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서울대학교 대학원
협동과정 기술경영경제정책과정
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Abstract

Electricity Use and Economic Growth in Kazakhstan

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Kazakhstan is a young country. It declared itself an independent country only on December 16, 1991, but its economy is now the largest in Central Asia. Kazakhstan's economy is influenced by many factors. One of these is the electricity activity. Much research has been done to find the relationship between the electricity use and economic growth of different countries, but in the case of Kazakhstan, this problem has not been sufficiently researched mostly due to data limitations.

This study attempted to investigate the causal relationship between the electricity activity and the economic growth of the Republic of Kazakhstan, from its independence until the present, by applying the unit root test and the VAR and vector error correction model (VECM) of the Granger causality model. In addition, it was investigated in this study if the electricity activity is different from the consumption of

other energy sources and from the total energy use without electricity in terms of their relation with economic growth, based on other studies.

Keywords: Electricity generation and consumption, economic growth, cointegration, vector error correction model, Granger causality

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Chapter 1. Introduction

1.1 Background

The studies on the causal relationship between electricity consumption and economic growth occupy a substantial portion of the economic literature. These studies have been extensively conducted after the oil embargos in the 1970s, and recently in developing countries, because access to modern energy as electricity has been found to be important for poverty reduction. The central issue has been whether economic growth stimulates energy consumption or whether energy consumption itself is a stimulus for economic growth via the indirect channels of effective aggregate demand, improved overall efficiency, and technological progress.

The role of electricity consumption in economic growth has produced varying results across time and countries. Some empirical studies identified a causal relation running from electricity consumption to economic growth while a few ones reported the opposite. A few others provided evidence of bidirectional causality between electricity consumption and economic growth, but a handful of studies reported a neutral causal relation between them. The findings from the studies not only vary across countries but also depend on the methods used within the same country.

The Granger causality test, cointegration test, and vector error correction model were mostly employed to examine the existence of short- and long-run equilibrium and direction of causality of electricity use and economic growth.

The empirical findings can be separated into four parts[1]:

- no causality (GDP-EU) or "neutrality hypothesis – no causality between economic growth and economic growth";
- unidirectional causality running from energy consumption to economic growth (EU→GDP) or "growth hypothesis";
- unidirectional causality running from economic growth to energy consumption (GDP→EU) or "conservation hypothesis"; and
- bidirectional causality between energy consumption and economic growth (EU↔GDP) or "feedback hypothesis" shows a simultaneous interaction between energy consumption and economic growth.

This kind of information is useful for making an inference about the energy policy implications. Since its independence, Kazakhstan has passed two stages of electricity use development, from a significant shortage in energy production to almost sufficient energy production.

Although the methods of cointegration and causality have been adopted by many countries, the study on Kazakhstan's energy economy is still in its infancy.

[1] Mudarissov B.A. (2012). "Energy consumption and economic growth in Kazakhstan."

1.2 Study purpose

After a repeated study of the energy market in the country and based on other researches, the author conducted this study mainly to empirically establish the existence of a causal relationship between electricity consumption and economic growth in Kazakhstan, and found a difference between electricity consumption and other energy uses in terms of relation with economic growth.

The direction of causation between electricity consumption and economic growth has significant policy implications for oil-dependent countries enjoying implicit generous subsidies (low domestic prices) for energy. This task is critical in determining the right strategy to conduct energy policy.

If, for example, there is a unidirectional Granger causality from GDP to electricity consumption, it may mean that electricity conservation policies have little adverse or no effects on economic growth. On the other hand, if unidirectional Granger causality runs from electricity consumption to GDP, reducing electricity consumption could lead to a fall in GDP.

1.3 Thesis structure

The rest of this paper is organized into six chapters, as follows. Chapter 2 provides an overview of the electricity use in Kazakhstan. In Chapter 3, a review of the literature is provided. In Chapter 4, information is provided on the method that was used for this study, but the forecast method that was used is not provided.

The empirical study that was conducted is presented in Chapter 5. First, the data that were used are described, followed by the process of choosing variables. Finally, Chapter 6 presents the conclusion and policy implications. The appendix is provided at the end of the paper.

Chapter 2. Electricity Consumption Overview

2.1 Structure of the electricity sector

The social and economic development of Kazakhstan is heavily dependent on the energy sector. Electricity consumption is closely related to business development and to the living standards of the population. The development of the sectors of the economy and the improvement of technology and of the quality and improvement of the living conditions cannot be without the use of electricity and enhances the requirements for reliable and uninterrupted power. In the 1990s, Kazakhstan embarked on energy industry reform. This was due to the fact that the former unified energy system of the USSR broke up into separate, isolated power systems. During its 20-year independence, the power sector has undergone significant changes. Structural changes have been implemented in the industry, such as the deregulation and privatization of energy companies. The reforms included the separation of the power companies by type of activity to highlight the potentially competitive electricity production and marketing of natural monopoly transmission and dispatching, and the creation of wholesale and retail electricity markets.

The unified energy system (UES)[2] of Kazakhstan is a highly automated complex of power plants and power grids united by a common mode of operation, a single centralized operational control room and emergency control, single system development planning, and

[2] Ministry of Industry and New Technology of the Republic of Kazakhstan

technical, policy, regulatory, and legal control. The Grid of the Republic includes the following:

- National System [3] for electricity transmission, consisting of overhead line voltage kV 110-220-500-1150 served by electricity grid KEGOC JSC;

- eight power plants of national importance (Ekibastuz (State District Power Plant) GRES-1 and GRES-2, Aksu GRES, Karaganda GRES-2, Zhambyl GRES Bukhtarminsk and cascades of hydropower, Ust-Kamenogorsk HPP, and Shulbinskaya HPP), which provide large amounts of generated electricity directly connected to the national transmission network;

- 49 power plants, integrated with the territories connected to the national network, either directly or through a network of distribution companies and the network of other legal entities;

- 21 electricity distribution companies containing a network of 110 kV and below, and those directly connected to the national grid; and

- large consumer substations directly connected to the national network.

UES Kazakhstan has an area of more than 2 million square km and is located in the center of the main transport grid, 500-1150 kV Eurasian continent, with the following directions:

- the European part of Russia's UES;
- the Asian part of Russia's UES (Siberia IPS); and
- ECO Central Asia.

[3] Official Website of the KAZAKHSTAN ELECTRICITY GRID OPERATING COMPANY; available at www.KEGOC.kz.

The UES CIS electrical grid UES of Kazakhstan plays an important role as a link UES of Russia[4] (between the Urals and Siberia IPS) as well as in association with Central Asia ECO UES CIS. Electrical networks consisting of KEGOC VL 500-1150 kV in the North Kazakhstan region were formed as part of the UES of USSR and were calculated for electricity transmission and hydroelectric Siberia Kansk-Achinsk FEC to the Urals and Central Russia. While 12-14 billion kWh was planned to be transferred in the first phase, in the second stage, it was increased to 25-30 billion kWh. Considering that only the first phase of the construction of the Siberia-Kazakhstan–Ural power grid has been carried out, within 12-14 billion kWh electricity exports can be provided from Kazakhstan to Russia over the existing networks. Since September 2000, Kazakhstan UES has been running parallel to Russia's UES and ECO Central Asia.

Sixty-six energy-producing organizations are engaged in the manufacture and sale of electricity to consumers and wholesale power companies. The total installed capacity of Kazakhstan as of 1.01.2011 was 19,440.5 MW, and the available capacity was 15,291.0 MW. The power stations are divided into stations of national importance, industrial plants, and regional destination stations. Of the 66 stations, eight are of national importance. Eleven energy-producing organizations are part of the large industrial companies and participate with them in the production and supply of electric power.

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[4] Official Website of the KAZAKHSTAN ELECTRICITY GRID OPERATING COMPANY; available at www.KEGOC.kz.

The electric stations of national importance[5] include the following large thermal power plants to ensure the production and sale of electricity to the customers in the wholesale electricity market:

- LP Ekibastuz-1;
- JSC Ekibastuz GRES-2;
- JSC Eurasian Energy Corporation (Aksu TPP);
- LP GRES Kazakhmys Corporation;
- JSC Zhambyl GRES and a large hydroelectric power plant additionally used to control the following load curve EECs:
- Bukhtarminskaya HPP Kazzinc;
- LP AES Ust-Kamenogorsk HPP; and
- LP AES Shulbinskaya HPP.

The power stations of regional importance are CHP-integrated with the territory, in which electric energy is supplied through a network of regional power grid companies and power transmission organizations, and through the heat in nearby towns. The transmission sector is a combination of substations, switch gears, and their connecting lines (0.4-1150 kV voltage) for the transmission and (or) distribution of electric energy.

The total length of the 35-1150 kW power lines[6] is 23,321.967 km (circuits), including:

- 1150 kV - 1421.225 km;
- 500 kV - 5323.262 km;
- 220 kV - 15,975.912 km;

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[5] Ministry of Industry and New Technology of the Republic of Kazakhstan

[6] Official Website of the KAZAKHSTAN ELECTRICITY GRID OPERATING COMPANY; available at: www.KEGOC.kz.

- 110 kV - 558.668 km; and

- 35 kV - 42.9 km.

Kazakhstan UPS consists of three zones: North, South, and West. The North Zone includes the Akmola, Aktobe, Kostanay, Pavlodar, North Kazakhstan, East Kazakhstan, and Karaganda regions. The energy management in this area is combined through a common network, KEGOC, and has a relationship with the Russian power system.

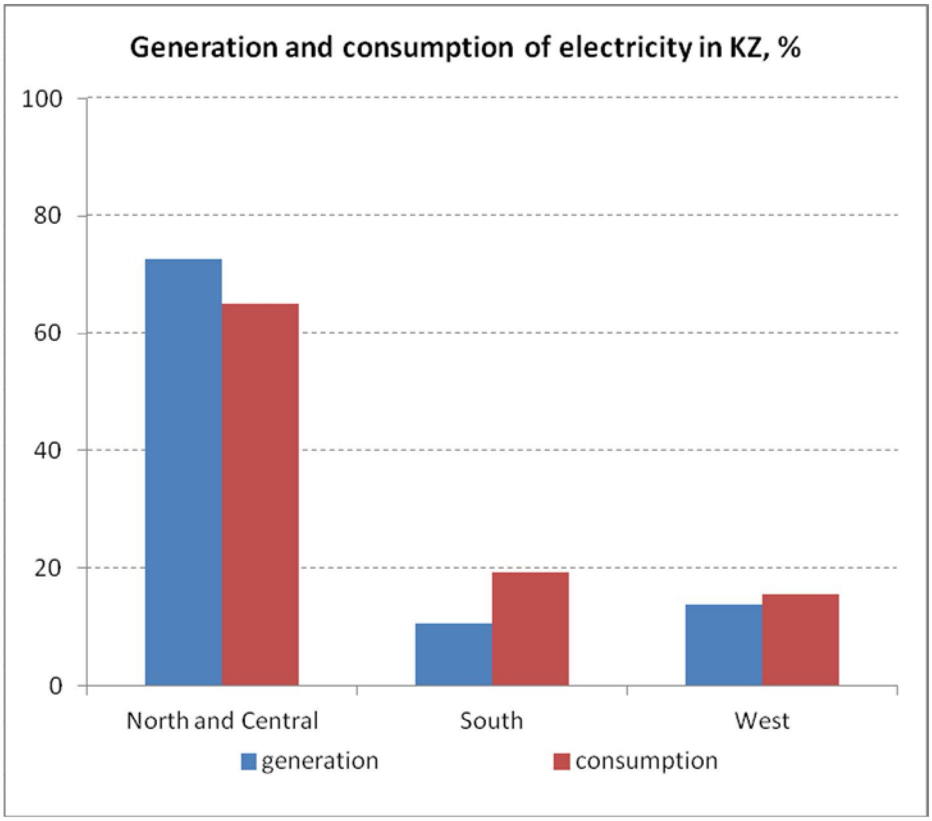
The South Zone includes the Almaty, Zhambyl, Kyzylorda, and South Kazakhstan regions and has a shared network via KEGOC and a connection with the power systems of Kyrgyzstan and Uzbekistan.

The West Zone consists of the Atyrau, West Kazakhstan, and Mangistau regions and has a shared network via KEGOC and a relationship with the Russian power system.

Table 1. Production and consumption of electricity in the zones

	2004	2005	2006	2007	2008	2009	2010
Electricity Production	66645,4	67572,3	71553,4	76365,0	80074,2	78433,7	82295,6
Including							
North Zone	53104,3	52444,5	55419,9	57872,6	59080,7	59723,7	65204,0
South Zone	6771,9	7106,2	7635,8	9224,0	10914,1	8161,1	8229,4
West Zone	6769,1	8021,6	8497,7	9268,3	10079,4	10548,9	8862,2
Electricity Consumption	64807,2	68129,0	71916,3	76440,0	80619,6	77959,7	83767,1
Including							
North Zone	43269,9	44831,6	47206,5	49695,0	52237,2	50813,5	58327,2
South Zone	12542,6	13727,5	14331,7	15523,0	16425,7	15016,2	16176,4
West Zone	8994,7	9569,9	10378,1	11222,0	11956,7	12130,0	9263,5

Source: Statistics Agency of the Republic of Kazakhstan



Source: Statistics Agency of the Republic of Kazakhstan

Coal deposits, the main fuel for electricity generation, are concentrated in Northern and Central Kazakhstan, where the main station was placed. The electricity production in the northern zone consistently exceeds the consumption (Table 1), creating a surplus, which is offered for the domestic market or for export to Russia.

The southern region does not have enough primary resources and power generation based on imported coal and gas. The growth rate of electricity consumption exceeds the growth rate of power generation. The energy deficit is covered by imports from Central Asia and supplies from the north. The transfer of surplus electricity from the northern zone only partially solved the energy supply problem of the south. Due to the high cost of electricity produced by Zhambyl GRES (the gondola runs on gas and fuel oil), it is not able to compete with other electricity suppliers from the northern zone or from Central Asia.

The West Zone covers the electricity deficit through imports from Russia. In October 2008, the commissioned section of the 248-km-long 500kV SK GRES-Shu in the implementation of the first phase of the project "Construction of the Second Line of 500kW-Power North-South Kazakhstan" connecting SS-500 and Shu SKGRES additionally supplied 100 MW power in the southern area, where there was power shortage.

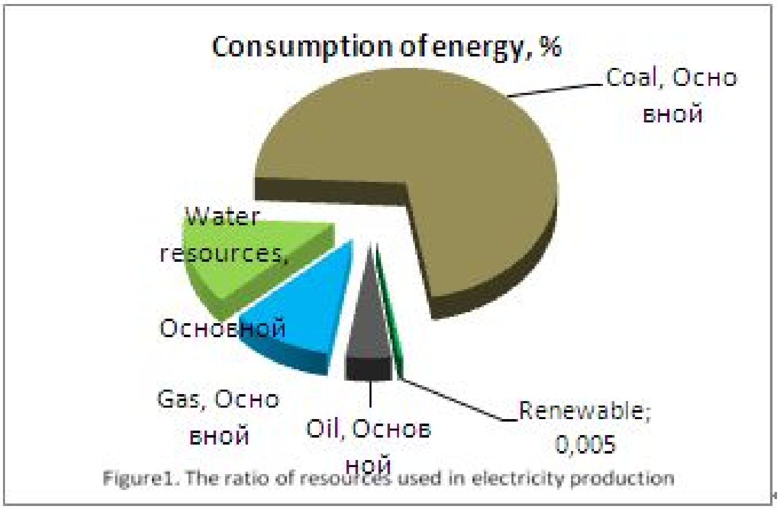
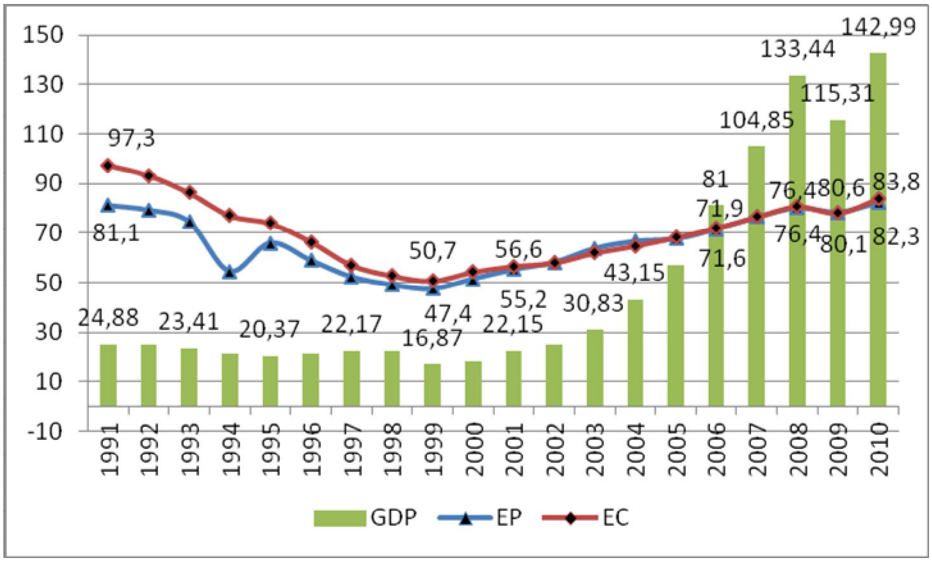


Figure1. The ratio of resources used in electricity production

Source: Statistics Agency of the Republic of Kazakhstan

2.2 Macroeconomic role of the electricity sector

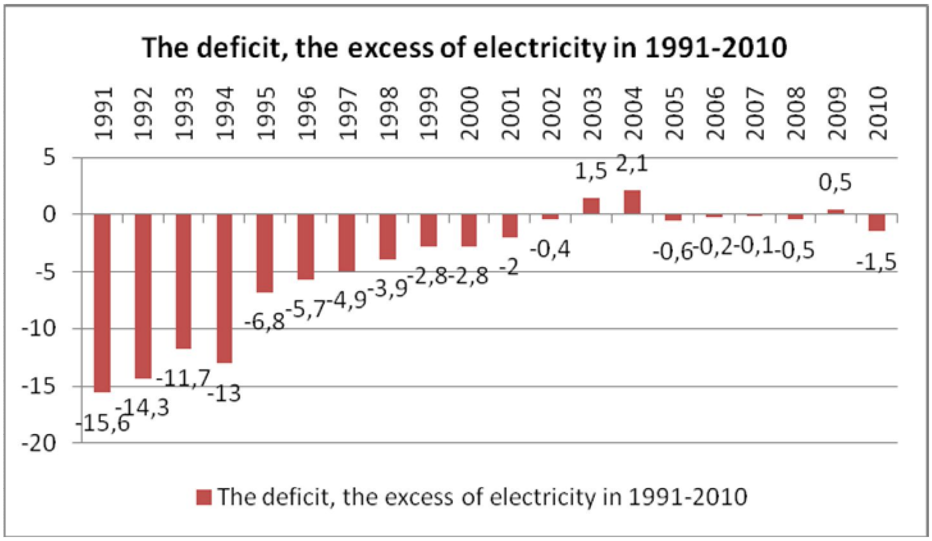
Electricity is a basic sector of the economy. The reliable and efficient operation of the industry and a stable supply of electricity and thermal energy are the bases of economic development and ensure civilized living conditions. The maximum level of electricity consumption was achieved in 1990: 104.7 billion kWh. The depreciation in 1992-1999 has led to a reduction in electricity production and consumption. There was a sharp, twofold decrease of kWh.



Source: Statistics Agency of the Republic of Kazakhstan and World Development Indicators

Figure 2. Electricity consumption and production.

To stabilize the economy and to realize a 10% average annual increase in 2000-2008, a steady 4-5% increase in electricity production and consumption was effected. In 2003, for the first time, the electricity generation exceeded the electricity consumption (Figure 3), and Kazakhstan began exporting electricity to Russia. The global financial and economic crisis partly explains why in 2009, the electricity consumption decreased by 3.3% compared to 2008, and amounted to 77.96 billion kWh. In 2010, the economic recovery led to the growth of electricity consumption to 83.8 billion kWh but failed to bring it to the level in 1990.



Source: Statistics Agency of the Republic of Kazakhstan

Figure 3. Deficit and excess electricity in 1990-2010.

The energy structure of the industry has decreased threefold, from 15.7% in 1995 to 4.6% in 2009. Half of the electricity demand was accounted for by industry, although compared to 1990, it decreased significantly (Table 2). The consumption shares of agriculture and transport also fell in 20 years. This can be explained by the structural changes that occurred in the economy, such as the fact that the contribution of agriculture to the country's GDP declined from 34.0% in 1990 to 6.7% in 2010, which led to a redistribution of the material, human, and financial resources across sectors.

Table 2. Electricity balance (unit: RK, billion kWh)

	1990	2000	2005	2006	2007	2008	2009
Electricity generation	87.38	51.62	67.85	71.66	76.6	80.33	78.71
Electricity imports	31.4	6.03	3.52	3.96	3.38	2.77	1.71
Consumption, total	104.72	54.37	67.72	71.88	76.67	80.61	78.04
Including							
Industry	63.96	33.58	43.33	45.97	48.61	50.71	48.5
Construction			0.69	0.76	0.85	0.97	0.97
Agriculture	13.7	2.65	2.35	2.41	2.45	2.42	2.33
Transport and communications	6.46	3.07	3.45	3.94	4.3	4.93	4.84
Other industries	12.42	8.96	10.95	12.15	13.27	14.48	14.96
Losses across a public network	8.19	6.91	6.94	6.65	7.19	7.11	6.46
Electricity exports			3.65	3.73	3.3	2.48	2.38

Source: Statistics Agency of the Republic of Kazakhstan

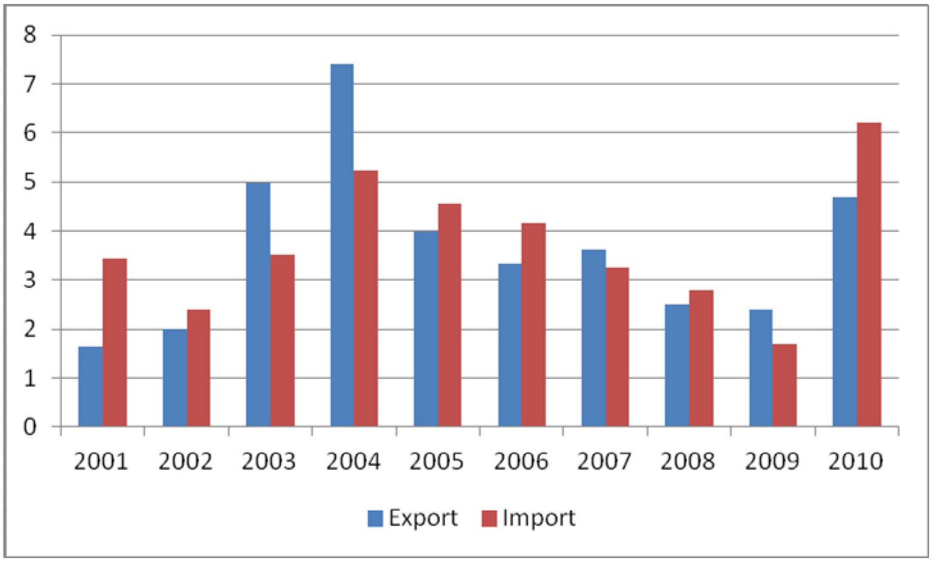
The main consumers of electricity are the major industries, accounting for 40% of the electricity consumption in 2010.[7] The electricity market is characterized by a high degree of concentration: the four power plants accounted for 43.3% of the total electricity production in 2010:

- Aksu GRES - 16.7%;
- LP Ekibastuz-1 - 14.2%;

[7] Statistics Agency and Ministry of Industry and New Technology of the Republic of Kazakhstan

- JSC Ekibastuz GRES-2 - 6.6%; and
- Karaganda GRES-2 Kazakhmys - 5.8%.

The Russian electricity exports to Kazakhstan decreased significantly due to the construction lines associated with the energy sources of the Aktobe region of Northern Kazakhstan. In the south, the electricity imported by Kazakhstan was mainly from Kyrgyzstan. According to KEGOC, in 2010, the electricity exports to Russia amounted to 1.54 billion kWh, and the electricity imports, 3.0 billion kWh (from Russia, 1.37 billion kWh; from Kyrgyzstan, 1.63 billion kWh) (Figure 4).



Source: Statistics Agency of the Republic of Kazakhstan

Figure 4. Electricity export and import (TWh).

For further economic growth to ensure the sustainable growth of electricity generation, the program aiming to develop the electric power of Kazakhstan from 2010 to 2014 forecasts a 4-4.5% annual growth in energy consumption.

Kazakhstan's economy is highly energy-consuming due to the country's severe climate and large distances. The basis of the energy strategies of developed countries is the energy conservation policy. The state's energy policy should be aimed not only at reducing the energy consumption but also to increase the energy efficiency. A comparison of the electricity intensity of Kazakhstan's GDP and other countries shows that Kazakhstan is far behind the developed countries with regard to this indicator.

2.3 Government policy with regard to electricity management

The concept of the power sector reform of Kazakhstan, developed in 1993, sets the direction of the industry restructuring. In 1995, the "On the Electric Power Industry"[8] law established the principles of the state regulation of the industry, which were:

- licensing of the activities in the fields of electric power generation, transmission, and distribution and in the electricity export-import operations;
- state regulation of prices (tariffs) for electricity;
- distribution of energy, including to the holiday consumers, in accordance with the existing agreements;
- demonopolization and privatization of electricity;

[8] Ministry of Industry and New Technology of the Republic of Kazakhstan

• state oversight of the reliability, safety, and efficiency of energy generation, transmission, distribution, and consumption; and

• establishment of mandatory rules relating to the generation, transmission, distribution, and consumption of electricity and heat as well as the reliability and safety of the construction of electric power plants, and their use.

In 1996, a program of privatization and restructuring was adopted in the electricity sector, which included the deregulation and further privatization of the state assets of the electricity sector. This program was implemented by the Energy Production Department of the National Energy System (NES), and under it, corporatization was studied. As a result, the program developed the following structure of the electricity sector:

• all the electric-power-related companies were transformed into joint stock companies (JSCs), which were given economic and legal independence;

• based on the 110kV- to 0.4kV-asset electric networks, JSC Electric Distribution Company (EDC) was created; and

• based on the assets of the electrical networks with higher voltage levels (1150, 500, and 220 kV) and Central Dispatch Administration of the UES of Kazakhstan, Kazakhstan Company Electricity Grid (Kazakhstan Electricity Grid Operating Company, KEGOC) was established.

Most power plants were privatized at an accelerated pace, as follows:

• large electric power companies of national importance were sold to strategic investors, including foreign ones;

• large hydroelectric power was conceded;

• industry's combined heat and power was generated at the time mainly to provide electricity and heat supply to large industrial complexes that referred to them for possession and control; and

• the combined heat and power, in general, was transferred to communal ownership and was privatized by different legal entities.

The program involving the further development of the electricity market in 1997-2000 defines a model organization of the electricity market, a phased government action plan on the development of the electricity market, and the tasks of the Ministry of Energy and Fuel Resources and KEGOC to self-regulate the competitive electricity market and to define the aims and methods of state regulation in this area. The national company KEGOC was entrusted as the organizer of the wholesale electricity market.

As a result, the power sector reform initiatives were identified:

• competitive parts – electricity production and consumption, provision of services by specialized companies (construction, installation, design, research, adjustment, etc.); and

• natural monopoly – electricity transmission and distribution; the "On Natural Monopolies" law determines the scope of regulation of natural monopolies in the electricity sector.

The program of electric power development until 2030 adopted in 1999 set out the aims of energy development: self-sufficiency in power and energy independence, creation of competitive energy resources, and development of a competitive electricity market.

The strategic directions of the development of the power industry provide the following:

- formation of the UES of Kazakhstan;
- restoration of parallel operation with Russia's UES and the energy systems of Central Asia;
- development of a model of the open competitive electricity market;
- maximization of the use of the existing energy sources, and their reconstruction and modernization;
- development of new capacity only as an import substitution;
- improvement of the structure of electricity generation through the development of alternative energy sources;
- reconstruction and modernization of heating systems with combined power and heat as energy-efficient technologies to significantly reduce the consumption of fossil fuels and reduce the greenhouse gas emissions; and
- introduction of modern, self-contained, high-quality sources of heat wherever it is economically and environmentally justified, compared with the combined heat and power and district heating from the boiler.

The program covered the issues and the development of alternative energy sources. Thus, plans to build 500MW wind farms[9]

[9] Ministry of Industry and New Technology of the Republic of Kazakhstan

(WEC) were established, and US$500 million was invested for this purpose.

The possibility of building a nuclear power plant (NPP) program predicted after 2020 the bases for the development of nuclear energy, which, according to the authors of the program, are the "existence of its own raw materials and mining industry (1), a developed industry of raw materials, the partial enrichment and production of the finished fuel (2), an engineering complex able to manufacture equipment and materials for the reactor (3), the scientific and technical potential and management device that can ensure the functioning of the complex as well as its manageability, control, and security (4)."

The use of associated gas from oil production was optimistically assessed. To create a gas turbine unit (GTU) utilizing associated petroleum gas with a total capacity of 500 MW, there is a plan to invest US$450 million. In general, investment in new capacity and rehabilitation of the existing power plants planned US$12.2 billion (Table 3).

Table 3. Approximate volume of investments for new power generation capacities

Activities		Power	Investments, million $
Expansion of Ekibastuz GRES-2	Input power units №3 and №4	To 525 MW	610
	Input power units №5 and №6	To 525 MW	950
South Kazakhstan TPS version of coal plants		4x320 MW	1600
Reconstruction and modernization of power plants	Until 2005	1816 MW	900
	Until 2010	4549 MW	2300

	Until 2030	4384 MW	2200
Expansion	Akmola HPP-2	185 MW	210
	Karaganda HPP -3	110-140 MW	
	Ust-Kamenogorsk HPP	80 MW	
Construction	Maynakskoy HPP	300 MW	520
	Kerbulak HPP	50 MW	
Construction of Semipalatinsk hydropower plants		78 MW	220
West Kazakhstan TPS		450 MW	400
Creation of a gas turbine plant utilizing associated petroleum gas		500 MW total capacity	450
Construction of small hydropower plants		600 MW total capacity	850-900
Construction of wind farm		500 MW total capacity	500
Expansion of Almaty HES-2, HES Atyrau, Shymkent HES-2, Zhambyl HES-4, Aktau HES-1, HES-2			400
Total			12060-12160

Source: Ministry of Industry and New Technology of the Republic of Kazakhstan

This would be considered the ability to export electricity to the west (Russia and Europe) and the south (southern Kazakhstan and Central Asia). The main disadvantage of this program was the fact such countries were not sources of funding for the project's implementation.

The program evaluates an indicative investment for new electric grid facilities. Later, in 2007, this program was adjusted to reflect the actual state of the industry and what is required for the development of new facilities and the modernization of the existing facilities.

The weaknesses of the program include the following facts about the electricity industry:

• significant deterioration of the resource-generating equipment that limits the electricity production of the existing power plants (CHP national park resources residual values ranging from 18 to 30%);

• lack of maneuverability of the electricity generation capacity to meet peak loads associated with a low share of hydropower stations (12-33%) in the structure of the electricity generation capacity;

• uneven distribution of the electricity generation capacity: 42% of the installed capacity is concentrated in the UPS Kazakhstan Pavlodar region);

• a high degree of wear of the electrical networks of the regional power companies (~65-70%);

• lack of a mechanism for the construction of new power plants; and

• dependence of Western Zone UPS Kazakhstan (West Kazakhstan, Atyrau region) on the electricity supply from Russia to the lack of electrical connections with UES Kazakhstan.

It features the electric power industry, including the union of the Western Zone with the main part of the UES of RK, achieving energy security in individual regions, establishment of an input capacity market, providing self-sufficient domestic energy resources in the region, increasing the export and transit facilities, and measures to increase the investment attractiveness of the industry.

The “On the Support of Renewable Energy” law and the “On Amendments and Additions to Some Legislative Acts of the Republic of Kazakhstan on the Support of Renewable Energy Sources” were adopted on 07.04.2009, under the renewable energy sources means continuously renewed by naturally occurring natural processes: solar, wind, and hydrodynamic energy of water for plants with a capacity of 35 MW.

The draft law “On Energy Saving and Energy Efficiency” was approved by the government of Kazakhstan on August 27, 2011. The bill aims to reduce the energy intensity by at least 10% by 2015 and by 25% by 2020, through the effective use of energy resources.

Chapter 3. Literature Review

3.1 Previous research - Electricity use and economic growth

The causal relationship between energy use and output growth has been a debated subject of the extensive empirical literature in the past three decades, but no common consensus on the existence or direction of the causal relationship between energy use and output growth has emerged. This depends on the institutional, structural, and policy differences of the countries under consideration, the variety of variables and the data span chosen, and the differences in method used. The aim of this chapter is to summarize the empirical literature of the causal relationship between electricity consumption and economic growth, and to present the inconsistencies of these studies.

After being suggested by Granger (1969), the cointegration and causality methods became widespread as an analytical tool to determine the causal relationship between the energy consumption and economic growth of countries. The pioneering study of Kraft and Kraft (1978) using this technique finds the unidirectional causality running only from the gross national product (GNP) to the energy consumption for the United States over the period 1947-1974. Therefore, the economy is not energy-dependent. It implies that the policies reducing energy consumption may be implemented with little adverse or no effect on economic growth.

Yu and Choi (1985) examined the causal linkage between GNP and the aggregate and several disaggregate categories of energy consumption, including solid fuels, liquid fuels, natural gas, and others (i.e., hydro, nuclear, electricity) for five countries with various stages of economic development for the time period 1950-1976 based on the Sims and Granger tests of causality. This study indicated unidirectional causality from aggregate energy consumption to GNP for the Philippines, and from GNP to aggregate energy consumption for South Korea, but no causality in either direction for the U.S., the United Kingdom (UK), and Poland. If causality runs only from energy consumption to GNP, it implies that the economy is energy-dependent, and that energy shortage may negatively affect economic growth. Erol and Yu (1987) used the results of the Sims and Granger causality tests between energy consumption and GNP in some industrialized countries for the period 1950-1982 to conclude that there is a unidirectional causality running from energy consumption to GNP for Canada, from GNP to energy consumption for both West Germany and Italy, neutrality of energy consumption with respect to GNP for France and UK, and bidirectional causality in Japan. Many authors have expanded and diversified these pioneering studies. That is, energy consumption has been disintegrated into its subcomponents, and the relationship between GDP and these subcomponents has been investigated, such as with oil and electricity consumption. During this process, depending on the developments in the econometrics techniques, the Granger causality test was applied as a single method or with a variety of cointegration methods.

The studies that have examined electricity consumption and economic growth in the causality framework can be seen in Table 4. As can be seen in the table, different results have been obtained regarding the direction of causality. The differences in the causality results allows for four hypotheses[10]:

(1) the "neutrality hypothesis" (if no causality exists between GDP and energy consumption, then energy consumption is not correlated with GDP;

(2) the "conservation hypothesis" (the unidirectional causal relationship moves from GDP to energy consumption);

(3) the "growth hypothesis" (the unidirectional causal relationship moves from energy consumption to GDP); and

(4) the "feedback hypothesis'' (if there is a bidirectional causal relationship between GDP and energy consumption).

Whether or not electricity consumption positively affects the GDP, the relationship is crucial for electricity conservation policies (Narayan & Smyth, 2005b; Ghosh, 2002). If a positive unidirectional causal relation from electricity consumption to GDP does not exist, then this provides a basis for electricity conservation policies, such as electricity rationing. In the absence of this causal relationship, the implication is that a country is not dependent on electricity for growth and development. If a unidirectional causal relationship runs from electricity consumption to GDP, then reducing the electricity consumption could lead to a decrease in economic growth. This implies that a negative shock to electricity consumption leads to higher electricity prices or electricity conservation policies and has a negative impact on the GDP (see Narayan & Singh, 2007). Payne (2010) emphasized the bidirectional causality test results.

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[10] Mudarissov B.A. (2012). "Energy consumption and economic growth in Kazakhstan."

Table 4. Empirical results of causality studies

Author(s)	Country	Period	Method	Main Variables	Causality
Conservation Hypothesis					
Erol and Yu (1987)	Germany, Italy	1952-1982	Sim's causality analysis, Granger causality	GDP, energy consumption	Y → ENR
Yu and Hwang (1984)	USA	1947-1979	Sim's causality analysis	GNP, electricity consumption	Y → EC
Ghosh (2002)	India	1950-1997	Granger causality	GDP, electricity consumption	Y → EC
Yoo (2006)	Indonesia, Thailand	1971-2002	Johansen-Juselius cointegration	GDP, electricity consumption	Y → EC
Mozumder and Marathe (2007)	Bangladesh	1971-1999	Cointegration and error correction model	GDP, electricity consumption	Y → EC
Zhang and Cheng (2009)	China	1960-2007	Granger causality	GDP, electricity consumption	Y → EC
Chen, Quo, and Chen (2007)	India, South Korea, Malaysia, Philippinnes, Singapore	1971-2001	Cointegration, Granger causality	GDP, electricity consumption	Y → EC
Cheng (1998)	Japan	1952-1995	Hsiao's Granger causality	GDP, electricity consumption	Y → EC
Cheng (1999)	India	1952-1995	Cointegration, ECM, Granger causality	GDP, electricity consumption	Y → EC
Aqeel and Butt (2001)	Pakistan	1955-1996	Hsiao's version of the Granger causality method, cointegration	GDP, electricity consumption	Y → EC
Ghosh (2009)	India	1970-71 to 2005-06	ARDL, Granger causality	GDP, electricity supply	Y → EC
Ang (2008)	Malaysia	1971-1999	Johansen cointegration, VEC model	GDP, electricity supply	Y → EC
Zachariadis (2007)	Canada, UK	1960-2004	Granger causality, VAR, error correction, ARDL	GDP, electricity supply	Y → EC

Masih, Masih (1996)	Indonesia	1955-1990	Granger causality	GDP, electricity supply	Y → EC
Growth Hypothesis					
Erol and Yu (1987)	Canada	1952-1983	Sim's causality analysis, Granger causality	GDP, energy consumption	ENR → Y
Bowden and Payne (2009)	USA	1949-2006	Toda-Yamamoto long-run causality tests, Granger causality	GNP, electricity consumption	EC → Y
Shiu and Lam (2004)	China	1971-2000	Error correction model	GDP, electricity consumption	EC → Y
Yoo (2006)	Malaysia	1971-2002	Johansen-Juselius cointegration	GDP, electricity consumption	EC → Y
Yoo (2006)	Singapore	1971-2002	Johansen-Juselius cointegration	GDP, electricity consumption	EC → Y
Yuan, Zhao, Yu, and Hu (2007)	China	1978-2004	Cointegration and error correction model	GDP, electricity consumption	EC → Y
Chen, Quo, and Chen (2007)	Indonesia	1971-2001	Cointegration, Granger causality	GDP, electricity consumption	EC → Y
Narayan and Prasad (2008)	Czech Republic, Italy, Portugal, Slovak Republic	1960–2002	Bootstrapped Granger causality	GDP, electricity consumption	EC → Y
Masih, A. and Masih, R. (1996)	India	1955-1990	Granger causality	GDP, electricity consumption	EC → Y
Murray and Nan (1996)	Turkey	1970-1990	Granger causality	GDP, electricity consumption	EC → Y
Lee, Chang (2005)	Taiwan	1955-2003	Granger causality, cointegration, VECM	GDP, electricity consumption	EC → Y
Thoma, M. (2004)	USA	1973-2000	Causality	GDP, electricity consumption	EC → Y
Glasure, Lee (1998)	Singapore	1961-1990	Cointegration, error correction	GDP, electricity consumption	EC → Y

Soytas et al. (2001)	Turkey	1960-1995	Cointegration, Granger causality	GDP, electricity consumption	EC → Y
Feedback Hypothesis					
Erol and Yu (1987)	Japan	1952-1984	Sim's causality analysis, Granger causality	GDP, energy consumption	EC←→Y
Hwang and Gum (1991)	Taiwan	1961–1990	Cointegration, error correction	GNP, energy consumption	EC←→Y
Narayan and Prasad (2008)	Iceland	1960–2002	Bootstrapped Granger causality	GDP, electricity consumption	EC←→Y
Paul and Bhattacharya (2004)	India	1950-1996	Cointegration and Granger causality	GDP, electricity consumption	EC←→Y
Mishra, Smyth, and Sharma (2009)	Pacific Island	1980-2005	Panel cointegration, Granger causality	GDP, electricity consumption	EC←→Y
Mahadevan, Asafu-Adjaye (2007)	20 countries	1971-2002	Panel VECM	GDP, electricity consumption	EC←→Y
Ghali, El Sakka (2004)	Canada	1961-1997	Multivariate cointegration analysis	GDP, electricity consumption	EC←→Y
Yang (2000)	Taiwan	1954-1997	Granger causality	GDP, electricity consumption	EC←→Y
Masih, Masih (1996)	Pakistan	1955-1990	Granger causality	GDP, electricity consumption	EC←→Y

A common problem associated with bidirectional analysis, however, is the possibility of omitted variable bias, which draws into question the validity of the inferences of a causal relationship. Furthermore, with the exception of the studies by Wolde-Rufael (2006), Squalli (2007), and Tang (2008), the past studies did not examine the coefficients with respect to both the sign (positive or negative) and the magnitude of the relationship between electricity consumption and economic growth (Payne, 2010).

Among the first studies conducted to investigate the relationship between economic growth and energy consumption in Kazakhstan was that carried out by Nicholas Apergis and James E. Payne (2009) within a multivariate panel data framework. They found a cointegrated relationship between energy consumption and economic growth in the Commonwealth of Independent States (CIS, including Armenia, Azerbaijan, Belarus, Georgia, Kazakhstan, Kyrgyzstan, Moldova, Russia, Tajikistan, Ukraine, and Uzbekistan) over the period 1991-2005. The results of the error correction model reveal the presence of unidirectional causality from energy consumption to economic growth in the short run and bidirectional causality between energy consumption and economic growth in the long run. The results support the feedback hypothesis associated with the relationship between energy consumption and economic growth. The feedback hypothesis asserts that energy policies that improve the efficiency in the production and consumption of energy may not have a detrimental impact on economic growth but may also enhance the environmental quality as such policies will curb excessive energy consumption and the use of inefficient energy production methods. In the case of CIS, the data revealed a great deal of variation across the countries in terms of the level of economic development as well as the composition of energy production and usage.

The research conducted by A. M. Bauyrzhan (2011), using the VECM and Granger causality methods, showed that a unidirectional causal relationship runs from energy use to GDP in the long run, and that a unidirectional Granger causality flow runs from GDP to energy use in the short term. The result of energy consumption leads to economic growth in the long-term perspective, which means that Kazakhstan has an energy-dependent economy and that more energy is required to foster economic development. This also implies that an increase in energy consumption may boost the country's economic growth, and that the application of strong energy conservation policies can hinder the economic growth.

In any case, there have been no studies on the relationship between economic growth and electricity use in Kazakhstan. All the studies that have so far been conducted studied energy in general, including electricity and such sectors as oil, gas, and mineral resources. In this study, only electricity use (electricity generation and consumption, to cover the impact of exports and imports) was employed, and the relationship between the other energy sources and the GDP of Kazakhstan was estimated to determine if the country's electricity activity differs from its consumption of other energy sources in terms of the relation with economic growth.

Chapter 4. Method

The following chapter describes the method part, particularly the unit root test, cointegration test, VECM, and Granger causality, to attain the aim of this study.

4.1 Stationarity and integration

Before the 1970s, the models of econometrics were basically built on the assumption of time series stationarity. When an economic time series is non-stationary, the coefficients may have different distributions, and therefore, the regression may not be reliable. According to Stock and Watson (1989), the causality test is sensitive to the time series stationarity of Kazakhstan's GDP and energy consumption.

Stationarity requires the mean, variance, and autocovariance 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 if its $\mathrm{Var}(x_t)$ does not appear to systematically change over time. In this case, it will tend to fluctuate around the mean $E(x_t)$ steadily. A series x_t, on the other hand, is said to be non-stationary if it has a non-constant mean $E(x_t)$ and if its variance $\mathrm{Var}(x_t)$ appears to be systematically changed over time. If the difference of a non-stationary series is stationary, the series is said to be integrated (i.e., $I(1)$). If a non-stationary series has to be differenced d times to become stationary, then it is said to be integrated to the d order (i.e., $I(d)$). Only when two series are integrated in the same order can a test for the presence of cointegration be conducted.

The following is the regression equation:

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

where ε_t is the residual (the same as the following). Then the null hypothesis H_0: $\rho=1$ (x_t is non-stationary) is tested against H_1: $\rho<1$ (x_t is stationary).

4.2 Cointegration

Statistically, the long-term equilibrium between non-stationary series is called *cointegration*. This indicates that even though two series have their own fluctuating features, there can be a long-term equilibrium between them as long as they are cointegrated. Only in this case is it reliable to conduct regression on them.

According to Engle and Grange (1987), if two series are both non-stationary but are integrated in the same order, and if there is a linear combination within them that is stationary, then the two series are cointegrated, and the relationship between them is defined as cointegration. Only when two series are integrated in the same order can they be tested for the presence of cointegration.

According to the two-step method developed by Engle and Granger in 1987, if two series, x_t and y_t, have been found to be non-stationary, but both of them are integrated in the same order, the regression equation can be set up as

$$x_t = \alpha + \beta y_t + \varepsilon_t, \tag{2}$$

and the cointegration between x_t and y_t can thereby be tested by examining the stationarity of the residual ε_t. If x_t and y_t are not cointegrated, any one of their linear combinations will be non-stationary, and therefore, the residual ε_t will also be non-stationary. Contrariwise, if the residual ε_t is found to be stationary, then the cointegration between x_t and y_t can be justified.

4.3 Vector autoregressions (VARs)

Vector autoregression (VAR) is commonly used for forecasting systems of interrelated time series and for analyzing the dynamic impact of random disturbances on the system of variables. The VAR approach sidesteps the need for structural modeling by treating every endogenous variable in the system as a function of the lagged values of all the endogenous variables in the system.

The mathematical representation of VAR is

$$y_t = A_1 y_{t-1} + \cdots + A_p y_{t-p} + B x_t + \epsilon_t, \quad (3)$$

where y_t is a k vector of the endogenous variables, x_t is a d vector of the exogenous $A_1 \ldots A_p$ variables, B is a matrix of the coefficients to be estimated, and ϵ_t is a vector of the innovations that may be contemporaneously correlated but are uncorrelated with their own lagged values and uncorrelated with all the righthand-side variables.

As an example, suppose that industrial production (IP) and money supply (M1) are jointly determined by VAR, and let a constant be the only exogenous variable. It may be written as

$$IP_t = a_{11} IP_{t-1} + a_{12} M1_{t-1} + b_{11} IP_{t-2} + b_{12} M1_{t-2} + c_1 + \epsilon_{1t}, \quad (4)$$

$$M1_t = a_{21}IP_{t-1} + a_{22}M1_{t-1} + b_{21}IP_{t-2} + b_{22}M1_{t-2} + c_2 + \epsilon_{2t}, \quad (5)$$

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

4.4 Vector error correction model

As mentioned in the "Cointegration Test Methods" section, the spurious regression problem is also considered when analyzing the causality. If cointegration exists among the non-stationary variables, the causality analysis based on VECM must be conducted.

Consider a bivariate vector of the integrated order one, and assume that Y_t is 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) with the following equations:

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

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

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.

While the causality analysis using the VAR model is able to present only one causal path, the causality analysis using VECM is able to present three types of causal path: short-run, long-run, and strong (joint) causality. The short-run causality tests the statistical significance of the two types of hypotheses, as in the VAR case (test on γ^{j}_{12} and γ^{j}_{22} for the above equations), and the long-run causality tests the hypothesis of both short- and long-run causality (and for the above equations) (Kim, Jinsoo, 2010).

4.5 Granger causality

In this 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 y_t, only the past information of both x_t and y_t can be used. According to the Granger causality test, there is causality from x_t to y_t if the past information of x_t can help forecast y_t more precisely.

When applying to the Granger causality test, the bivariable autoregression model is first set up, as follows:

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

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

Then F Test is carried out to test the null hypothesis H_0: β_i (i=1,2,…,m)=0, which is equal to the hypothesis that "x_t has no Granger causality to y_t." If H_0: β_i (i=1,2,…,m)=0 is rejected, then the hypothesis "x_t has no Granger causality to y_t" can also be rejected, and it can thereby be concluded that x_t has no Granger causality to y_t. Similarly, the hypothesis H_0: β_j (j=1,2,…,m)=0 can be tested to verify if there is Granger causality from y_t to x_t.

Chapter 5. Empirical Analysis

5.1 Unit root test

To illustrate the above methodology, the relationship between electricity use and real gross domestic product (GDP) for Kazakhstan was estimated. The yearly data on electricity use and GDP from 1991 to 2010 was collected from the World Bank (2011) and the Statistics Agency of the Republic of Kazakhstan's online database (annual report), respectively. The electricity consumption (EC) and energy use without electricity (EU) was measured in million tonnes of oil equivalent, and the GDP was measured in constant price (2000) and was denominated in millions of U.S. dollars. In conducting the test, the variables were divided into two groups: EC and GDP, and EU and GDP. Empirical analysis was done using the EVIEWS 7.0 statistical package.

As has been mentioned, the stationarity of the series is necessary to carry out the cointegration and causality tests. The analysis of the time series variables used in the study (EC, EU, and GDP) to test the stationarity of the series over time and to determine the degree of integration is based on the well-known Augmented Dickey Fuller and Phillips-Perron unit root tests.

The results reported in Table 5 clearly show that the unit root test does not reject the null hypothesis for the variables in all levels. The unit root test was further applied to the first differences in the variables, and the results reject the null hypothesis, which implies that the levels are non-stationary and that the first differences are stationary.

Table 5. Unitroot test results

Variables	Model		Critical Value			Test Statistics	p-value	Lag/ Bandwidth
			1%	5%	10%			
EC	ADF	Level	-3.92035	-3.065585	-2.673459	-1.991421	0.2871	3
		1st difference	-3.857386	-3.040391	-2.660551	-1.456446	0.5318	0
	PP	Level	-3.831511	-3.02997	-2.655194	-1.911993	0.3201	3
		1st difference	-3.857386	-3.040391	-2.660551	-1.22049	0.6415	3
EU	ADF	Level	-3.886751	-3.052169	-2.666593	-1.4953	0.5116	2
		1st difference	-3.886751	-3.052169	-2.666593	-1.388351	0.563	1
	PP	Level	-3.831511	-3.02997	-2.655194	-1.199948	0.6519	2
		1st difference	-3.857386	-3.040391	-2.660551	-3.180901	0.0383	2
GDP	ADF	Level	-3.959148	-3.081002	-2.68133	-2.911647	0.0674	4
		1st difference	-3.92035	-3.065585	-2.673459	-2.279136	0.1895	2
	PP	Level	-3.831511	-3.02997	-2.655194	1.776649	0.9993	1
		1st difference	-3.857386	-3.040391	-2.660551	-3.363606	0.0268	2

*, **, and *** indicate the rejection of the null hypothesis at the 10, 5, 1% levels.
p-value
Null hypothesis: has a unit root
Lag is automatic based on SIC (Schaward infor criterion), Maxlag=4

5.2 Cointegration

Another test was conducted for the presence of a long-run cointegration relationship between the variables. Given the sample size, a maximum lag length of one was considered, and the model was tested downwards. The optimal lag length was found to be one based on the SC model selection criterion in Table 6. The lag structure was used for the remaining analyses.

Table 6. Selection of lag length for the cointegration test

EC GDP						
Lag	**LogL**	**LR**	**FPE**	**AIC**	**SC**	**HQ**
0	-219.6627	NA	7.26E+08	26.07797	26.17599	26.08771
1	-180.7938	64.01933*	12084809	21.97575	22.26982*	22.00498
2	-175.6781	7.222174	10902838	21.84449	22.33461	21.89321
3	-170.1506	6.502956	9751230.*	21.66478*	22.35096	21.73299*

EU GDP						
Lag	**LogL**	**LR**	**FPE**	**AIC**	**SC**	**HQ**
0	-255.5598	NA	4.95E+10	30.30115	30.39918	30.3109
1	-220.3616	57.97347	1.27E+09	26.63078	26.92486	26.66001
2	-216.5117	5.435202	1.33E+09	26.64844	27.13856	26.69716
3	-205.1853	13.32514*	6.01e+08*	25.78651*	26.47269*	25.85472*

* indicates the lag order selected based on the criterion.
LR: Sequential modified LR test statistic (each test at a 5% level)
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

The cointegration rank r of the time series was tested using two test statistics. By indicating the number of cointegrating vectors as r_0, the maximum eigenvalue (λ_{max}) was calculated under the null hypothesis H_0: $r_0=r$ against the alternative hypothesis H_1: $r_0>r$. The trace test was conducted under H_0: $r_0 \leq r$, against H_1: $r_0>r$. Table ___ shows the results of the Johansen maximum likelihood cointegration tests. Hence, the presence of cointegration between per-capita energy and per-capita GDP was determined. It can be seen here that the maximal eigenvalue statistics is 8.875828 (EC GDP), which is below the 5% critical value of 17.14769 (EC GDP). Hence, at the 5% significance level, the null hypothesis of r0=0 is rejected. There is a similar situation with the trace test: the null hypothesis of no cointegration was accepted at the 5% significance level. Consequently, it is implied that at the 5% significance level, the hypothesis of no cointegrating equation is accepted.

Under H0: r0≤1, however, the trace and maximum eigenvalue statistics are equal to 6.015643 (EC GDP), which are above the 5% critical value of 3.841466 (EC GDP). Therefore, the null hypothesis at the 5% significance level is rejected. This indicates that there is no cointegrating equation between the two time series.

It can also be seen here that the maximal eigenvalue statistics is 14.9782 (EU GDP), which is above the 5% critical value of 14.2646 (EU GDP). Hence, at the 5% significance level, the r0=0 null hypothesis is rejected. There is a similar situation with the trace test: the null hypothesis of no cointegration was accepted at the 5%

significance level. Consequently, it is implied that at the 5% significance level, the no cointegrating equation hypothesis is rejected.

Under H0: r0≤1, however, the trace and maximum eigenvalue statistics are equal to 3.6981, which are below the 5% critical value of 3.841466 (EU GDP). Therefore, the null hypothesis at the 5% significance level is accepted. These results imply that the EU and GDP series have one cointegrating equation; in other words, they have a long-run relationship.

Table 7. Cointegration test results

	No. of cointegrations	Eigen value	Trace Test		Maximum Eigenvalue	
			Trace statistics	5% critical value	Max. eigen statistics	5% critical value
EC GDP	None	0.57472	17.64396	18.39771	13.68011	17.14769
	At most 1	0.219438	3.96385	3.841466	3.96385	3.841466
EU GDP	None	0.60786	18.6763	15.49471	14.9782	14.2646
	At most 1	0.206365	3.6981	3.841466	3.6981	3.841466

*(**) denotes rejection of the hypothesis at the 5% significance level.

5.3 Granger causality test

The frequent practice in analyzing the direction of causality between electricity consumption and GDP is to use a cointegration test on the integrated series. The crucial question in this study, however, is that there is no cointegration between electricity consumption and economic growth in Kazakhstan. To test the causality between electricity use and real GDP, a standard Granger-type causality test can be used on the stationary data, where stationarity is achieved by differencing the data. On the other hand, the VAR test can also be applied.

This table shows the results of the Granger causality tests in the VAR structure. The null hypothesis of non-causality from EC to GDP cannot be rejected at the 5% significance level. At the same time as testing the non-causality from GDP to EC, the null hypothesis cannot be accepted at the 5% significance level. These results imply the existence of unidirectional causality running from GDP to electricity consumption, without any feedback effect.

Table 8. Estimated VAR results

	EC	GDP
EC(-1)	0.781108	-1695.227
	-0.07077	-2542.52
	[11.0376]	[-0.66675]
GDP(-1)	6.81E-06	1.139534
	-2.20E-06	-0.08079
	[3.02622]	[14.1048]
C	0.955348	10304.77
	-0.41329	-14848.6
	[2.31155]	[0.69399]

Table 9. Results of the Granger causality test

Dependent variable: EC			
Excluded	Chi-sq	df	Prob.
GDP	9.158009	1	0.0025
All	9.158009	1	0.0025

Dependent variable: GDP			
Excluded	Chi-sq	df	Prob.
EC	0.444557	1	0.5049
All	0.444557	1	0.5049

The cointegration found between EU and GDP implies the existence of causality in the long run and in at least one direction. It does not show, however, the direction and short-term perspective of a causal relationship between energy use and economic growth.

Therefore, to identify these, there is a need to apply the VECM-based causality tests.

Table 10. Granger causality test result from the VECM model

	Short term		Long term	
Dependent variable: D(EU)				
Excluded	Chi-sq	Prob>chi2	T-statistics	Prob>t
D(GDP)	9.92734	0.0192	-0.01632	0.89946
Dependent variable: D(GDP)				
D(EU)	6.222806	0.1013	1.95374	0.01809

According to the test result of Table 10 on the short-term causality at the 1% level, the "GDP does not Granger-cause EU" null hypothesis can be rejected, and the unidirectional causality running from per-capita GDP to per-capita energy use can be found. As the opposite is true in the case of a long-term relationship at the 5% significance level, the null hypothesis "EU does not Granger-cause GDP" can be rejected, and a unidirectional causal relationship running from energy use to GDP is shown.

The results imply that the long-run relationship between non-electricity energy use (consumption) and economic growth is consistent with the "growth hypothesis" theory. Therefore, the more the energy used, the better the economic growth will be. On the other hand, in the short term, the opposite directional relationship between energy use and economic growth was obtained. This means that the energy conservation policy should be taken into account to maintain the country's economy.

Chapter 6. Policy Implications and Conclusion

In this study, the causal relationship between growth in electricity consumption and economic growth in Kazakhstan was investigated, and other energy uses, excluding electricity consumption, were compared in terms of relation with economic growth. The fact that a unidirectional causality running from GDP to electricity use exists in Kazakhstan was discovered through several empirical steps.

The empirical results of this study confirm the absence of a long-term equilibrium relationship between electricity consumption and economic growth in Kazakhstan but the existence of unidirectional causality running from economic growth to electricity consumption when examined in a vector autoregression structure.

On the other hand, there is a bidirectional relation between “EU (non-electricity energy use)” and “GDP.” Non-electricity energy use is the growth engine for Kazakhstan, and an energy conservation policy can be harmful to economic growth. Instead, a policy for clean-energy development (promotion) is recommended.

The previous studies have shown long-term unidirectional causality running from energy use to GDP, and unidirectional flow Granger causality running from GDP to energy use in the short term. When energy consumption leads to economic growth in the long-term perspective, it means that Kazakhstan has an energy-dependent economy and that more energy is required to foster economic development. This also implies that an increase in energy consumption may boost economic growth, and that the application of strong energy conservation policies can negatively affect the economic growth in the long term.

This study is helpful in developing appreciation for the role of electricity power in the process of improving economic growth. The result of this study implies that Kazakhstan is less electricity-dependent that electricity conservation policies may be designed without affecting the economic growth negatively in the short term. This study has important policy implications on Kazakhstan's electricity policy. Energy is an important input of economic growth. Economic growth causes expansion in the industrial sector.

In this case, decision makers may implement many electricity policies, such as those pertaining to the establishment of a new tariff structure, renewal of the existing electricity infrastructure, and reduction of the excess electricity demand, which decrease electricity use without affecting the final benefit. There may still be a considerable untapped efficiency improvement potential, however, that will require more direct policy involvement in the future.

The rational use of electricity and energy, finding and developing alternative energy sources, and introducing energy-saving technologies should be key priorities for policy implementation in Kazakhstan. These measures will not only facilitate the positioning of the independent Kazakhstan in the international arena as well as pave the way for the country's fuel and energy security but will also stimulate the general development of the Kazakh economy.

For the future studies, the use of more data with either multivariate models for total electricity use or bivariate models for disaggregated electricity use in the industrial, residential, and transport sectors is suggested.

The main problem of this study was data limitation. The initial aim of this study was to investigate the causal relationship between the electricity consumption and GDP of Kazakhstan from the time of the Soviet Union (1970) until today. Due to the lack of available data, however, the range of variables is not good enough to obtain accurate results.

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