of our model we indicated couple of long-run and short term causal relationships so then at first determined long-run unidirectional causality from electricity to GDP, long-run bidirectional causalities between GDP and oil consumption also between primary energy consumption and GDP so the support **"growth hypothesis"** in long term. Furthermore, short run unidirectional causalities are discovered from GDP to energy consumption.

- Moreover, the increase of electricity consumption positively affect the economic growth and any energy conservation policies can negatively affect the economic growth also energy, electricity efficiency policies are possible to implement.

Conclusion

- The main problem of this study is data limitation and due to the lack of data, its unavailability, the time series variables are insufficient to get more precise outcomes.

- 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 other natural resources exporting countries.

Thank you for your attention

Q & A