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Determinants of Economic indicators for Electricity Consumption in Pakistan

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Abstract: Economic Growth is often cited as a driving force behind electricity consumption. Pakistan has an under-developed Electricity Sector, and this restrains the economic activities in the country. Load-shedding, *which are power outages scheduled by the government*, are a frequent occurrence, and these outages affect all sectors of the Pakistani economy. The Energy Crisis (based on electricity shortage), Pakistan faces have serious implications for its economic growth. This study examines the relationship between the consumption of electricity and growth in economic variables such as agriculture, manufacturing and service sectors. It also looks at how increase in population and urbanization quantify the pressure on the electricity resources of Pakistan. The Empirical Approach is based on VAR-model estimation for short-run analysis and Vector Error Correction Model for long-run analysis; from period 1960 to 2009. The empirical results suggest that in the short-run agriculture growth significantly and positivity effects energy consumption. In the long-run GDP growth leads to increase in electricity consumption; this affirms with the previous studies. Services sector growth is found to be the driving-force for electricity consumption, and in demographical indicators urbanization growth and population growth have great impact on the growth of electricity consumption.

Electricity Consumption: *Total amount of electricity used in Pakistan's economy. It includes hydropower, coal, oil, gas, and nuclear power generation,* ***Electricity Demand:*** *Actual requirement of electricity in Pakistan's economy,* ***Electricity Demand Supply Gap or Electricity Crisis:*** *The difference between electricity demand and electricity consumption.*

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1. Research Questions

- Analysis of the major causes of the current electricity crisis that Pakistan faces? How is the economy of Pakistan suffered as a result of this crisis? What are the possible short-term and long-term solutions?
- Electricity consumption as a function of economic growth: Determination of critical economic indicators in quantifying the electricity consumption, for aiding policy planning in electricity sector of Pakistan.
    1) Causality Relationship between Electricity Consumption and Gross Domestic Product (GDP) in Pakistan. I wish to investigate the effect that Gross Domestic Product (GDP) has on Electricity Consumption.

    2) The impact of the increase in the growth rates of the Manufacturing, Agriculture, and Service sectors of the economy, on the Consumption of Electricity.
- What is the impact of the growth in Population and Urbanization on the Electricity Consumption in Pakistan? Pakistan has experienced a rise in both, the growth rate of Population and the growth rate of Urbanization, and I wish to analyze how these factors have influenced the Electricity Consumption of the country.

2. Aim and Justification

Why I plan to study this and what's its significance? To cope with the increasing *electricity demand* and rapid economic growth in Pakistan, the causal relationship between electricity consumption and other economic indicators should be investigated in order to facilitate policy making.
This study aims is to take broader approach in assessing the relationship between electricity consumption and GDP growth, manufacturing growth, agriculture growth, and services growth. As well as electricity consumption with respect to population growth rate, and urbanization growth rate. Pakistan, in recent times has experienced a

high population growth coupled with rapid urbanization, economic growth and high electricity consumption. The paper is unique in its approach due to its focus on electricity crisis, as well as including demographic factors such as urbanization and population. This would also help in cross-examination between economic sectors and demography, e.g. agriculture sector part in electricity consumption, and rural areas population role in agriculture sector. Previous researchers studied how economic growth was linked to energy consumption and mostly included energy sector as a whole. But to understand the base of the problem it is important to take electricity sector figures, because the problem rests in 'electricity' not the energy. Thus this research can be referred to as a pioneering effort to cover the gap in energy literature. Although we can refers to *electricity crisis as energy crisis*, because electricity lies within the energy sector.

I plan to use the times series analysis cointegration approach for investigating the causal relationship between disaggregate energy (electricity) and economic growth. I would be using data from 1960 to 2009. It is important to study key players for deriving accurate *Energy Sector* policies to avoid future electricity crisis, which also leads to *Economic Crisis*. So far, the energy policies in Pakistan have clearly failed.

At the end of my study I want to understand how economic indicators affect electricity consumption, and plan to offer my suggestions in light of the results I obtain.

3. Scope and Limitations

- Is electricity consumption growth rate driven by economic indicators such as GDP growth rate, manufacturing growth rate, agriculture growth rate, services sector growth?
- Is electricity consumption growth driven by population growth, and urbanization growth?

Although there are many factors as well economic indicators which could used to derive function for electricity growth, but I have chosen these four indicators (GDP growth rate, manufacturing growth rate, and agriculture growth rate, services sector growth) to see the combined effect as well as each variable's separate effect. I have also taken GDP growth rate, which itself incorporates other factors. Pakistan's population is largely employed in the agricultural sector, and with the service sector employment rate rising and the manufacturing sector's role diminishing, I want to examine consumption for electricity of each sector. In addition to this the issue of population growth is another problem for Pakistan, and the subsequent urbanization of the population. These must be examined to predict the electricity demand for the future.

The limitations of my study are set by inclusion of these variables, and by excluding other independent variables or economic indicators. Different economies have different economic indicators, and I have tried to select the most important ones for Pakistan. In Pakistan, service sector, and agriculture growth are crucial indicators whereas in many other developing economies they may not have the same impact. Other variables like employment growth rate, education growth, and infrastructural development are also key indicators, but they are beyond the scope of this study.

4. Previous Research – Literature Overview

a. Previous Research- Energy consumption and economic growth (Global)

Energy consumption and its connection with economic growth have been studied by various scholars. The pioneering study by Kraft and Kraft (1978) discovered that the causality of GNP growth to energy consumption was unidirectional in case of the US for period 1947-1974[1]. The research showed that there was low dependency of U.S economy on energy, due to which U.S pursued energy conservation policies, without having adverse affects on income[2]. Jumble (2004) analyzed the causality between electricity consumption, agriculture income, and non agriculture income by using error correction model and Granger causality analysis for the period 1970 to 1999 on, Malawi.

[1] Kraft, J and A. Kraft (1978) Comments from: On the Relationship between Energy and GNP(*The Journal of Energy and Development* 3, 402–403)

[2] Jumbe, C. B. L. (2004) Cointegration and Causality between Electricity Consumption and GDP: Empirical Evidence from Malawi. *Energy Economics* 26, 61–68

The results indicated that agriculture and non agriculture income had causal effect on electricity consumption, and on the other hand electricity caused the total income[3].
A similar study was carried out by Erol and Yu (1987) on England, France, Italy, Germany, Canada and Japan. They found diverse empirical evidence on the relation between economic growth and energy consumption for the period 1952- 1982. The results showed that there was bidirectional causality for Japan case, for Canada there was unidirectional causality from energy consumption to GDP, for Germany and Italy there was unidirectional causality from GDP to energy consumption, and for France and England there was no causality[4].

Pachauri (1977) and Tyner (1978) established a correlation between economic development and energy consumption in India, and there was evidence of bidirectional causality[5]. The relationship between gross national product (GNP) of five countries was examined by Yu and Choi (1985), reasoning that there was unidirectional causality from energy consumption to GNP for Philippines, for South Korea the causality was opposite, and there was no evidence of causality in the case of U.S, UK, and Poland[6]. Cheng (1995 and 1997), by engaging a multivariate approach, reasoned that there was no evidence of causality energy consumption and Capital towards economic growth for U.S, Mexico, and Venezuela[7]. Cheng (1995 and 1997),

Asafu-Adjaye (2000) studied the causal relationship between energy consumption, prices, and economic growth for Asian developing counties such as India, Indonesia, Philippines, and Thailand over the period of 1971 to 1995. They also found evidence of unidirectional causality from energy consumption and prices towards income in the case of India, and Indonesia, on the other hand for Thailand and Philippines there was mutual causality between energy consumption, income and prices[8].

[3] Jumbe CBL (2004). Cointegration and causality between electricity consumption and GDP: Empirical evidence from Malawi, Energy Econ., 26: 61-68
[4] Erol, U. and E. H. S. Yu (1987) P 113–122
[5] Pachauri, R. K., 1977, *Energy and Economic Development in India*. New York: Praeger Publishers
[6] Yu, S. H. and J. Y. Choi, (1985), Vol. 11, 2 :P 249-272
[7] Cheng (1997), Vol. 4, 8 :P 476-674
[8] Asafu-Adjaye, J. (2000) P 615–625

Yoo (2005) also found that in Korea, economic growth is affected by electricity consumption and that economic growth seems to also affect the consumption of electricity[9]. The casual relationship between GDP and the energy consumption, which took into consideration the energy sources natural gas, coal and electricity; was carried out by Yang (2000). He found bidirectional causality between total energy consumption and GDP in case of India, and in case of Pakistan and Indonesia, it was GDP that caused energy consumption[10].

Yoo (2006) carried out a study of ASEAN member economies including Thailand, Malaysia, Indonesia, and Singapore. He considered the relationship between electricity consumption and economic growth. Data considered was from 1971 up to 2002. A one way causal relation from economic growth to energy consumption (electricity consumption) existed in Indonesia and Thailand. In Malaysia and Singapore, a bi-variate causal link was established between electricity consumption and economic growth[11].

A cointegration approach was employed by Chen et al. (2007) to study the data from 10 Asian countries. Bi-variate causality was seen to exist in the panel. However the causality went from GDP per capita to electricity consumption per capita under the heterogeneous causality approach[12].

Narayan and Singh (2007) reported uni-variate causality from electricity consumption to economic growth in the case of Fiji, and Narayan and Smyth (2009), for Middle Eastern countries, reported that if the electricity consumption rises by one percent, then this would result in a 0.04 percent rise in the GDP[13].

Narayan and Prasad (2008) documented a study for 30 OECD countries that investigated the relationship between electricity consumption and economic growth. A rise in the use of electricity caused a rise in the real gross domestic product per capita in Australia,

[9] Yoo, S. (2005) P 1627–1632
[10] Yang, H. Y., (2000), Vol. 22, 3 : 309-317
[11] Yoo, S. (2006), 34: P3573–3582
[12] Jaruwan Chontanawat, Modeling Causality between Electricity Consumption and Economic Growth in Asian Developing Countries, P-324
[13] Jaruwan Chontanawat, Modeling Causality between Electricity Consumption and Economic Growth in Asian Developing Countries, P-323

Iceland, Italy, the Slovak Republic, the Czech Republic, Korea, Portugal, and the UK[14]. For South America, Yoo and Kwak (2010) report that a uni-variate causal link from electricity consumption to economic growth (real GDP used as a proxy) for Argentina, Brazil, Chile, Columbia, and Ecuador but two-way causality for Venezuela, and no causal relationship between electricity consumption and economic growth could be established for Peru[15]. Akinlo (2009) found that for Nigeria, a developing country, electricity consumption seems to cause GDP growth[16]. Zaid Mohamed and Pat Bodger (2003) studied the electricity consumption using economic as well as demographic variables using multiple linear regression analysis for New Zealand. It was found that electricity consumption was correlated with population growth, and the results were comparable with the results of national forecast[17].

Pernille Holtedahl, Frederick L. Joutz (2003) examined the residential demand electricity as a function of price elasticity, income, population growth, and degree of urbanization through error correction model, for Taiwan. It was concluded the urbanization measured for the cities with population of 100,000 or more has positive long-run and short-run effects on electricity consumption[18].

Lariviere and Lafrance (1999) used statistical modeling to establish relationship between electricity consumption per capita and urban density, demography, meteorological factors for cities in Canada. Their result suggested that greater urban density was factor in reducing energy consumption[19].

[14] Narayan, P. K., Prasad, A. (2008). 36: P 910–918
[15] Yoo, S.H., Lee, J.S. and Kwak, S.J., (2007), 35, P 5702–5707
[16] Akinlo AE (2009), 31: P 681-693
[17] Zaid Mohamed, Pat Bodger (2003), P-1842
[18] Pernille Holtedahl, Frederick L. Joutz (2003), P-201, 209
[19] Larivière I and Lafrance, G. (1999), P-53, 64

b. Previous Research- Energy consumption and economic growth in Pakistan

Among the first studies to investigate the relationship between economic growth and energy consumption in Pakistan was carried out be by Riaz (1984)[20]. He investigated this relationship using a log linear regression analysis. The regression analysis of the energy-growth relationship showed independence between socioeconomic variables and energy consumption. Masih and Masih (1996) found a co-integrated relationship between energy consumption and gross domestic product in India, Pakistan, and Indonesia. They analyzed the aggregate as well several disaggregated categories. In the case of India, it was bidirectional causality between GDP and total energy consumption. It was a different case for Pakistan and Indonesia – energy consumption was found to be caused by GDP[21]. Anjum and Butt (2001) found that energy consumption was caused by economic growth, but economic growth didn't led to increase in petroleum consumption, also in the gas sector, there was no causality between economic growth and gas consumption; furthermore; electricity consumption lead to economic growth without feedback[22]. Alam and Butt (2002) in their research concluded that energy consumption, economic growth, capital, and labor were co-integrated and that causality ran from energy consumption to economic growth in short and in long run[23].
Siddiqui and Haq (1999) analyzed the electricity demand function at aggregate and disaggregate levels, and found that at aggregate level, electricity demand was very much influenced by output, price, and number of consumers. Though later studies have shown that these results were inauthentic, due to traditional methods, and short data span[24]. Khan and Qayyum (2007) established a causal relationship between energy consumption and economic growth in Pakistan, Bangladesh, India and Sri Lanka. Their results suggest causality running from energy consumption to economic growth. They

[20] Riaz, T., (1984), P431-453
[21] Masih, A. M. M., and R. Masih R., (1996), Vol. 18, 3: P 165-183
[22] Anjum and Butt, (2001), Vol. 8, 2 : P 101-110
[23] Alam and Butt, (2002), Vol. 12, 2 : P 151-165
[24] Siddiqui, R. and Haq, R., (1999), Research Report No. 174

are of the opinion that economic growth is retarded by a shortage of energy[25]. Research by Qazi and Riaz (2008) shows that in the short run, there is a bivariate causal relationship between energy consumption and economic growth. In the case of the long run, they found that the direction of causality runs from economic growth to energy consumption[26].

Table1. Summary of literature review

Previous Research	**Country**	**Methodology**	**Period**	**Result**
All are Time-series studies (otherwise mentioned as Panel studies)				
Kraft and Kraft (1978)	U.S	Cointegration (B)	1947-1974	EG→EC
Jumbe (2004)	Malawi	Granger causality(G.C) and ECM	1970-1999	ec↔EG
Erol and Yu (1987)	England, France	Granger causality(G.C) Cointegration (B)	1952- 1982	EC ◊EG
	Italy, Germany			EG→EC
	Canada			EC→EG
	Japan			EC↔EG
Pachauri (1977) and Tyner (1978)	India	Granger causality(G.C) Cointegration (B)	1947-1974	EG↔EC
Yu and Choi (1985)	Philippines	Granger causality(G.C) Cointegration (B)	1954-1976	EC→EG
	South Korea			EG→EC
Cheng (1995 and 1997)	U.S, Mexico, Venezuela	Granger causality (G.C) Cointegration (M)	1947-1990	EC ◊EG
Asafu & Adjaye (2000)	India, Indonesia	Granger causality(G.C) Cointegration (M)	1975-1995	EC→EG
	Philippines, Thailand			EC↔EG
Yoo (2005)	Korea	Granger causality(G.C) Cointegration (B) VECM	1970-2002	EC ↔EG
Yang (2000)	India	Granger causality(G.C) Cointegration (B)	1954-1997	EC↔EG
	Pakistan			EC↔ G
	Indonesia			EC↔EG
Yoo (2006)	Thailand	Hsiao's Granger (B)Cointegration (B)	1971-2002	ec→EC
	Malaysia			ec↔EG
	Indonesia			ec→EC
	Singapore			ec↔EG
Chen et al. (2007)	10 Asian Countries **Panel studies- result** (Hon Kong, Korea, Indonesia, India, Singapore, Taiwan and Thailand)	Granger causality(G.C) Cointegration (B)	1971-2001	ec→EC
Narayan and Singh (2007)	Fiji	Bounds testing approach to cointegration (M)	1970-2002	ec →EG

[25] Qazi. M. A. H & S. Riaz (2008), P 45-58

		ARDL, VECM		
Narayan & Smyth (2009)	6 Middle Eastern Countries **Panel studies-** (Iran, Israel, Kuwait, Oman, Saudi Arabia and Syria)	Granger causality(G.C) Cointegration (M)	1966-1999	ec→EG
Naranyan & Prasad (2008)	30 OECD: Results for: Australia, Iceland, Italy, the Slovak Republic, the Czech Republic, Korea, Portugal, UK	Bootstrapped Causality Test (B)	1971-2002	ec→EG
Yoo and Kwak (2010)	Argentina	Granger causality(G.C) Cointegration (B), VECM	1975-2006	ec →EG
	Brazil			ec→EG
	Chile			ec →EG
	Columbia			ec →EG
	Venezuela			ec↔EG
	Peru			ec ◊EG
Akinlo (2009)	Nigeria	Granger causality(G.C) Cointegration (B)	1980-2006	ec →EG
Zaid Mohamed and Pat Bodger (2003)	New Zealand	Cointegration (M)	1965-1999	PP→ec
Pernille Holtedahl, Frederick L. Joutz (2003)	Taiwan	Granger causality (G.C), Cointegration (M), VAR, VECM	1955-1996	UR→ec
Lariviere and Lafrance (1999)	Canada	Regression analysis	1991-1999	UR→ec
Riaz (1984)	Pakistan	Log linear regression analysis	1947-1979	EG◊EC
Masih and Masih (1996)	India	VECM and VAR	1955-1991	EG↔EC
	Indonesia			EG→EC
	Pakistan			EG→EC
Aqueel & Butt (2001)	Pakistan	Hsiao's Granger (B)	1955-1996	EC →EG
Alam and Butt (2002)	Pakistan	Granger causality(G.C) Cointegration (B)	1971-2002	EC →EG
Siddiqui and Haq (1999)	Pakistan	Granger causality (G.C) Cointegration (B)	*1983-1999	EG→ec
Khan and Qayyum (2007)	Pakistan	Granger causality(G.C) Cointegration (B)	1970–2006	EC →EG
Qazi and Riaz (2008)	Pakistan	Bounds-testing approach to co-integration, Granger causality (G.C)	1971-2007	EG→EC

Note:
EC denotes Energy Consumption
ec denotes Electricity Consumption
UR denotes Urbanization
PP denotes population
EG denotes Economic Growth
→ denotes '(one way) or uni-directional causality'
↔ denotes '(two ways) or bi-directional causality'
◊ denotes 'no causality'
B denotes Bivariate model, M denotes Multivariate model

The results from literature review tell us that most of the studies test causality between Electricity and GDP, by using time series analysis. On the other hand less studies test causality using panel approach using bivariate model. Another important point to be noted is that causality results vary across countries, and they also vary within country, depending upon the methods, models, approach, time span, and variables.

5. Economic Growth

Economic growth has, and will continue to be one of the leading macroeconomic aims for every nation's government. Though there are now other measures to gauge the standard of living in a country, like the Human Development Index and the Human Poverty Index, the increase in the output of a nation, the gross domestic product, and the subsequent gross domestic product per capita are strong indicators of a nation's economic growth.

Introduction: Defining economic growth, with reference to existing literature.
Economic growth is the rise of per capita gross domestic product (GDP). It can be quantified as the rate of change in real GDP. Economic growth relates to the quantity of goods and services produced in a country over a specific period of time.
Solow-Swan Growth model, which is also known as the neo-classical model was evolved from Harrod-Domar model of productivity growth; is based on the notation of economic growth rate in terms of the level of saving and productivity of capital. But this new model took in consideration the 'productivity growth' as important tool in a nation's economic growth, and where new capital is valued on the basis of technological advancements over the period of time. The main contributor to this accomplishment was Robert-Solow. Nowadays, economist and researches around the world use this model as source of growth accounting for estimating the dissever effects of technological change, capital, and labor on the economic growth.[27] *(Solow Growth Model by Fiona Maclachlan, The Wolfram Demonstrations Project).*

[27] Solow Growth Model by Fiona Maclachlan, The Wolfram Demonstrations Project

As the time progressed the growth theory was advanced further this time by famous economist Paul Romer, at the end of 80s. Other important new growth theorists like Robert E. Lucas and Robert J. Barro also worked on exogenous theory for modifications[28].

To explain economic growth, neo-classical production function takes into account capital, technology and increases in labor. But with the ever-increasing dependence on energy of countries, energy is now considered to be an integral part of all studies on economic growth. Energy is now a vital part of the production function.

Among the first economist to incorporate the use of engineering information into the study of production was Hollis Chenery (1949, 1950). The paramount importance of energy in the growth of economies was highlighted by the oil crisis during the 70s. Ever since then, apart from labor and capital, energy is firmly considered as a production factor. The LINEX production function was introduced by Kümmel et al. (1985; 1998/2000). This production function was considered variables associated with technology in addition to economic considerations. Nicholas Georgescu-Roegen (1971) stressed the important role that energy plays in the economy of a nation.

The concept of my model development and research analysis is derived from Solow-Growth Model[29], as well as other researchers, some mentioned above; who have looked in Economic Growth as a function of Energy Consumption, but here I have reversed the relationship and consider Electricity Consumption instead of Energy Consumption.

6. Theoretical framework and Context of the Study

a. Role of Energy in the Economy of a Nation

Energy is an essential component for the social and economic development of societies and the usage levels of electricity is an indication of the economic successfulness of nations. The growth rate of GDP is also the principal driver for energy demand (IEA, 2006). Electricity has been a major factor in the increase in the standard of living of

[28] Joseph Cortright Impresa, Inc 2001, New Growth Theory, Technology and Learning: A Practitioner's Guide

[29] Haines, Joel D, Competitiveness Review: *A framework for managing the sophistication of the components of technology for global competition*

advanced economies and it has played a critical role in the technological and scientific progress in these countries. The quest for economic prosperity by the developing nations, and to asseverate this prosperity in the developed nations; the demand for the use of energy has risen many times. It is debated that the use of electricity is affiliated with the improvement in healthcare and educational sectors at the national level. At the personal or individual level, energy consumption is an important factor in improvement of welfare. It is the major source of development, especially in today's 'digital economic world'. Recent link between economic growth and electricity consumption has become a 'hot research topic' particularly regarding policy matters with regard to limited natural resources[30].

A significant study was done by Kraft and Kraft (1978), on United States, concluding that causality runs from energy consumption to economic growth. This appealing idea encouraged researches to include other factors such as increase in population, urbanization, employment, education, and infrastructural development; to explore long-run relationship and direction of causality between economic growth and energy consumption. Aug (2007) using the VECM techniques, explored the causality between pollutant emissions, energy consumption, and output for France. The results suggested that there was influence of economic growth on energy growth as well as pollution growth in the long-run scenario, but opposite was observed in the short-run. Lee and Chang (2008) used capital stock, labor, and energy consumption for Asian economies. They found affirming results that positive relationship exists between energy consumption and economic growth. It was noted that maintain long-run economic growth efficient use of energy is necessary, but this might not be the case in short-run, because economic growth is not affected by slow-down in energy usage in short-run. Population growth leads towards rapid urbanization, as pressure mounts on rural resources, thus urbanization leads to further increase in energy demand. Therefore interrelationship between population growth, urbanization growth, and energy (in my case study electricity) is worth examining. Estimates from Bartleet and Gounder (2010)

[30] Jaruwan Chontanawat, Modeling Causality between Electricity Consumption and Economic Growth in Asian Developing Countries, P-318

bivariate & multivariate models determined causality between energy consumption and economic growth, for the study done on New Zealand. They found that real GDP, energy consumption, and employment were cointegrated in the long-run scenario, and causality direction was from real GDP to energy use, indicating that economic activity drives the energy use[31].

In a study by IEA (International Energy Agency), the economic growth of some developing countries was investigated, and it was concluded that energy, when included in the production functions of these countries, contributed more than other factors of production (IEA, 2004:360).

As economies expand, and the output increases, in terms of the primary, secondary and the tertiary sectors of the economy, the energy demand multiplies (Ebinger (1981). This is especially significant because with so many developing economies in the world today, the manufacturing sectors of these countries will require increasing amounts of energy. In 1971, the share of developing countries in the world energy consumption was only 15 percent. It increased to 27 percent in 1991, and it was expected to rise to 40 percent by the year 2010 (Schneider 1994).

Today, the need for energy is a leading cause of concern for many nations around the world as consumption levels continue to soar. The growth rate of GDP directly increases the demand for energy (IEA, 2006)[32]. And *electricity* being the integral part of the energy sector, It may lead to the conclusion that economic growth results in an increased consumption of electricity. So it can be said that as countries experience economic growth, the dependency on the manufacturing sector rises and with this comes a higher energy demand. *Another examination of the above scenario may lead us to conclude that a higher use of energy increases the efficiency of the production process, and this greater efficiency increases economic growth.*

Hence, the direction of the causal relationship between electricity consumption (part of energy consumption) and economic growth may not always be identical for different

[31] Muhammad Shahbaz, Bounds Test Approach to Cointegration and Impact of Financial Development on Energy Consumption for Pakistan, P 1-3

[32] IEA (2006). *World Energy Outlook 2006*. International Energy Agency, Paris, France

nations. Moreover, in the short run, and in the long run, economic growth and electricity consumption may differ.

b. Electricity growth

The relationship between electricity consumption and economic growth is an essential component in the designing of policies. As per IEA (2006) projections the global electricity demand is to double over the next 25 years, from 14,376 terawatt-hour (TWh) in Year 2004 to 28,093 TWh in Year 2030, growing at rate of 2.6% per year. According to ASEAN, energy consumption in the ASEAN world is anticipated to increase to about 583 million tons of oil equivalent (MTOE) in 2020 compared with 280 MTOE in 2000, and on the other hand demand in developing giants such as China, and India is expected to grow threefold as fast as in OECD countries. Therefore, the investment in the energy sector, especially in electricity, is essential for sustaining economic growth in these countries[33].

c. Electricity as a measure of standard of living

Electricity consumption is considered by the UN Human Development Index to be associated with standard of living. Most countries that have a per capita consumption below 1,000 kWh were found to have HDI scores of less than 0.6. Further to this, it was found that as the consumption level increased, the HDI score improved (Energy Sector Assessment for Usaid/Pakistan June 2007).

According to the paper ‘Energy Crisis in Pakistan’ By Awaam, the HDI moves towards a medium value with the consumption of 500kwh per capita. Living conditions improve as electricity becomes available for basic amenities like light and refrigeration[34].

d. The Critical Thresholds

For electricity consumption, four values (minimum) were highlighted by the Awaan[35].

[33] Jaruwan Chontanawat, Modeling Causality between Electricity Consumption and Economic Growth in Asian Developing Countries, P-318, 319

[34] Awaam: ‘Energy Crisis in Pakistan’ P-9-11

[35] Awaam: ‘Energy Crisis in Pakistan’ P-12

1. Low HDI can be removed by the consumption of 500 Kwh of electricity per capita per year.
2. Use of 1000 Kwh of electricity per capita per year can provide a basic yet stable standard of living. The UN set this as the minimum level in 2002.
3. Use of 2000 Kwh of electricity per capita per year is the world average.
4. Developed nations were found to use 4000 Kwh per capita per year.

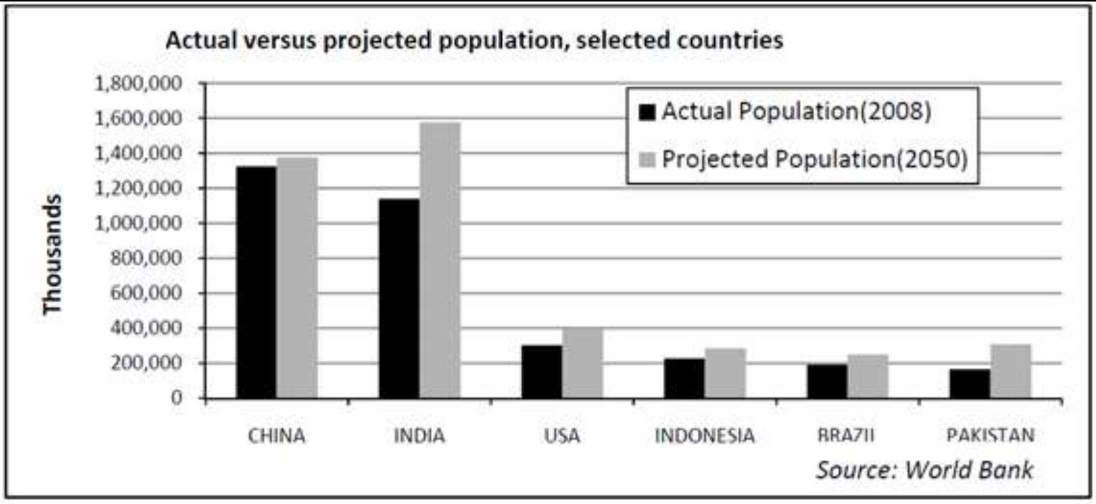
e. Pressures on the Demand for Electricity in Pakistan

- *With respect GDP growth, Agriculture growth, Manufacturing growth, Services growth, Population growth, and Urbanization growth.*

i. Population

The demand for energy increases due to a growth in population, and for Pakistan, *can be one* of the contributing factors towards the increased demand for energy. Developing nations typically have high birth rates, caused by factors such as illiteracy and traditional beliefs about birth control. In Pakistan, the rate of population growth has reduced in recent years, but the population continues to increase at an alarming rate. The population problem is a serious problem for policy makers in Pakistan. Currently, Pakistan is the world's sixth most populous country. It had a population of 69.9 million as at end-June 2009, and the annual population growth rate is estimated at 2.05 percent. This means that Pakistan will become the fourth most populous nation by 2050

Figure 1.



From the Figure 1 above, it is evident that in the next forty years or so, the population will exert tremendous pressure on the energy resources of the country. The electrification of rural areas continues to increase the number of consumers over the coming years. But till now rural electricity demand is not the driving force behind the country's increasing electricity consumption, because of the labor intensive agriculture sector. A 4.5 percent increase in consumers was reported during July-March 2009-10. This was an increase against the 4.2 percent rise in same period the previous year. This is shown in the Figure 2.

Figure 2. Consumers by Economic Groups (Thousands)

Year	Domestic	Commercial	Industrial	Agriculture	Others	Total
2006-07	14,354	2,152	233	236	11	16,987
2007-08	15,226	2,229	242	245	11	17,955
2008-09	15,482	2,257	250	255	11	18,255
July-March						
2008-09	15,687	2,271	250	255	12	18,475
2009-10	16,416	2,342	260	269	13	19,300

Source: PEPCO

Source: Economic Survey Of Pakistan 2009-2010 Chapter 13-Energy, P-185

Figure 3.

Electricity Consumption by Economic Groups (% Share)

Year	Domestic	Comm-ercial	Industrial	Agri-culture	Public Lighting	Bulk Supply	Traction	Supply to KESC
2006-07	43.00	6.36	26.09	12.00	0.47	4.84	0.02	7.27
2007-08	43.21	6.55	26.00	12.59	0.51	5.01	0.01	6.12
2008-09	42.56	6.44	24.56	13.32	0.53	4.90	0.01	7.68
July-March								
2008-09	42.20	6.40	25.20	13.30	0.50	4.90	0.01	7.50
2009-10	42.15	6.45	23.92	14.03	0.57	4.92	0.01	7.94

Source: PEPCO

Source: Economic Survey Of Pakistan 2009-2010 Chapter 13-Energy, P-196

Domestic consumption leads the list, with industrial and agricultural demands following Figure 3.

ii. The Agricultural, Manufacturing and Service Sectors of Pakistan's Economy

Pakistan is a developing country whose economy, in terms of people employed but not in terms of gross domestic product, is firmly based in the primary sector. This also exerts its own pressure on the energy resources of the country.

About 25% of the GDP is contributed by the manufacturing sector, higher than the 21% contributed by agriculture sector. Cotton textile production and apparel manufacturing are Pakistan's largest industries, accounting for about 51.4% of total exports. Other major industries include food processing, beverages, construction materials, clothing, and paper products. Manufacturing sector growth has slowed in the last 2 years due to energy shortages and capacity constraints (CIA Factbook). The service sector makes up the remaining part of the gross domestic product, which is a54% share.

Figure 4.

Employed Labour Force by Sectors (%)

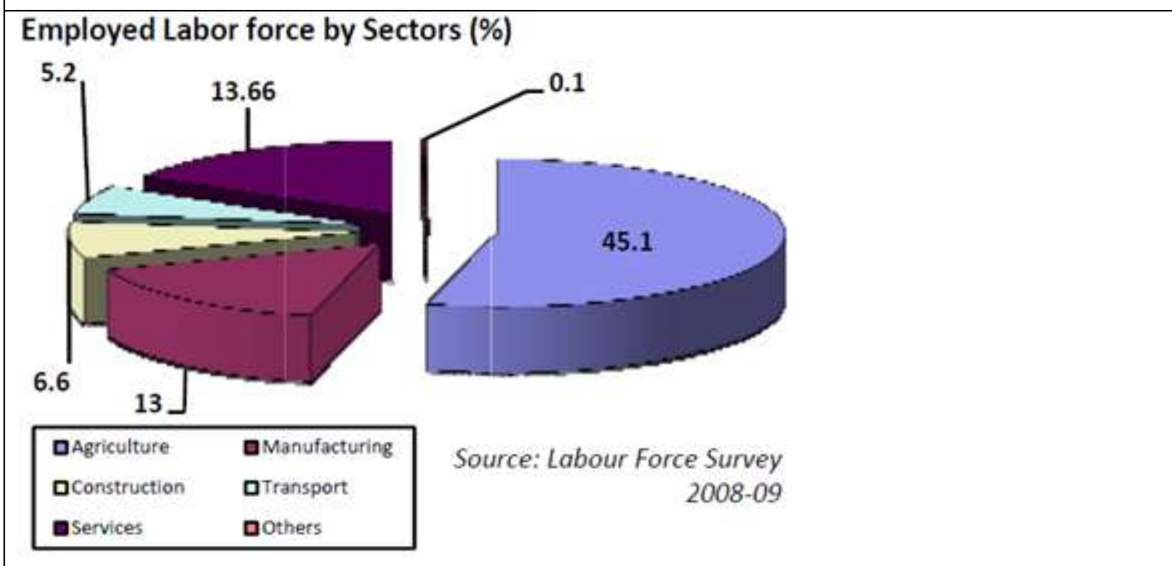
Sector	2007-08			2008-09		
	Total	Male	Female	Total	Male	Female
Agriculture	44.6	36.9	75.0	45.1	37.3	74.0
Manufacturing	13.0	13.3	11.8	13.0	13.3	11.9
Construction	6.3	7.8	0.4	6.6	8.3	0.4
Transport	5.5	6.8	0.2	5.2	6.6	0.2
Services	13.7	14.4	10.6	13.66	11.1	11.6
Others	2.3	2.9	0.2	0.10	2.9	0.3
Total	100.00	100.00	100.00	100.00	100.00	100.00

Source: Labour Force Survey 2008-09 Federal Bureau of Statistics

Source: Labor force survey 2008-2009, Federal Bureau of statistics

As is evident from the figure 4, and figure 5, the contribution of the agricultural sector towards the GDP is 21 percent, but in terms of labor force employed, it is by far the largest sector in the country. About 45% of the nation's labor force is employed in the agricultural sector.

Figure 5.



Source: Labor Force Survey 2008-2009, Federal Bureau of statistics

This is due to the fact that nearly 62 percent of the country's population lives in rural areas. The agriculture sector has grown at an average rate of 3.7 percent per annum over the last six years. The rate of growth ranges between 6.5 percent and 1.0 percent due to the fluctuations that are associated with the agriculture sector.

However according to statistics from Pakistan Federal Bureau of Statistics, the agriculture growth rate, when compared with previous decades, is actually declining (Figure 6.).

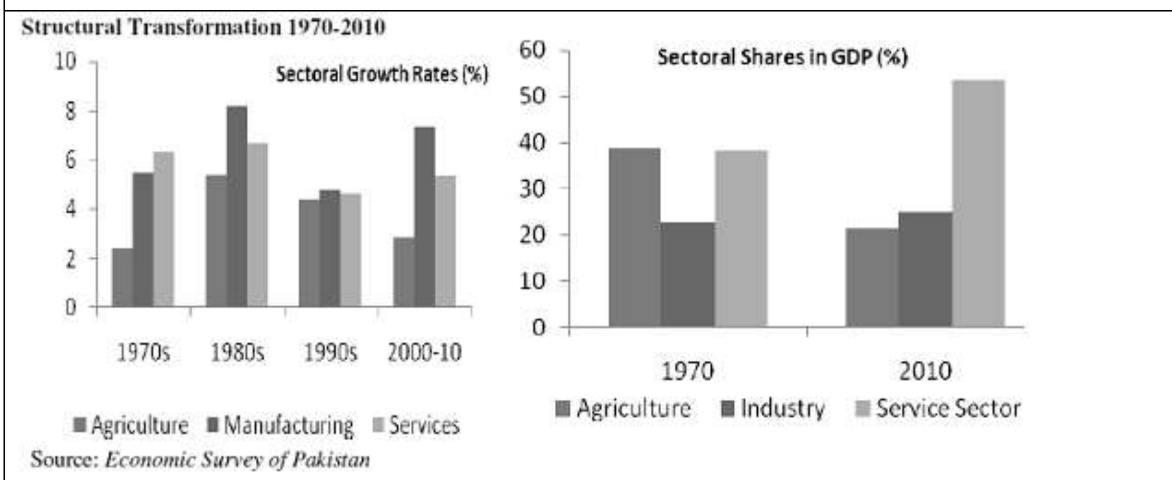
Figure 6. Historical Growth Performance Agriculture Sector

Year	Percent
1960s	5.1
1970s	2.4
1980s	5.4
1990s	4.4
2000s	3.2

Source: Federal Bureau of Statistics

The service sector of Pakistan has experienced the highest growth rate of the three sectors, namely agriculture, manufacturing and service sectors, indicating gradual structural transformation (Figure 7.). I would check with my statistical test, if this shift towards services sector is supported my results, and also look for reasons behind this transformation, later.

Figure 7.



Source: Economic Survey of Pakistan, 2006-2010

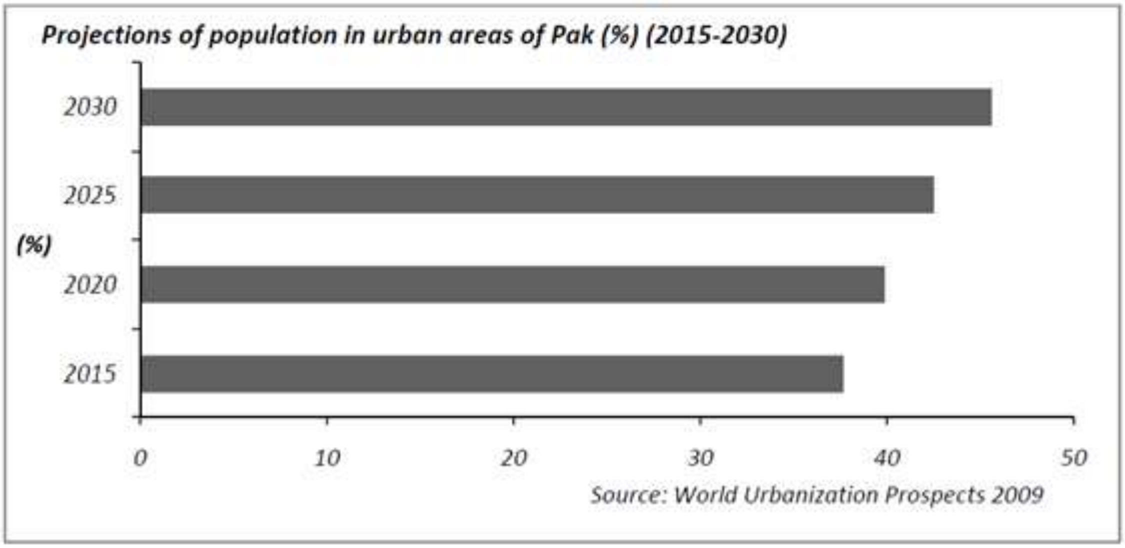
iii. Urbanization

The upsurge in the demand for electricity can also be traced to another issue that Pakistan is facing – urbanization. Urbanization in Pakistan is constantly rising, as more and more people move out of the rural areas in search of better living conditions in the city. Greater employment opportunities lure the rural dwellers towards the cities, and this exerts a tremendous pressure on the energy resources of Pakistan.

Over the last twenty years or so, the Pakistan's urban population has increased fourfold [Blacker (n.d.)]. A 7% average economic growth rate in Pakistan translates into the creation of millions of new jobs. Between 2000 and 2008, the manufacturing and service sectors expanded considerably, and urban migration rose to fill the vacancies. According to a report published as 'Life in the City: Pakistan in Focus', by the United Nations Population Fund, Pakistan is the leader in south Asia in terms of the level of urbanization. The rural and urban population will almost be the same by the year 2030. The urbanized population in 1975 was 10% and this rose to about 25% to 35% by the year 1995. From then onwards, the UN forecast says Pakistan urbanizing may reach 35% to 60% by the year 2035.

About 75% of the nation's gross domestic product is generated by the urban population, and nearly all of the tax revenue of the government is collected from cities (Riaz Haq 2007).

Figure 8.



It is estimated by World Urbanization Prospects (Figure 8.) that over the next 25 years, the urban population is expected to increase significantly. By 2030, the urban population would have swelled by 80 million, reaching 135 million, or almost 50% of the total population. Apergis and Payne, (2009a, 2009b, 2010) and Wolde-Rufael, (2009) highlight the fact that when incomes rise in developing countries, the demand for electricity increases. A reliance on electronic devices like the computer, cell phone and the internet have all multiplied the demand for electricity in Pakistan.

Hence, population, growth in the agriculture and service sector, and urbanization should all be taken into consideration when examining the relationship between energy consumption and economic growth.

7. Focus on Pakistan – The Electricity Crisis

a. Economic growth, electricity crisis

Throughout the 1960s, Pakistan was praised as a model for economic growth, around the globe[36]. Country's economic progression led many countries emulating Pakistan's economic planning strategy. South Korea designed its world financial center in Seoul after Karachi's model (Terra 2011). But this success could not be sustained. Severe

[36] Terra, March 2011, Growing Pakistan Economy, In Business, Featured, Money

financial constraints were faced by Pakistan as a result of the wars with India during the period 1965 and 1971. The wheel of economic growth slowed down considerably. Also economic mismanagement, corruption, unstable governments, financial imprudent economic policies led to huge increase in public debt, and led to slower growth in the 90s. The annual GDP growth rates in 70s was 4.8% and 80s it was around 6.5%, and fell to 3.13% in late 90s.

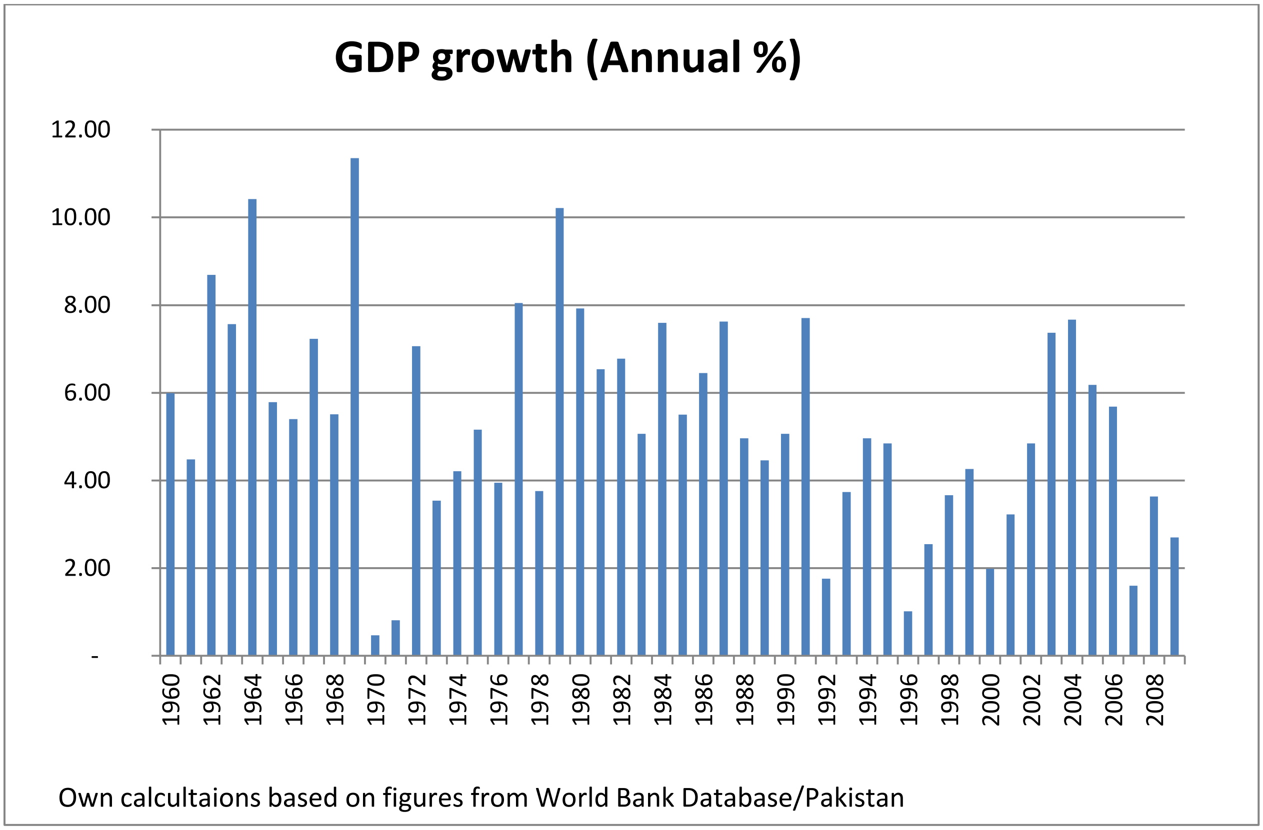


Figure 9.

Pakistan's economy experienced a boom period, especially in the period from 2002 to 2007. Annual GDP growth reached around 8% mark, and Karachi Stock Exchange, was by the International Business Week recognized as the "Best Performing Stock Market of the World for the year 2002" (CFPE 2004). But, why a sudden crisis? - It can be noted from graph below that and supported by SA Investor Review 2008[37] that around the year 2007, severe energy crisis, based on electricity sector; started to take root in Pakistan. Since then, the shortfall of electricity has continued to rise. Khalid Hussain, in his

[37] Pakistan's Electric Power Crisis Worsens (2008), South Asia Investor Review

research ‘Energy Crisis in Pakistan’ has analyzed the energy crisis beginning in 2007, which is due to electricity shortage.

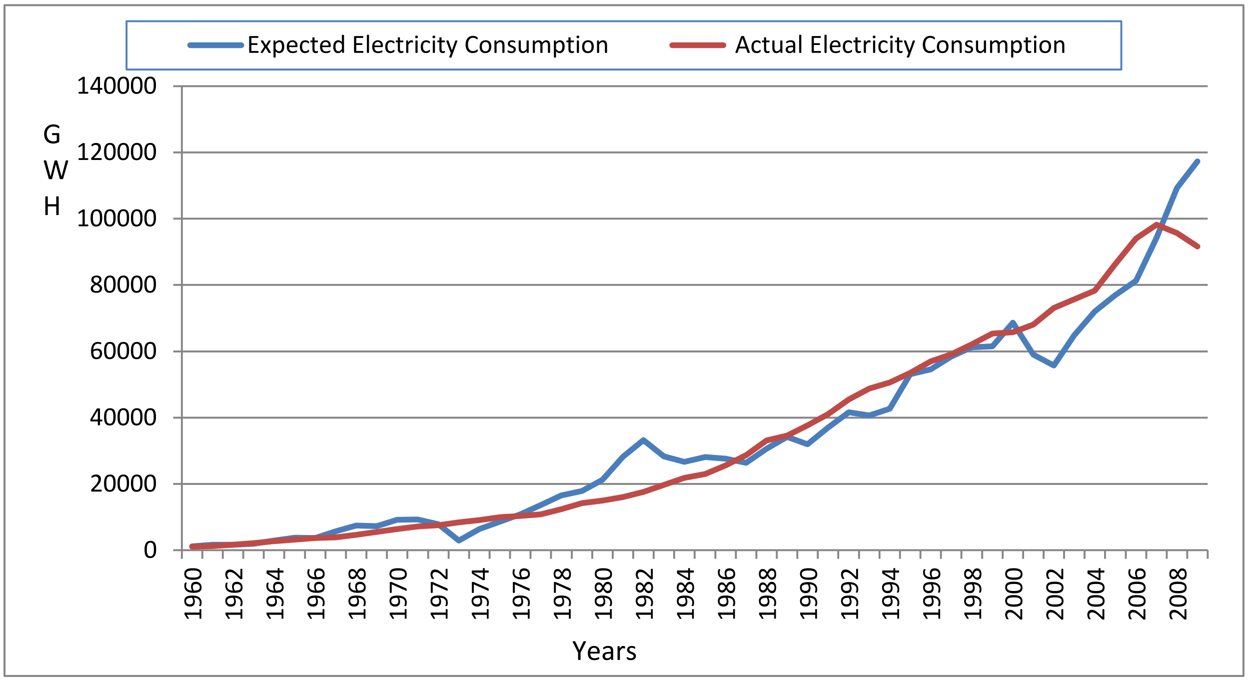


Figure 10.

Source: Own calculations based on data from State Bank (1960 – 2009)

Note: Calculating The Expected Electricity Consumption Using The Historical Data From 1960 To 2009 And Using Formula: Expected Electricity Consumptiont = At + B * Manufacturing Growtht + B * Agriculturet + B * Servicet + Et

The irony remains; in this entire situation, Pakistan is rich in agriculture, and mineral reserves. It is amongst the biggest wheat, milk, and meat producers in the world, has one of the largest untapped coal reserves, as well as great potential for hydro electricity development potential, which can easily be exploited with veracious investment strategy to overcome current electricity crisis (A. Salahudin (2010)). But still faces energy crisis…

It is lack of coherent investment strategy regarding key sectors that results in grievous energy crisis, as the one Pakistan is facing today. For example in the year 2009, 46% of the government revenues were allocated for servicing Pakistan’s debt, vast majority going towards paying interest. In addition to this huge federal government spending and

ponderous defense budget the problem is evident. Pakistan is taking billions of dollars at eminent rates whilst at the same time making huge old debt payments[38].
As Barbara Plett puts it "We are like a company that invests all its revenues on improving its head office building, and paying an army of security guards, and there is no money left for spare parts and raw materials[39].

b. The Electricity Sector of Pakistan

In Pakistan, both the private and public sector are involved in the supply of electricity. Pakistan has three sources of energy, namely hydro, thermal (gas/ steam/ furnace oil) and nuclear.
According to (Haq and Hussain, 2008) Poor management adversely affects Pakistan's energy infrastructure, and the problem that it is under-developed compounds the problem. Resultantly, there exists a severe disparity between the supply and demand of electricity which has evolved into a crisis in recent times with load-shedding a common occurrence in major residential areas, as well as industrial and services sectors. This has resulted in severe constraints on the economy, increasing unemployment, healthcare problems, and hampering educational growth. The estimated cost of electricity power load-shedding the country faces is Rs. 210 billion (1USD=85Rs.), this is more than 2% of the GDP, plus over $1 billion is lost in exports revenue, and 400,000 workers lose their jobs. The costs are even higher if agriculture and service sector are included[40].
Though the supply of electricity over the last 25 years has increased by about 40 times, it hasn't been able to keep up with demand.
A generation capacity of about 60 MW existed when Pakistan became an independent nation in 1947, whereas the country's population was about 31.5 million. By 1959, the generation capacity had expanded to 119 MW. To streamline projects, Water and Power Development Authority (WAPDA) was created in 1958. Electricity generation expanded up to 3000W by the end of the 70s. During the 1980s about 86% of the energy demand was met by domestic sources of energy and remaining 14% gap was filled by the imports.

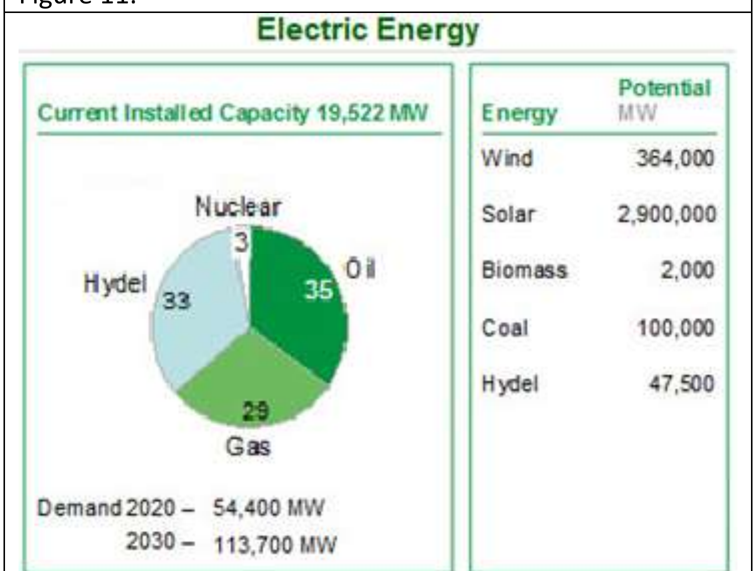
[38] A. Salahudin (2010), A Radical Approach to Pakistan's Economic Crisis
[39] Barbara Plett (2008), Pakistan's economic crisis worst in decade
[40] Shahid Javed Burki, Cost of power outages to the economy

The gap had raised to 7,000 MW in 1990/91, and the rate of increase in the demand of electricity swelled up to between 9 and 10%, and by the early 1990s, the difference between supply and demand came into existence. Since then, the demand-supply gap has been widening and reached around 47% by the end of 2000 (SBP, 2006).

The private sector was invited to play a role in the provision of electricity under the government's 'Policy Framework of Package of Incentives for Private Sector Power Generation Projects' in 1994. After this restructuring, there are four major power producers in country: WAPDA (Water & Power Development Authority), KESC (Karachi Electric Supply Company), IPPs (Independent Power Producers) and PAEC (Pakistan Atomic Energy Commission). The majority of the electricity generated is hydro-electricity, and thermal stations.

Hydropower contributes 33 percent and thermal-based generation is 64.05 percent. Nuclear plants contribute only slightly more than 2-3% of the electricity produced in the country.

Figure 11.



Source: Board of Investment, Government of Pakistan

During 2009 – 2010, total installed generation capacity increased by 2.1 percent, which was an improvement over the 1.0 percent increase in the previous year. The role of the private sector became more prominent - 31.6 percent of total installed capacity during the same time (2009-10). This meant a growth rate of 7.1 percent.

The estimated shortfall of electricity in the country currently is 5,500 MW in 2009/10. In fact, more than 20, 000 MW of electricity is demanded currently each day, and this gap is responsible for serious problems in the country. This shortage is detrimental to businesses and economic growth (Haq and Hussain, 2008). The overall requirement of Pakistan in 2010 was about 80 MTOE, up by 50% from 2008.

Figure 12.

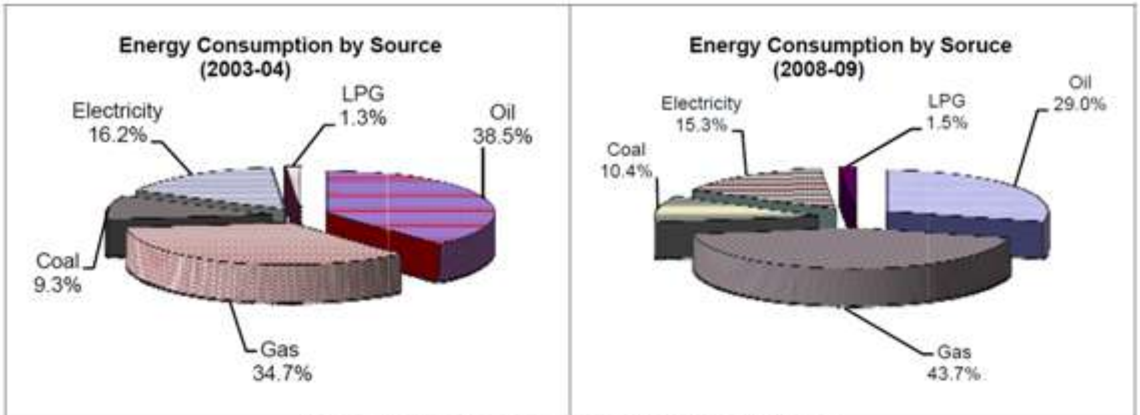
No.	Year	Firm Supply (MW)	Peak Demand (MW)	Surplus/(Deficit) (MW)
1	2008/09	15,055	19,080	(4,025)
2	2009/10	15,055	20,584	(5,529

Source: Hydrocarbon Development Institute of Pakistan (HDIP)

With the increase in economic activities, per capita energy consumption had also been increased. Industrialization, growth in agriculture and services sectors, urbanization, rising per capita income and rural electrification has resulted in a phenomenal rise in energy demand (NBP, 2008). Inefficiency and the wastage of electricity have further widened the demand-supply gap, and alternate sources of power like gas are being over-used.

The figure 13, shows Pakistan energy sector composition, which includes primary electricity, plus Oil and LPG (liquid petroleum gas) used in transportation sector, natural gas and coal are used for heating, home use (gas shoves), and industrial activities. And figure 14; show Pakistan electricity sector composition by different sources. Electricity is 15.3% of the energy sector, and is divided in hydro, thermal, and nuclear (Figure 15.).

Figure 13, 14.



Source: Hydrocarbon Development Institute of Pakistan

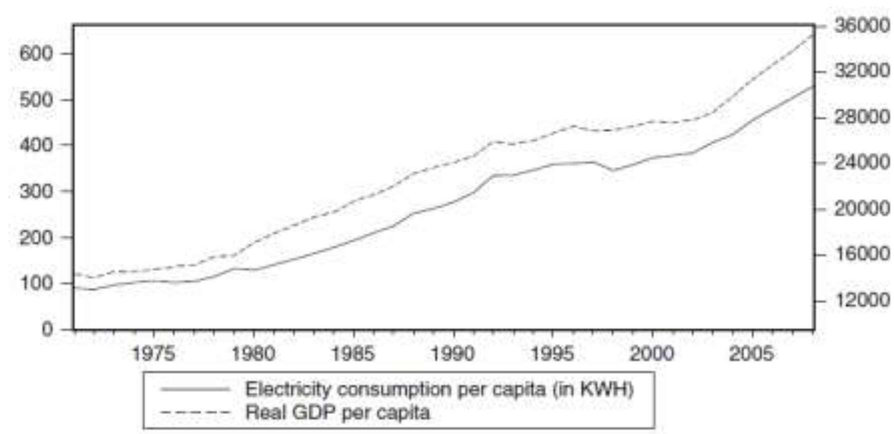
Figure 15.

Energy Sector	
Natural gas	43.7%
Oil	29.0%
Electricity	15.3%
Coal	10.4%
LPG	1.5%

The trade and service sectors, and the agricultural and industrial sectors have been growing, and the electricity shortfall adversely affect all these. About three quarters of Pakistan's electricity needs (Figure 14.) are met by resources, which include hydroelectricity, gas, oil and nuclear. *Natural gas has emerged as the most important fuel in the recent past and the trends indicate its dominant share in the future energy mix (Sahir and Qureshi, 2007).* However, to **compound** the energy crisis in Pakistan, recently, widespread shortages of natural gas have become a common occurrence in the county.

The excess demand for energy has been increasing year-by-year and creating alarming situation for the country (Looney, 2007). The average excess demand for energy is equal to 0.48 QBtu for the period 1980-2005. According to Pakistan's Energy Security Plan (2005-2030), the total primary energy consumption in Pakistan is expected to increase seven-fold from 55 MTOE to 360 MTOE, and there would be over eight-fold increase in the requirement of power by 2030 (ISSI, 2007b).

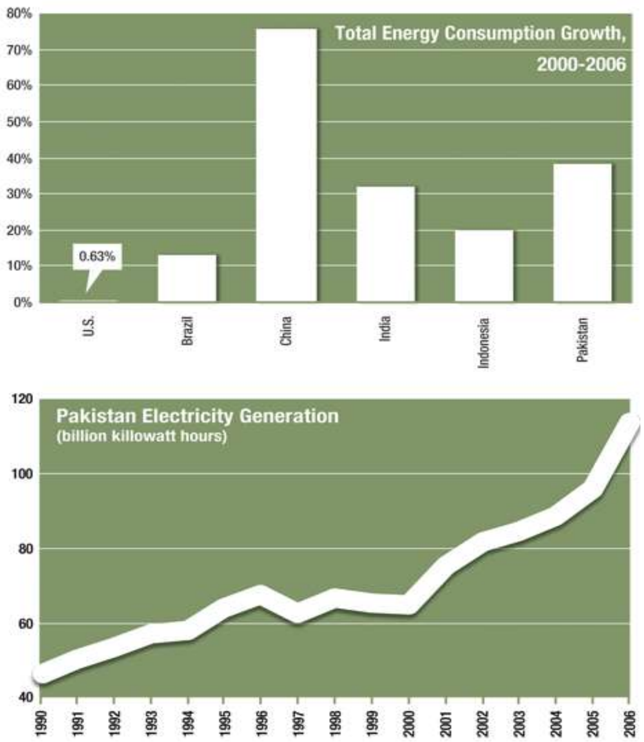
Figure 16.



Source: Electricity consumption and economic growth empirical evidence from Pakistan Muhammad Shahbaz, Mete Feridun

It is evident from the above graph (Figure 16.), as the real Gross Domestic Product per Capita rises, so does the Electricity Consumption per Capita. It is interesting to note that 83.1 % of electricity uses are residential consumers, which is in stark contrast to other countries in the region, like India and China. In fact, it is very unusual for a developing country to experience a fall in the industrial sector's electricity requirement, but this is true in the case of Pakistan (Qazi, Muhammad, Salman - Managing Energy Demand). Even though at present, Pakistan is the sixth most populous nation of the world, the per capita energy consumption is the lowest of these six nations: China, India, the U.S., Indonesia, Brazil, and Pakistan. In fact, Pakistan ranks 165th in per capita access to electricity (GOP, Framework of Economic Growth 2011). However, the consumption growth rate of Pakistan is the second highest, only behind china. A 5.5 % increase in the total energy consumption took place between 2000 and 2006. (This is shown in the Figure 17. below)This is indicative of an expanding economy, which grows at between 6 to 7 percent each year (Pakistan Energy Commission).

Figure 17.



Source: energytribune.com

c. Major issues in the electricity sector of Pakistan

i. Policy Problem

In Pakistan, the policy makers, when deciding energy process, tend to take into account social goals instead of economic goals. The resultant extensive cross-subsidies between industry and domestic consumers prove to be a stumbling block in the path of economic prosperity (Energy Sector Assessment for Usaid/Pakistan June 2007).

Other major issues the electricity sector faces are:

ii. Efficiency of Existing Power Plants

Apart from not ensuring that supply of electricity keeps up with the demand, the problem of the disparity is increased by the not realizing the full potential of the current generation capacity. Maintenance should be given due importance, with the generation plants working overtime. More fuel, such as oil or coal is then required to produce the same amount of electricity.

iii. Circular Debt

The problem of circular debt is created when power generation companies fail to pay the fuel suppliers in time. The power generation companies fail in the collection of revenues from the private sector, non-payment of dues by the public sector are the major causes for inter-corporate debt. Rs. 216 billion circular debt was reported as on June 30, 2009 by the Ministry of Finance. Another problem is that the costs are not passed on to the consumers, and electricity is hence subsidized. The lower tariffs gap stood at Rs.3.43/kWh on January 1, 2010[41].

iv. External Variables

There are external variables responsible for the current situation as well. Worldwide recession leading to constraints on foreign direct investment in Pakistan, It was estimated in a report by Asif Ali (citi bank, power sector) that investment of $56billion is required by Pakistan to develop its energy sector. In 2007, $1.3bn was investment in oil exploration sector, to fulfill the demand for electricity in short-term basis[42].
And another contributing factor is the hike in international fuel prices. Currently around 29% of electricity generation is from oil, most of it is being imported[43].

v. Declining Hydropower

A cheap method of electricity generation is hydropower, but Mangla and Tarbela reservoir-based power generation projects are the only major facilities in Pakistan.

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[41] Tahir Dhindsa, Under the Mountain of Debt, Vol. 2 No. 2 February 2011, Sustainable Policy Economic Bulletin
[42] Asif Ali (2008), Industry Focus, Pakistan Power, Asia Pacific Pakistan Power & Natural Gas (Citi), P-45
[43] Board of Investment, Government of Pakistan
investinpakistan.pk/portal/index.php?option=com_content&view=article&id=233&catid=46&Itemid=110

vi. Depletion of Natural Gas Reservoirs

Gas works out to be cheaper than oil-based generation electricity generation. But quick depletion of natural gas reservoirs means that expensive oil imports have to be used.

vii. Failure to Exploit Gas & Coal Reserves

According to world energy estimates, Pakistan has 187 billion tons of coal, which can generate more than 100,000 MW of power. But due to mismanagement, and negligence they have been exploited yet.

Table 2.

	Potential	Untapped[1] (%age)	
Oil sector (Million TOE)	20.10	5.93 (32.1%)	▪ Exploration and Production, Refineries, Pipelines, Distribution
Gas Sector (Million TOE)	30.24	14.84 (49.1%)	▪ Exploration, Compression, Transportation, Distribution, Storage
Coal Mining (Billion Tons)	187	99.9%[2]	▪ Exploration, Extraction, Gasification, Integrated Power Generation

Source: Board of Investment, Government of Pakistan

viii. High Losses in during transmission of electricity

Losses during transmission are one of the biggest problems plaguing power sector of the country. It is said that around 20% is being lost through line transmission and distribution. The figures are very high compared to the total electricity generation. These losses are usually due to the outdated and bedraggled equipment being used, as well as because of theft of electricity, known as 'kundi' in local terms[44].

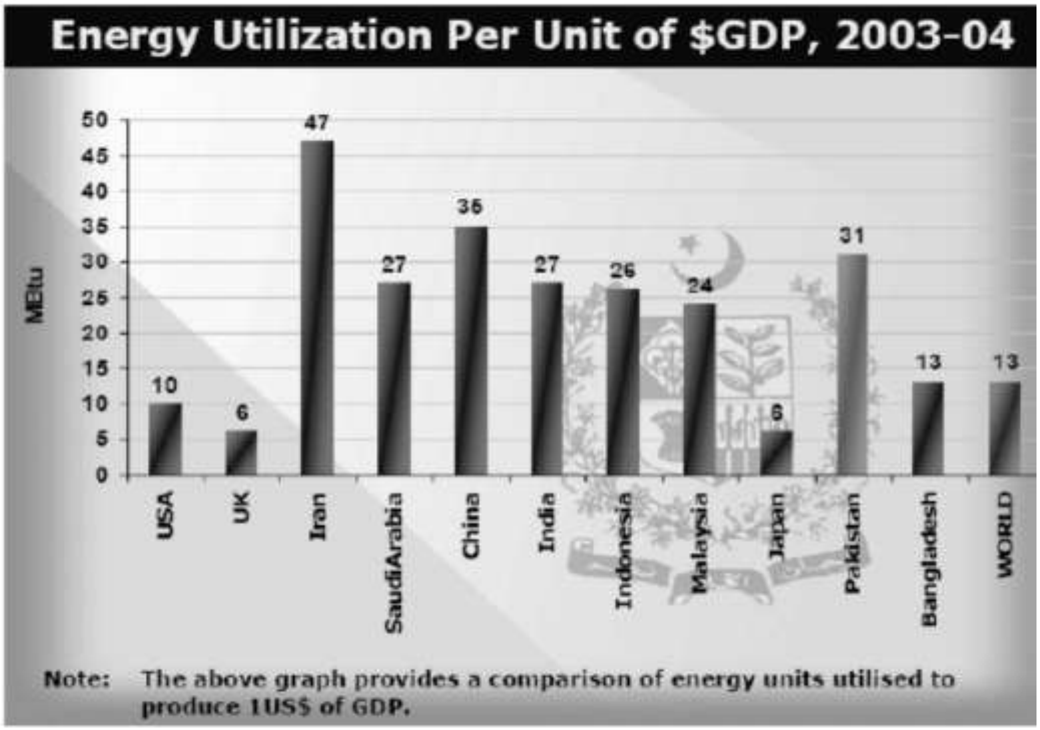
ix. Energy Intensity

Pakistan needs a relatively large amount of energy to produce one unit of Gross Domestic Product (GDP). I have included this analysis as to further investigate the

[44] Abid Jamal and Edmond Lee (2007), Asia Pacific Equity Research, Pakistan Power Space, JPMorgan, P-10,

relationship between energy consumption and Gross Domestic Product (GDP). The Figure 18, below makes a comparison of the energy intensity of various economies.

Figure 18.



Source: Energy Sector Assessment for Usaid/Pakistan June 2007

It is clear, that for a developing country, to produce $1 unit of Gross Domestic Product, the energy Pakistan uses is too high. Especially when taking into account the fact that Pakistan is not rich in crude oil deposits. In contrast, countries like Iran, which have higher energy intensity, may be able to sustain a level of energy consumption

Energy intensity varies greatly depending upon the level of industrialization, country's geographical location, infrastructural development, and efficient energy conversation methods. Equatorial region countries generally have higher energy intensities due greater energy consumption at offices, homes, malls, because of air conditioners, water coolers, and freezers. But we can see from the graph above that countries like India, Bangladesh, Saudi Arabia, which are located in the same region have lower energy intensities than Pakistan. The problem lies in the inefficiency of energy usage.

8. Research Methodology

The research methodology of this paper is grounded on empirical analysis based and linking it with the theoretical analysis on the electricity crisis in Pakistan. I would use Stata to perform the econometrics time series statistical test for my models. This includes causality analysis in the panel context of four steps. Starting with panel unit root tests such as Augmented Dickey-Fuller (ADF) is undertaken with logged time series and first difference. This would lead us to VAR-model estimation for short-run analysis. If they are integrated at order one I(1), a Johansen cointegration test is employed. If series has cointegration, then the long-run cointegration Vector Error Correction (VEC) model is estimated using the Panel fully modified ordinary least square. This would show the dynamic relationship between multiple variables Electricity Consumption as function of GDP, Agriculture growth, Manufacturing growth, Services growth. A long-run relationship implies that there must be causality in at least one direction, and for ascertaining if the one time series practicable in forecasting another, Granger causality test is conducted. However, if cointegration does not subsist, panel causality would still be tested in the short-run VAR model.

My research hypothesis would be test based on two specified models: VAR-Model and VEC-Model.

a. VAR Model

Before proceeding to VAR analysis, logged time-series and first difference were used for testing stationarity. Augmented Dickey-Fuller Test was conducted in order to do that.

The hypothesis for ADF Unit Root Test:

H0: Time-series is not stationary or there is a unit root.

H1: Time-series is stationary or there is no unit root.

If unit root exists (H0 = β = 0) then I have to accept the null hypothesis otherwise the alternative hypothesis is accepted (HA = β < 0). The null hypothesis of the ADF-test is that the series is non-stationary (or: there is a unit root). Augmented Dickey Fuller test (ADF) is a test is used to find out unit root in a time series. It is usually helpful in complicated and large sample of data.

i. VAR Model Estimation:

After taking log and first differences to ensure the stationarity of the variables, now VAR model can be estimated. In order to determine the number of lags in both models Akaike's Information Criterion (AIC, Schwarz and Hannan-Quinn information criteria as well as Likelihood-Ratio Test were used.

This model is used for analyzing relatedness between my variables, and points out the degree to which these variables affect each other on the basis of current and past economic values in the short-run scenario.

ii. Granger Causality Test

To observe the direction of causality between my variables, Granger Causality Test is performed. It would determine whether time series of one variable is useful in predicting another variable. For example if change in X variable is followed by change in Y variable, it is said that 'X granger causes Y'.

H01: Yt does not cause Xt

H11: Yt causes Xt

Here Xt and Yt are random time series.

b. VEC Model

i. Johansen Test for cointegration

In order to perform the VEC model estimation, number of cointegrating equations has to be determined. Johansen Test is applied, with logged values of the variables, and the number of lags is determined in same criteria as in VAR model. VEC model would indicate whether there is long-run relationship between the variables.

Hypothesis:

H02: There are no cointegration relationships

H12: There is at most 1 cointegration relationship

ii. VEC Model Estimation

VEC estimation is performed after finding of cointegrating vectors through Johansen Cointergration test. We can analyze the long-run relationship between different variables by considering the cointergration equations. The short-run relationship can be analyzed by observing logged values in VEC estimation that shows causality amongst variables with regard to past and current values.

9. Model 1. Electricity Consumption growth and GDP growth

a. Hypothesis

First hypothesis of my first model research is growth in Electricity Consumption significantly and positively depends on the growth in GDP. I have used GDP proxy variable for Economic Growth. As the country becomes prosperous its electricity requirements increase.

b. Model Specifications and Variables

Regression model will be used where Y (dependent factor) will be year-on growth in electricity consumption and X (Independent factor) will be my economic indicator.

Model 1: Electricity Consumption as a function of GDP

Years	**Electricity consumption in MW**	**Growth in electricity consumption % (Y)**	**GDP growth rate %, X**

(1) Formula for testing electricity consumption with respect to independent variable

GDP growth: $Y = \alpha + \beta * X$

(2) -> Lny_t = constant+ f { ln (x) }$_t$ + error$_t$

Estimation of the above equation econometrically, would leads following testable model:

(3) -> Ln(Electricity Consumption growth)$_t$ = α_t + f { ln(GDP growth) }$_t$ + e_t

Where, Y represents growth in Electricity Consumption, X is growth in GDP, α and β are coefficients (α is constant, β is elasticity), t denotes time period, e_t is the error term with the usual statistical properties.

c. Data

For my first model where electricity consumption growth is a function of GDP growth the data comprises over the period of 50 years for conducting empirical analysis. I would be using data from 1960 to 2009, where GDP growth Data is taken from World Bank Database website and electricity consumption Data is taken from State Bank of Pakistan's Handbook of Statistics on Pakistan Economy 2010. Furthermore, before using my data I would obtain natural logarithm prior to conducting VAR and causality analysis.

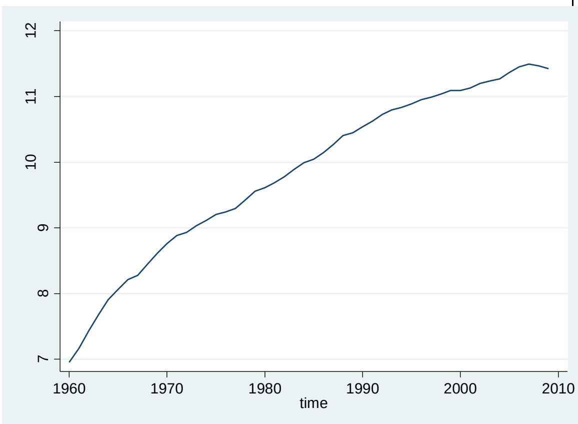
d. Empirical Analysis Model 1: Electricity Consumption Growth, and GDP Growth

i. Analysis of the data

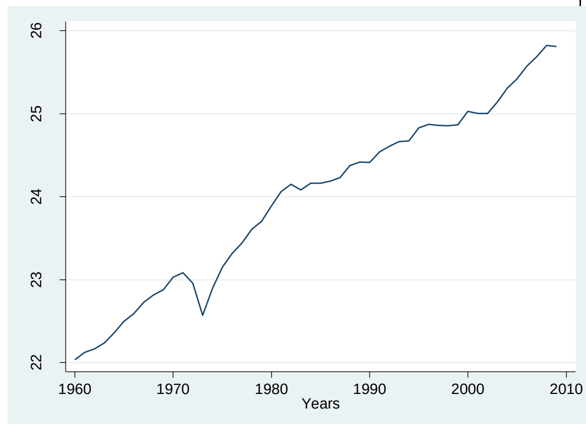
Since I'm using logged values of my original time-series to create new time series: ln_electricity_consumption and ln_gdp which are logged (electricity_consumption and gdp)

In order to interpret the behavior of the time-series through years, we need to view the graphs.

Figure 19



a. electricity consumption



b. gdp

Figure 19 (a,b) illustrates clear approaching trends for our time-series. We can say that Electricity Consumption increased smoothly over the span of 50 years, but there were fluctuations in GDP growth in the mid 70s.

ii. Testing time-series for stationarity

As the ocular inspection clearly shows that there are upcoming trends for variables, and data can be trend-stationary data. And inconstant variation during the given period of time tells us that there is non-stationary. I'll use Augmented Dickey-Fuller unit root test, in order to observe stationarity of time series. And to define the number of lags I'll use the Autocorrelogram for logged variables *(Oscar Torres-Reyna,* ver. 1.3, *Draft*, Time Series).

Augmented Dickey-Fuller Unit Root Tests					
Variables	Test statistics Z(t)	5% Critical value	10% Critical value	Deterministic Regressors	Results
ln_electricity_consumption	(2.24)	(3.51)	(3.19)	constant	non-stationary
ln_gdp	(2.91)	(3.51)	(3.19)	constant + trend	non-stationary
Lagged differenced terms are added in order to produce white noise residuals, which explain any autocorrelation in the time series. The variable which has unit root is non-stationary at the level form, but it become Stationary after taking the first difference.					
dln_electricity_consumption	(4.14)	(3.51)	(3.19)	constant + trend	stationary
dln_gdp	(5.35)	(3.51)	(3.19)	constant	stationary

The analysis of the data shows that time series are not I(0), and both time series are I(1), we can now do further analysis in first difference terms.

iii. Short-Run (VAR) Model Estimation And Testing

To determine the number of lags I will use the selection-order criteria, and the information criteria and the LR-Test suggests having dln_electricity_consumption dln_gdp: 1 lags

```
. varsoc dln_electricity_consumption dln_gdp

   Selection-order criteria
   Sample:  1965 - 2009                          Number of obs      =        45
```

lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	109.336				.000029	-4.77051	-4.74057	-4.69021
1	119.464	20.256*	4	0.000	.000022*	-5.04287*	-4.95306*	-4.80198*
2	121.885	4.8401	4	0.304	.000024	-4.97265	-4.82298	-4.57116
3	122.989	2.2084	4	0.697	.000027	-4.84394	-4.63441	-4.28187
4	126.912	7.8468	4	0.097	.000027	-4.84054	-4.57114	-4.11787

```
   Endogenous:  dln_electricity_consumption dln_gdp
    Exogenous:  _cons
```

Now we can proceed directly to estimation of VAR-model. Running the models gives us the following output Tables:

VAR-Model Estimation: Electricity Consumption and GDP growth

```
. var  dln_electricity_consumption dln_gdp, lags(1)

Vector autoregression

Sample:  1962 - 2009                            No. of obs      =        48
Log likelihood =  126.0765                      AIC             = -5.003188
FPE            =   .000023                      HQIC            = -4.914797
Det(Sigma_ml)  =  .0000179                      SBIC            = -4.769288
```

Equation	Parms	RMSE	R-sq	chi2	P>chi2
dln_electricit~n	3	.042577	0.5482	58.24517	0.0000
dln_gdp	3	.106893	0.0449	2.254594	0.3239

	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
dln_electr~n						
dln_electr~n						
L1.	.7461097	.0977923	7.63	0.000	.5544404	.937779
dln_gdp						
L1.	-.0095245	.0566036	-0.17	0.866	-.1204655	.1014166
_cons	.0192557	.0118403	1.63	0.104	-.0039509	.0424623
dln_gdp						
dln_electr~n						
L1.	.2695456	.2455144	1.10	0.272	-.2116538	.7507451
dln_gdp						
L1.	.1459678	.1421074	1.03	0.304	-.1325576	.4244931
_cons	.039951	.0297259	1.34	0.179	-.0183107	.0982128

In the short-run scenario the electricity consumption does not significantly depend on the growth rate of GDP. The p-values of the estimated coefficients are greater than 0.1, which means that they are not significant at 10% significance level. If we look at the electricity consumption growth, it only depends significantly on the electricity consumption growth for the previous period. 1% increase in the last year's growth adds 0.75% in this year's electricity consumption's growth.

iv. Granger Causality Test

In order to make the position more understandable it is important to look at the results of Granger causality test, which demonstrate the direction of short-term relationships/Causality.

Model1. Electricity consumption growth is not Granger-caused by changes in the growth rate of GDP, and vice versa.

```
. vargranger
```

Granger causality Wald tests

Equation	Excluded	chi2	df	Prob > chi2
dln_electricity~n	dln_gdp	.02831	1	0.866
dln_electricity~n	ALL	.02831	1	0.866
dln_gdp	dln_electricity~n	1.2053	1	0.272
dln_gdp	ALL	1.2053	1	0.272

v. Testing the models Stability

In order to check the stability of the VAR-models we can analyze the eigenvalues for each equation. From the results below we can tell that all the eigenvalues are less than 1 and lie inside the unit circle, which signifies that the models are stable.

```
. varstable
```

Eigenvalue stability condition

Eigenvalue	Modulus
.741801	.741801
.1502765	.150277

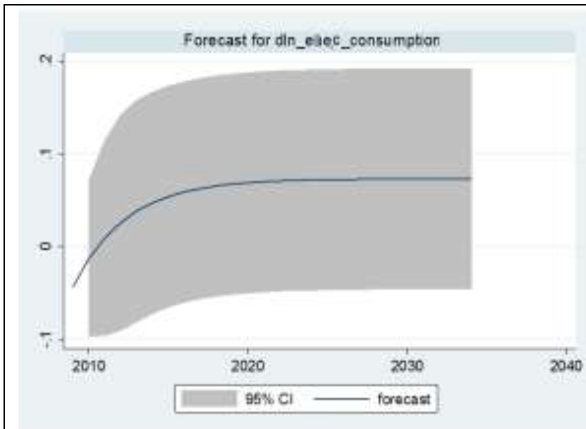
All the eigenvalues lie inside the unit circle.
VAR satisfies stability condition.

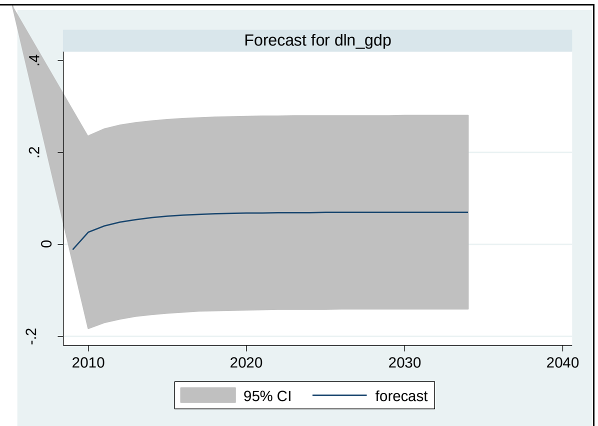
vi. Forecasting

By using the estimated VAR-models I'll forecast for the next 25 years, to see the general patterns of future growth.

Looking at the graph below, we can tell that:

- Electricity Consumption is expected to increase at an accelerating growth rate, and eventually increasing at around 7% growth.
- GDP growth rates are supposed increase over time, but with decelerating tempos, at about 6.5%.





vii. Long-Run (VEC) Model Estimation And Testing

Estimation of VEC-models, it is important to define the number of cointegrating equations. For doing that I have to perform Johansen Test for Cointegration on my original logged time series.

Johansen Test

```
. vecrank  ln_electricity_consumption ln_gdp, lags(1)

                       Johansen tests for cointegration
Trend: constant                                         Number of obs =      49
Sample:  1961 - 2009                                             Lags =       1
-------------------------------------------------------------------------------
                                                         5%
maximum                                      trace    critical
  rank    parms      LL         eigenvalue  statistic    value
    0       2     106.74345          .       52.8220     15.41
    1       5     132.11559      0.64499      2.0777*     3.76
    2       6     133.15443      0.04152
-------------------------------------------------------------------------------
```

Johansen test suggests having 1 cointegrating relationship for VEC-model.

Lags for VEC estimation: It is important to use same lags as in VEC estimation as underlying VAR-model in levels. So the number of lags is set at 2 based on the selection order criteria.

```
. varsoc ln_electricity_consumption ln_gdp

   Selection-order criteria
   Sample:  1964 - 2009                        Number of obs      =        46
  +---------------------------------------------------------------------------+
  |lag |    LL      LR      df    p      FPE       AIC      HQIC      SBIC    |
  |----+----------------------------------------------------------------------|
  |  0 | -57.2516                      .045068   2.57615   2.60594   2.65566  |
  |  1 |  125.076  364.65    4  0.000  .000019  -5.17721  -5.08786  -4.93869* |
  |  2 |  130.666   11.18*   4  0.025  .000018* -5.24633* -5.09742*  -4.8488  |
  |  3 |  132.523  3.7147    4  0.446   .00002  -5.15318  -4.94469  -4.59663  |
  |  4 |  133.159  1.2724    4  0.866  .000023  -5.00693  -4.73887  -4.29137  |
  +---------------------------------------------------------------------------+
   Endogenous:  ln_electricity_consumption ln_gdp
    Exogenous:  _cons
```

viii. Results of estimated VEC-model (Cointegration Equations)

Model 1

Normalized cointegrating equation coefficients (Appendix 3.)		
ln_electricity_consumption	ln_gdp	Constant
1	-0.8310628	9.707635
s.r	0.0785389	

$\ln y_t = \text{constant} + f\{\ln(X)\}_t + \text{error}_t$

The equation is the following:

$\text{Coequation}_{1t} = \ln(\text{electricity\_consumption}_t) - 0.831 \ln(\text{gdp}_t)$

This implies that in long-term equilibrium (when cointegration equations are equal to 0):

$\text{ln\_electricity\_consumption}_t = +\,0.831\ \text{ln\_gdp}_t$

Long-run: The growth in electricity consumption is significantly correlated with the growth in GDP. During the VAR-model test analysis we saw that in short-run electricity consumption growth is not influenced by GDP growth, but in the long-run scenario we can see a positive relation. 1% increase in GDP growth would result in .831% growth in electricity consumption. We accept the hypothesis of research that growth in electricity consumption significantly and positively depends on the growth of GDP.

Now we need to study, what happens if long-term equilibrium is broken, there is a positive cointegrating error, which means that cointegration equation is not equal to 0, but is greater than 0):

$\text{ln\_electricity\_consumption}_t - 0.831 \text{ ln\_gdp}_t > 0$

We will examine the ce1 values of the variables to see the deviations from cointegrating values. We can see that the correction error for ln_electricity_consumption is statistically significant at 5% level and is -0.0829. This is yearly negative adjustment of $\text{ln\_electricity\_consumption}_t$, will be .083% of deviation of in $\text{ln\_electricity\_consumption}_{t-1}$ from its cointergrating values. Also for the ln_gdp the correction error is .12, and is statistically significant. This means that yearly positive adjustment of ln_gdp_t, will be .12% of deviation of $\text{ln_gdp}_{t-1}$from its cointegrating value. So if we believe that the long-run relationship is broken, we can electricity consumption level and GDP level would react against error by adjusting.

Short run perspective VEC-model estimation: Model 1

```
. vec  ln_electricity_consumption ln_gdp, lags(2)

Vector error-correction model

Sample:  1962 - 2009                              No. of obs      =        48
                                                  AIC             = -5.249256
Log likelihood =  134.9821                        HQIC            = -5.116669
Det(Sigma_ml)  =  .0000124                        SBIC            = -4.898406

Equation           Parms    RMSE     R-sq      chi2     P>chi2
----------------------------------------------------------------
D_ln_electrici~n     4     .037203   0.8909   359.2027   0.0000
D_ln_gdp             4     .103199   0.4297   33.14841   0.0000
----------------------------------------------------------------

------------------------------------------------------------------------------
             |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
D_ln_elect~n |
        _ce1 |
         L1. |  -.0829191   .0214533    -3.87   0.000    -.1249668   -.0408714
ln_electri~n |
         LD. |   .3506388   .1351201     2.60   0.009     .0858082    .6154694
      ln_gdp |
         LD. |  -.0663883   .0531579    -1.25   0.212    -.1705759    .0377993
       _cons |   .0317573    .011164     2.84   0.004     .0098762    .0536383
-------------+----------------------------------------------------------------
D_ln_gdp     |
        _ce1 |
         L1. |   .1230996   .0595099     2.07   0.039     .0064624    .2397369
ln_electri~n |
         LD. |   .8566517   .3748134     2.29   0.022     .1220309    1.591272
      ln_gdp |
         LD. |   .2303863   .1474562     1.56   0.118    -.0586224    .5193951
       _cons |   .0213915   .0309681     0.69   0.490     -.039305    .0820879
------------------------------------------------------------------------------
```

In order to comment on the short-run perspective we need to look at the values on the top columns of the table, and as LD values with variables. We can say that electricity consumption significantly depends upon the growth rate of itself from the previous period. 1% increase in electricity consumption from the previous period would add 0.35% in electricity consumption in this period. On the other hand, current period GDP growth rate significantly depends upon the growth of electricity consumption from previous period. 1% increase in electricity consumption from previous period would add 0.85% in this period's GDP.

10. Model 2. Electricity Consumption Growth, Manufacturing Growth, Agriculture Growth, Services Growth

a. Hypothesis

Second hypothesis of research is growth in electricity consumption significantly and positively depends on the growth in manufacturing, growth in agriculture, and growth in services.

As a nation becomes more prosperous, the more electricity it would require to sustain the growth process, until it has reached the optimal threshold level. For example, as the manufacturing sector grows, more machinery would be applied, thus leading to increase in volume of production, and which would consequently result in accelerating electricity consumption.

Electricity consumption as a function of economic growth can be studied by analysis of different factors such as real GDP growth, real income growth, infrastructural development growth, growth in price level (Jorgenson, Dale W. and Peter J. Wilcoxen (1993)). More recently economists have studies economic growth with respect to GDP and Energy Prices, based on the notation how income and price elasticity are related to change in energy prices. They have used elasticity to understand demand behavior, and also to forecast future energy demands for policy making (Varian, 1988).

b. Model Specifications and Variables

Regression model will be used where Y (dependent factor) will be year-on Growth in electricity consumption and Xs (Independent factors) will be various economic indicators.

Model 2: Electricity Consumption as a function of Manufacturing growth, Agriculture growth, Services growth

Years	Electricity consumption in MW	Growth in electricity consumption % (Y)	Manufacturing Growth rate %, X1	Agriculture growth rate %, X2	Service growth rate %, X3

The following multifactor function framework can be used to find out the relation between different factors. This complex relationship would formulate a reasonable understanding of these independent variables and would help policy makers in understanding the drivers behind the electricity consumption.

(1) -> $Y = \alpha + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + e$

It is useful to take the logarithm of expression (1). Then we will get the following modified, linear equation

(2)-> $\text{Ln}y_t = \text{constant} + f\{\ln(x1, x2, x3)\}_t + \text{error}_t$

Estimation of the above equation econometrically, would leads following testable model:

(3)-> $\text{Ln(Electricity Consumption growth)}_t = \alpha_t + f\{\ln(\text{Manufacturing growth}), \ln(\text{Agriculture growth}), \ln(\text{Service sector growth})\}_t + e_t$

Where, Y represents growth in Electricity Consumption, X1 is growth in Manufacturing sector, X2 is growth in Agriculture sector, X3 is growth in Services sector, α and β are coefficients (α is constant, β is elasticity), t denotes time period, e_t is the error term with the usual statistical properties.

c. Data

In the second model I have broken down GDP into sub sectors of the Pakistani economy: manufacturing, agriculture, and services. I have taken electricity consumption as a function of these different economic indicators. The breakdown and description analysis of GDP growth factors would help in providing better understanding on how electricity consumption is driven by each sector. My study would be based upon annual data covering period from 1960 to 2009 (t=1…50). I have taken data on Electricity Consumption from State Bank of Pakistan's Handbook of Statistics on Pakistan Economy 2010, and the data on Manufacturing, Agriculture, and Services is taken from World Bank Database website. I have also obtained natural logarithms prior to conducting empirical analysis.

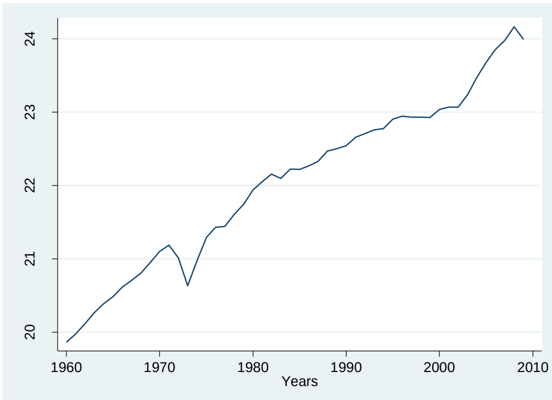
d. Empirical Analysis Model 2: Electricity Consumption Growth, Manufacturing Growth, Agriculture Growth, Services Sector Growth

i. Analysis of the data

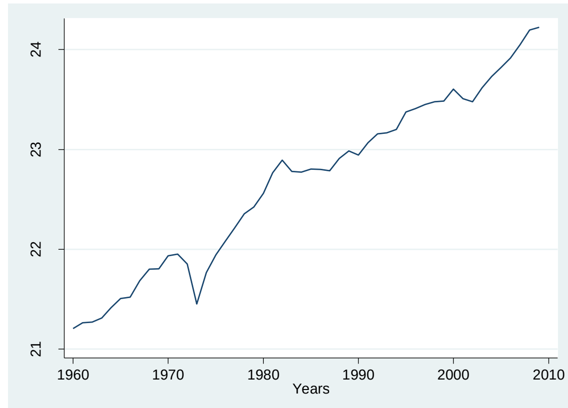
Since I'm using logged values of my original time-series, it is import to create new time series: ln_electricity_consumption ln_manufacturing ln_agriculture ln_service, which are logged (electricity_consumption, manufacturing, agriculture, service)
The summarization of the data for time-series shows us the following information (see Table 1 Appendix).

In order to interpret the behavior of the time-series through years, we need to view the graphs.

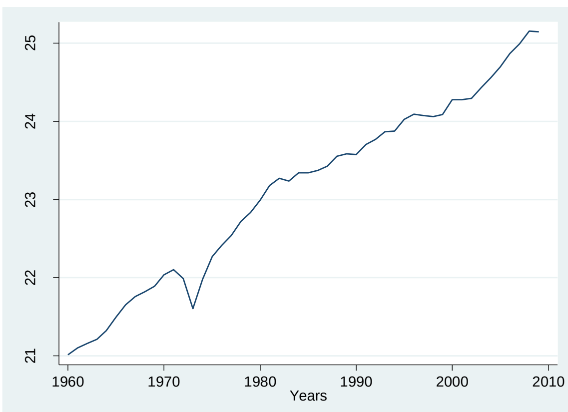
Figure 20



c. manufacturing



d. agriculture



e. service

Figure 20, exemplifies clear approaching trends for our time-series. We can articulate something about the character of growth: although electricity consumption increased smoothly over the span of 50 years, on the other hand we can see noticeable fluctuations especially during mid 1970's manufacturing growth, agriculture growth, services growth.

ii. Testing time-series for stationarity

As the ocular inspection clearly shows that there are upcoming trends in variables, and data can be trend stationary data. And inconstant variation during the given period of time tells us that there is non-stationary. I'll use Augmented Dickey-Fuller unit root test, in order to observe stationarity of time series. And to define the number of lags I'll use the Autocorrelogram for logged variables *(Oscar Torres-Reyna,* ver. 1.3, *Draft*, Time Series).

Augmented Dickey-Fuller Unit Root Tests					
Variables	Test statistics Z(t)	5% Critical value	10% Critical value	Deterministic Regressors	Results
ln_electricity_consumption	(2.24)	(3.51)	(3.19)	constant	non-stationary
ln_manufacturing	(3.39)	(3.51)	(3.19)	constant + trend	non-stationary
ln_agriculture	(3.14)	(3.51)	(3.19)	constant + trend	non-stationary
ln_service	(2.79)	(3.51)	(3.19)	constant + trend	non-stationary
Lagged differenced terms are added in order to produce white noise residuals, which explain any autocorrelation in the time series. The variable which has unit root is non-stationary at the level form, but it become Stationary after taking difference. We refer this type of variable is integrated of order one or two I (1) or I (2). It also depends on the number of times it was differenced. It is considered much important to further test for the linear combination between them.					
dln_electricity_consumption	(4.14)	(3.51)	(3.19)	constant + trend	stationary
dln_manufacturing	(5.36)	(3.51)	(3.19)	constant	stationary
dln_agriculture	(5.39)	(3.51)	(3.19)	constant	stationary
dln_service	(5.58)	(3.51)	(3.19)	constant	stationary

The analysis of the data shows that time series are not I(0), and all time series are I(1), we can now do further analysis in first difference terms.

iii. Short-Run (VAR) Model Estimation And Testing

Selection order criteria would be used for the determination of the number of lags.

```
. varsoc dln_electricity_consumption dln_manufacturing dln_agriculture dln_service

   Selection-order criteria
   Sample:  1965 - 2009                         Number of obs      =        45

  +---------------------------------------------------------------------------+
  |lag |    LL      LR      df    p      FPE       AIC       HQIC      SBIC    |
  |----+----------------------------------------------------------------------|
  |  0 |  259.303                       1.4e-10* -11.3468* -11.2869* -11.1862* |
  |  1 |  274.586  30.566    16  0.015  1.4e-10  -11.3149  -11.0156   -10.512  |
  |  2 |  285.062  20.952    16  0.180  1.9e-10  -11.0694  -10.5306  -9.62408  |
  |  3 |  292.129  14.134    16  0.589  2.9e-10  -10.6724  -9.89413   -8.5847  |
  |  4 |  315.235  46.213*   16  0.000  2.3e-10  -10.9882   -9.9705  -8.25817  |
  +---------------------------------------------------------------------------+
   Endogenous:  dln_electricity_consumption dln_manufacturing dln_agriculture
                dln_service
    Exogenous:  _cons
```

Now we can proceed directly to estimation of VAR-model. Running the models gives us the following output Tables:

VAR-model estimation: Electricity Consumption, Manufacturing growth, Agriculture growth, Service growth

```
. var  dln_electricity_consumption dln_manufacturing dln_agriculture dln_service , lags(1)
```

Vector autoregression

Sample:	1962 - 2009	No. of obs	= 48
Log likelihood =	292.4948	AIC	= -11.35395
FPE =	1.38e-10	HQIC	= -11.05931
Det(Sigma_ml) =	5.99e-11	SBIC	= -10.57428

Equation	Parms	RMSE	R-sq	chi2	P>chi2
dln_electricit~n	5	.040133	0.6164	77.14381	0.0000
dln_manufactur~g	5	.118513	0.0902	4.761488	0.3127
dln_agriculture	5	.108873	0.0604	3.084625	0.5438
dln_service	5	.111682	0.0531	2.693935	0.6103

		Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
dln_electr~n							
dln_electr~n	L1.	.8207932	.0985899	8.33	0.000	.6275605	1.014026
dln_manufa~g	L1.	-.0521365	.1342441	-0.39	0.698	-.3152502	.2109771
dln_agricu~e	L1.	.3444965	.1221627	2.82	0.005	.105062	.5839311
dln_service	L1.	-.2924606	.1728029	-1.69	0.091	-.6311481	.0462269
_cons		.0198926	.0112351	1.77	0.077	-.0021278	.0419131
dln_manufa~g							
dln_electr~n	L1.	.3759935	.291139	1.29	0.197	-.1946286	.9466155
dln_manufa~g	L1.	.330382	.3964269	0.83	0.405	-.4466005	1.107365
dln_agricu~e	L1.	-.1377039	.3607501	-0.38	0.703	-.8447611	.5693533
dln_service	L1.	-.0686604	.5102922	-0.13	0.893	-1.068815	.9314939
_cons		.033201	.0331777	1.00	0.317	-.031826	.0982281
dln_agricu~e							
dln_electr~n	L1.	-.0449681	.2674556	-0.17	0.866	-.5691713	.4792352
dln_manufa~g	L1.	.4746642	.3641785	1.30	0.192	-.2391125	1.188441
dln_agricu~e	L1.	-.2454535	.3314039	-0.74	0.459	-.8949933	.4040862
dln_service	L1.	-.1218886	.4687811	-0.26	0.795	-1.040683	.7969055
_cons		.0491588	.0304787	1.61	0.107	-.0105785	.108896
dln_service							
dln_electr~n	L1.	.1554469	.2743567	0.57	0.571	-.3822824	.6931762
dln_manufa~g	L1.	.2529904	.3735754	0.68	0.498	-.479204	.9851847
dln_agricu~e	L1.	-.2464891	.3399551	-0.73	0.468	-.912789	.4198107
dln_service	L1.	.0920902	.4808771	0.19	0.848	-.8504116	1.034592
_cons		.0544327	.0312652	1.74	0.082	-.0068459	.1157113

The results of growth in electricity consumption this with respect to growth in electricity consumption last year, agriculture growth last year, manufacturing growth last year, and services growth last year; are somewhat surprising in the short run scenario. Increasing electricity consumption growth in the previous period at 1% adds another 0.82% this year. Electricity consumption also depends significantly on the growth rate in agriculture sector in the previous period. 1% addition in the agriculture growth in the previous period adds 0.34% in electricity consumption growth in this period. Also adding 1% in last year's service sector growth, lead to -0.29% reduction in electricity consumption growth for this year. The results of estimation also show that electricity consumption doesn't significantly depend on the growth rate in manufacturing sector in the previous period, because the p-values of the estimated coefficients are greater than 0.1, showing insignificance at 10% significance level.

iv. Granger Causality Test

Now we will at the Granger causality test, which demonstrate the direction of short-term relationships/Causality.

As seen from the table below changes in growth rate of electricity consumption are caused by growth in agriculture sector, and also growth in Service sector, but is not Granger caused by growth in manufacturing sector. The results show us that there is one-way causality from agriculture growth, and service sector growth towards GDP growth.

```
. vargranger
```

Granger causality Wald tests

Equation	Excluded	chi2	df	Prob > chi2
dln_electricity~n	dln_manufacturing	.15083	1	0.698
dln_electricity~n	dln_agriculture	7.9523	1	0.005
dln_electricity~n	dln_service	2.8644	1	0.091
dln_electricity~n	ALL	8.5715	3	0.036
dln_manufacturing	dln_electricity~n	1.6679	1	0.197
dln_manufacturing	dln_agriculture	.14571	1	0.703
dln_manufacturing	dln_service	.0181	1	0.893
dln_manufacturing	ALL	3.087	3	0.378
dln_agriculture	dln_electricity~n	.02827	1	0.866
dln_agriculture	dln_manufacturing	1.6988	1	0.192
dln_agriculture	dln_service	.06761	1	0.795
dln_agriculture	ALL	2.9291	3	0.403
dln_service	dln_electricity~n	.32102	1	0.571
dln_service	dln_manufacturing	.45862	1	0.498
dln_service	dln_agriculture	.52572	1	0.468
dln_service	ALL	2.0431	3	0.564

v. Testing the models Stability

The results below we can tell that all the eigenvalues are less than 1 and lie inside the unit circle, which signifies that the models are stable.

```
. varstable

   Eigenvalue stability condition
```

Eigenvalue	Modulus
.7458474	.745847
.1513673 + .09899419*i*	.180864
.1513673 - .09899419*i*	.180864
-.0507701	.05077

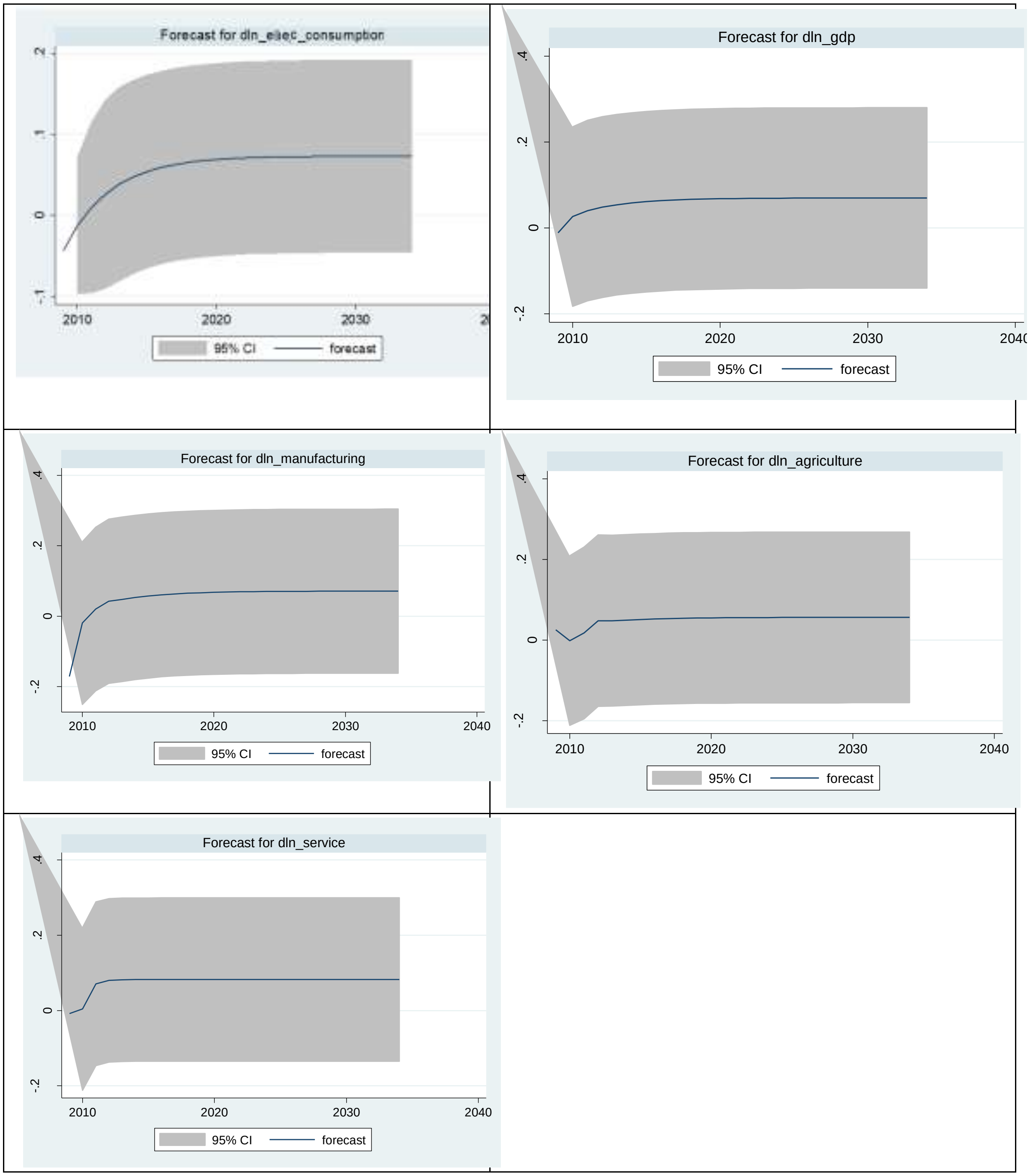
```
   All the eigenvalues lie inside the unit circle.
   VAR satisfies stability condition.
```

vi. Forecasting

By using the estimated VAR-models I'll forecast for the next 25 years, to see the general patterns of future growth.

Looking at the graph below, we can tell that:

- Electricity Consumption is expected to increase at an accelerating growth rate, and eventually increasing at around 7% growth.
- Manufacturing growth is expected to increase, with decelerating pace, and eventually at about 6.5% annually.
- Agriculture growth is expected to increase at a greater pace, and eventually growing at 5.5% annually.
- Services sector is expected to growth at greater pace and then becoming stable growth at around 8%.



vii. Long-Run (VEC) Model Estimation and Testing

Estimation of VEC-models, it is important to define the number of cointegrating equations. For doing that I have to perform Johansen Test for Cointegration on my original logged time series. I will run this test with one lag, as defined earlier by selection criteria.

Johansen Test

Johansen test suggests having at least 1 cointegrating relationship for VEC-model.

```
. vecrank   ln_electricity_consumption ln_manufacturing ln_agriculture ln_service, lags(1)

                       Johansen tests for cointegration
Trend: constant                                         Number of obs =      49
Sample:  1961 - 2009                                             Lags =       1
-------------------------------------------------------------------------------
                                                         5%
maximum                                      trace    critical
  rank    parms       LL        eigenvalue  statistic    value
    0       4     271.49447          .       83.4511     47.21
    1      11     300.80974      0.69776     24.8205*    29.68
    2      16     307.32914      0.23364     11.7817     15.41
    3      19     311.96509      0.17240      2.5098      3.76
    4      20        313.22      0.04993
-------------------------------------------------------------------------------
.
```

Lags for VEC estimation: It is important to use same lags as in VEC estimation as underlying VAR-model in levels. So the number of lags is set at 2 based on the selection order criteria.

```
. varsoc ln_electricity_consumption ln_manufacturing ln_agriculture ln_service

   Selection-order criteria
   Sample:  1964 - 2009                        Number of obs      =        46
  +---------------------------------------------------------------------------+
  |lag |    LL       LR      df    p      FPE       AIC      HQIC      SBIC    |
  |----+----------------------------------------------------------------------|
  |  0 |  69.3499                        6.9e-07   -2.8413  -2.78173  -2.68229  |
  |  1 |  291.685  444.67    16  0.000  8.7e-11  -11.8124  -11.5145* -11.0173*  |
  |  2 |  308.591  33.812*   16  0.006  8.5e-11* -11.8518* -11.3157  -10.4207  |
  |  3 |  316.446  15.712    16  0.473  1.3e-10  -11.4977  -10.7233  -9.43051  |
  |  4 |  325.601  18.308    16  0.306  1.9e-10     -11.2  -10.1874  -8.49682  |
  +---------------------------------------------------------------------------+
   Endogenous:  ln_electricity_consumption ln_manufacturing ln_agriculture
                ln_service
    Exogenous:  _cons
```

Results of estimated VEC-model (Cointegration Equations)

Model 2

Normalized cointegrating equation coefficients (Appendix 4.)				
ln_electricity_consumption	ln_manufacturing	ln_agriculture	ln_service	constant
1	4.21	4.09	-7.77	-16.889
s.r	1.01	1.23	1.44	

$\ln y_t = \text{constant} + f\{\ln(x1, x2, x3, x4)\}_t + \text{error}_t$

The equation is the following:

$Coequation_{1t}$ = $\ln(electricity\_consumption_t)$ + 4.21 $\ln(manufacturing_t)$ + 4.09 $\ln(agriculture_t)$ -7.77 $\ln(service_t)$

This implies that in long-term equilibrium (when cointegration equations are equal to 0):

$ln\_electricity\_consumption_t$ = -4.21 $ln\_manufacturing_t$ - 4.09 $ln\_agriculture_t$ +7.77 $ln\_service_t$

Long-run: The growth in electricity consumption is significantly correlated with the growth in Manufacturing, Agriculture, and Service sectors. The results here in long-run scenario are different from the short-run scenario. Here we can see that 1% growth in Service sector leads to 7.77% growth in electricity consumption, but on the other hand 1% increase in manufacturing growth leads to 4.21% decrease in electricity consumption and same is with agriculture sector where 1% increase results in 4.09% decrease in electricity consumption.

Now we need to study, what happens if long-term equilibrium is broken, there is a positive cointegrating error, which means that cointegration equation is not equal to 0, but is greater than 0):

$ln\_electricity\_consumption_t$ +4.21 $ln\_manufacturing_t$ + 4.09 $ln\_agriculture_t$ -7.77 $ln\_service_t > 0$

We will examine the ce1 values of the variables to see the deviations from cointegrating values. We can see that the correction error for ln_electricity_consumption is statistically significant at 5% level and is -0.0556. This is yearly negative adjustment of $ln\_electricity\_consumption_t$ will be .0556% of deviation of in $ln\_electricity\_consumption_{t-1}$ from its cointergrating values. We can also see that correction error for ln_manufacturing, ln_agriculture, and ln_service is not statistically significant, meaning that they will not react to cointegrating error. So if long-run relationship as broken, we would say that while the electricity consumption level react against error with adjusting but other variables level are not adjusting.

Short run perspective from VEC-model estimation: Model2

Vector error-correction model

Sample:	1962 - 2009	No. of obs	= 48
		AIC	= -11.72347
Log likelihood =	308.3634	HQIC	= -11.32571
Det(Sigma_ml) =	3.09e-11	SBIC	= -10.67092

Equation	Parms	RMSE	R-sq	chi2	P>chi2
D_ln_electrici~n	6	.033311	0.9165	460.9415	0.0000
D_ln_manufactu~g	6	.118595	0.4091	29.08285	0.0001
D_ln_agriculture	6	.109716	0.3024	18.20903	0.0057
D_ln_service	6	.113003	0.4090	29.06292	0.0001

	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
D_ln_elect~n						
_ce1 L1.	-.0556441	.012315	-4.52	0.000	-.079781	-.0315072
ln_electri~n LD.	.5300085	.1077804	4.92	0.000	.3187628	.7412541
ln_manufac~g LD.	.1242024	.124025	1.00	0.317	-.1188821	.3672869
ln_agricul~e LD.	.4316567	.1088528	3.97	0.000	.2183091	.6450043
ln_service LD.	-.5599986	.1626956	-3.44	0.001	-.8788761	-.2411211
_cons	-.0179499	.0129312	-1.39	0.165	-.0432946	.0073949
D_ln_manuf~g						
_ce1 L1.	-.0425287	.0438443	-0.97	0.332	-.128462	.0434046
ln_electri~n LD.	.153747	.3837251	0.40	0.689	-.5983403	.9058344
ln_manufac~g LD.	.4651577	.44156	1.05	0.292	-.4002841	1.330599
ln_agricul~e LD.	-.0710875	.3875433	-0.18	0.854	-.8306584	.6884834
ln_service LD.	-.2731394	.5792371	-0.47	0.637	-1.408423	.8621445
_cons	.0042781	.0460385	0.09	0.926	-.0859557	.0945118
D_ln_agric~e						
_ce1 L1.	-.0237093	.0405617	-0.58	0.559	-.1032088	.0557901
ln_electri~n LD.	-.1688682	.3549955	-0.48	0.634	-.8646467	.5269102
ln_manufac~g LD.	.5498003	.4085004	1.35	0.178	-.2508457	1.350446
ln_agricul~e LD.	-.2083156	.3585279	-0.58	0.561	-.9110173	.4943862
ln_service LD.	-.2358836	.5358696	-0.44	0.660	-1.286169	.8144015
_cons	.0330345	.0425915	0.78	0.438	-.0504434	.1165124
D_ln_service						
_ce1 L1.	-.0006228	.0417771	-0.01	0.988	-.0825045	.0812588
ln_electri~n LD.	.1521921	.3656327	0.42	0.677	-.5644349	.868819
ln_manufac~g LD.	.2549642	.4207408	0.61	0.545	-.5696726	1.079601
ln_agricul~e LD.	-.2455135	.3692709	-0.66	0.506	-.9692712	.4782442
ln_service LD.	.0890955	.5519265	0.16	0.872	-.9926605	1.170852
_cons	.0540091	.0438678	1.23	0.218	-.0319701	.1399884

In order to comment on the short-run perspective we need to look at the values on the top columns of the table, and as LD values with variables. We can say that electricity consumption significantly depends upon the previous period's growth rate of itself as well as on the growth rate of agriculture sector, and service sector, but not the manufacturing sector.

1% increase in electricity consumption from the previous period would add 0.53% in electricity consumption in this period. 1% increase in agriculture growth from the previous period would add 0.43% in electricity consumption in this period. 1% increase in Service sector growth from the previous period would decrease Electricity Consumption in this period by 0.56%. The results are quite similar to the results of VAR-model analysis, which also showed the same trend.

11. Model 3: Electricity Consumption Growth, and Population Growth

a. Hypothesis

Electricity consumption growth is positively significant related to the growth in population. I plan to examine Pakistan's population growth and its impact on electricity consumption, from 1960 to 2010; as Pakistan's population has increased 254% during this period. Such a huge increase in population makes it of particular value to analyze how increase in population has impact the country's electricity consumption. This can help in tackle electricity crisis, like the one Pakistan is currently facing.

b. Model Specifications and Variables

Regression model will be used where Y (dependent factor) will be year-on growth in electricity consumption and X (Independent factor) would be my demographic indicator, population.

Model 3: Electricity Consumption as a function of Population growth

Years	**Electricity consumption in MW**	Growth in electricity consumption % (Y)	Population growth rate %, X1

(1) Formula for testing electricity consumption with respect to independent variable population growth: $Y = \alpha + \beta * X$

(2) -> Lny_t = constant+ f { ln (x) $\}_t$ + $error_t$

Estimation of the above equation econometrically, would leads following testable model:

(3) -> Ln(Electricity Consumption growth)$_t$ = α_t + f { ln(Population growth) $\}_t$ + e_t

Where, Y represents growth in Electricity Consumption, X is growth in Population, α and β are coefficients (α is constant, β is elasticity), t denotes time period, e_t is the error term with the usual statistical properties.

c. Data

This part of my study would focus on electricity consumption as function of population growth. By using statistical analysis I would analyze and understand the fundamental relationship between my variables. The study would be based upon historical data spreading over from 1960 to 2009 (t=1…50), which is taken from World Bank Database website. I have obtained natural logarithms prior to conducting statistical tests.

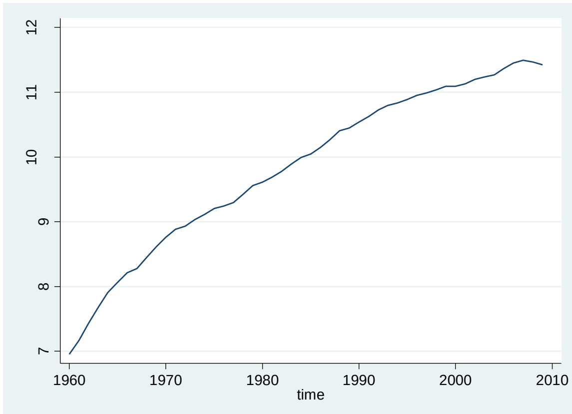
d. Empirical Analysis Model 3: Electricity Consumption Growth, and Population Growth

i. Analysis of the data

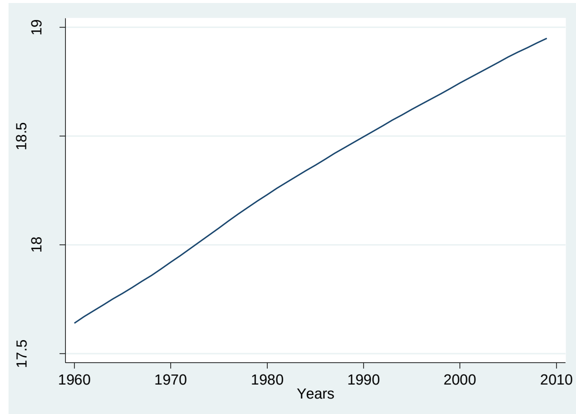
Since I'm using logged values of my original time-series, it is import to create new time series: ln_electricity_consumption ln_population, which are logged (electricity consumption and population)

In order to interpret the behavior of the time-series through years, we need to view the graphs.

Figure 21.



f.electricity consumption



g.population

Figure 21, exemplifies clear approaching trends for all our time-series. We can articulate something about the character of growth: Electricity Consumption, Population increased smoothly over the span of 50 years.

ii. Testing time-series for stationarity

As the ocular inspection clearly shows that there are upcoming trends in variables, can be trend stationary. I'll use Augmented Dickey-Fuller unit root test, in order to observe stationarity of time series. And to define the number of lags I'll use the Autocorrelogram for logged variables (*Oscar Torres-Reyna,* ver. 1.3, *Draft*, Time Series).

Augmented Dickey-Fuller Unit Root Tests					
Variables	Test statistics Z(t)	5% Critical value	**10% Critical value**	Deterministic Regressors	Results
ln_electricity_consumption	(2.24)	(3.51)	(3.19)	constant	non-stationary
ln_population	(0.69)	(3.52)	(3.19)		non-stationary
Lagged differenced terms are added in order to produce white noise residuals, which explain any autocorrelation in the time series. The variable which has unit root is non-stationary at the level form, but it become Stationary after taking difference. We refer this type of variable is integrated of order one or two I (1) or I (2). It also depends on the number of times it was differenced. It is considered much important to further test for the linear combination between them.					
dln_electricity_consumption	(4.14)	(3.51)	(3.19)	constant + trend	stationary
dln_population	(3.37)	(3.52)	(3.19)	constant + trend	stationary

iii. Short-Run (VAR) Model Estimation And Testing

To determine the number of lags I will use the selection-order criteria. The information criteria and LR-Test suggests having dln_electricity_consumption dln_population: 2 lag.

```
. varsoc dln_electricity_consumption dln_population

   Selection-order criteria
   Sample:  1965 - 2009                         Number of obs      =        45

  +---------------------------------------------------------------------------+
  |lag |    LL      LR      df    p      FPE       AIC      HQIC      SBIC    |
  |----+----------------------------------------------------------------------|
  |  0 |  275.71                       1.8e-08  -12.1649   -12.135  -12.0846  |
  |  1 | 355.167  158.91     4  0.000  6.2e-10  -15.5185  -15.4287  -15.2776* |
  |  2 | 361.818  13.303*    4  0.010  5.6e-10* -15.6364* -15.4867* -15.2349  |
  |  3 | 364.611   5.586     4  0.232  5.9e-10  -15.5827  -15.3732  -15.0207  |
  |  4 | 368.402  7.5822     4  0.108  6.0e-10  -15.5734   -15.304  -14.8508  |
  +---------------------------------------------------------------------------+
   Endogenous:  dln_electricity_consumption dln_population
    Exogenous:  _cons
```

Now we can proceed directly to estimation of VAR-model. Running the models gives us the following output Tables:

VAR-Model Estimation: Electricity Consumption growth and Population growth

```
. var dln_electricity_consumption dln_population,lags(2)

Vector autoregression

Sample:  1963 - 2009                               No. of obs      =        47
Log likelihood =   335.659                         AIC             = -14.02804
FPE            =  2.77e-09                         HQIC            = -13.93916
Det(Sigma_ml)  =  2.15e-09                         SBIC            = -13.79185

Equation           Parms      RMSE     R-sq      chi2     P>chi2
----------------------------------------------------------------
dln_electricit~n      3     .045575   0.3858   29.51627   0.0000
dln_population        3     .001091   0.8758   331.5321   0.0000
----------------------------------------------------------------

------------------------------------------------------------------------------
             |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
dln_electr~n |
dln_electr~n |
         L2. |   .4507422    .113996     3.95   0.000     .2273142    .6741702
dln_popula~n |
         L2. |   5.823959   2.384985     2.44   0.015     1.149475    10.49844
       _cons |  -.1154771   .0623278    -1.85   0.064    -.2376373    .0066831
-------------+----------------------------------------------------------------
dln_popula~n |
dln_electr~n |
         L2. |    .001776   .0027285     0.65   0.515    -.0035717    .0071237
dln_popula~n |
         L2. |   .9848896   .0570844    17.25   0.000     .8730062    1.096773
       _cons |  -.0000696   .0014918    -0.05   0.963    -.0029935    .0028543
------------------------------------------------------------------------------
```

In the short-run scenario the electricity consumption significantly depend on the growth rate of previous period's electricity consumption, and also pervious period's population growth, because the p-values of the estimated coefficients are less than 0.1, which means that they are significant at 10% significance level. 1% increase in population growth from last year would lead to 5.8% increase in electricity consumption this year.

And 1% increase in electricity consumption from last year would lead to .45% increase in electricity consumption this year.

iv. Granger Causality Test

In order to make the position more understandable it is important to look at the results of Granger causality test, which demonstrate the direction of short-term relationships/Causality.

Electricity Consumption growth is Granger-caused by changes in the growth rate of Population. However we can see that growth rate in Electricity Consumption is not cause of change in Growth rate of Population.

```
. vargranger
```

Granger causality Wald tests

Equation	Excluded	chi2	df	Prob > chi2
dln_electricity~n	dln_population	5.963	1	0.015
dln_electricity~n	ALL	5.963	1	0.015
dln_population	dln_electricity~n	.42369	1	0.515
dln_population	ALL	.42369	1	0.515

v. Testing the models Stability

For the stability check of the VAR-models we can analyze the eigenvalues for each equation. From the results below we can tell that the eigenvalues are just barely over 1, and less than 1, which lie inside the unit circle.

```
. varstable
```

Eigenvalue stability condition

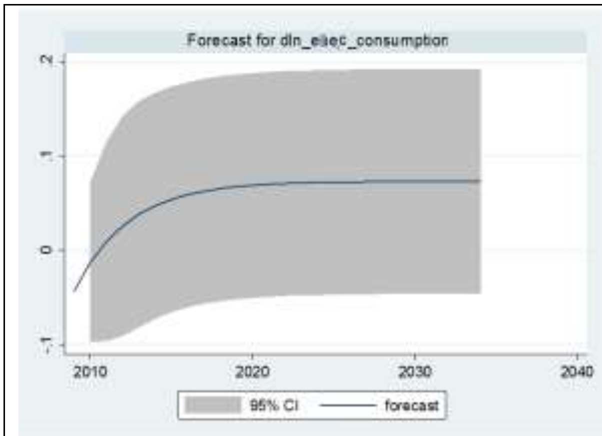
Eigenvalue	Modulus
1.001798	1.0018
-1.001798	1.0018
-.6572923	.657292
.6572923	.657292

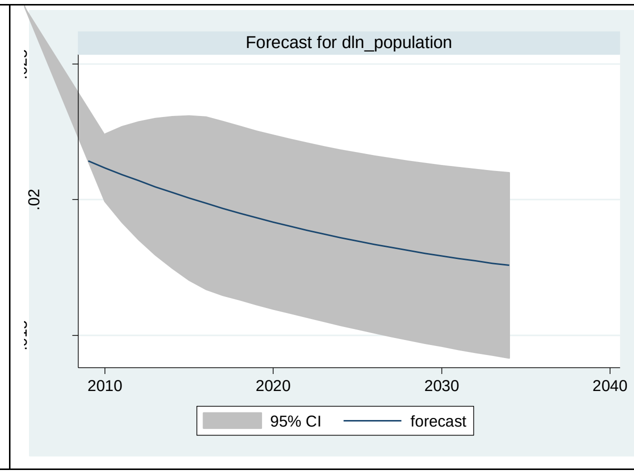
vi. Forecasting

By using the estimated VAR-models I'll forecast for the next 25 years, to see the general patterns of future growth.

Looking at the graph below, we can tell that:

- Electricity Consumption is expected to increase at accelerating growth rate, and eventually increasing at around 7% growth.
- Population is going to increase but at a decreasing growth rate.





vii. Long-Run (VEC) Model Estimation And Testing

For the estimation VEC model it is important to define number of cointegrating equations, by performing Johansen test. I would perform this test on my original time series.

Johansen test

The trace statistic test result is greater than critical value, so we don't reject the null hypothesis that these two variables are not cointegrated, we will move forward to estimate the VECM model. The null is rejected because the trace statistic is more than the critical value.

```
. vecrank ln_electricity_consumption ln_population, lags(2)

                       Johansen tests for cointegration
Trend: constant                                         Number of obs =      48
Sample:  1962 - 2009                                             Lags =       2
-------------------------------------------------------------------------------
                                                         5%
maximum                                      trace    critical
  rank    parms       LL       eigenvalue  statistic    value
    0       6     371.80904         .        41.5509    15.41
    1       9      386.1612     0.45009      12.8466     3.76
    2      10     392.58451     0.23482
-------------------------------------------------------------------------------
```

Lags for VEC estimation: It is important to use same lags as in VEC estimation as underlying VAR-model in levels. So the number of lags is set at 2 based on the selection order criteria.

```
. varsoc ln_electricity_consumption ln_population

   Selection-order criteria
   Sample:  1964 - 2009                         Number of obs      =        46

  +---------------------------------------------------------------------------+
  |lag |    LL      LR      df    p      FPE       AIC      HQIC      SBIC    |
  |----+----------------------------------------------------------------------|
  |  0 |  15.3692                       .001917  -.581268  -.551485  -.501762  |
  |  1 |  323.697  616.66    4  0.000  3.4e-09  -13.8129  -13.7236  -13.5744  |
  |  2 |   376.03  104.67*   4  0.000  4.2e-10  -15.9143  -15.7654* -15.5168* |
  |  3 |  380.392  8.7232    4  0.068  4.2e-10  -15.9301  -15.7216  -15.3735  |
  |  4 |  384.753  8.7229    4  0.068  4.1e-10* -15.9458* -15.6777  -15.2302  |
  +---------------------------------------------------------------------------+
   Endogenous:  ln_electricity_consumption ln_population
    Exogenous:  _cons
```

Results of estimated VEC-model (Cointegration Equations)

Model 3

Normalized cointegrating equation coefficients (Appendix 5.)		
ln_electricity_consumption	ln_population	Constant
1	-4.69	76.27
s.r	.27	

$\ln y_t$ = constant + f { ln (X) }$_t$+ error$_t$

The equation is the following:

Coequation$_{1t}$ = ln(electricity_consumption$_t$) -4.69 ln(population$_t$)

This implies that in long-term equilibrium (when cointegration equations are equal to 0):

ln_electricity_consumption$_t$ = + 4.69 ln_population$_t$

Long-run: The growth in electricity consumption is significantly correlated with the growth in population. During the VAR-model test analysis we saw that in short-run electricity consumption growth was also influenced by population growth, in the long-run scenario we can also see a positive relation. 1% increase in GDP growth would result in 4.69% growth in electricity consumption. So we accept the third hypothesis of my studies that growth in electricity consumption significantly and positively depends on the growth in population.

Now we need to study, what happens if long-term equilibrium is broken, there is a positive cointegrating error, which means that cointegration equation is not equal to 0, but is greater than 0):

$ln\_electricity\_consumption_t – 4.69\ ln\_popluation_t > 0$

By looking at ce1 values we can see that the correction error for ln_population is .0015 and is statistically significant. The yearly negative adjustment of $ln\_population_t$ would be .0015% of deviation of $ln\_population_{t-1}$ from its cointegrating value. If we consider long-run relationship to be broken, population level reacts against error by adjustment.

Short run perspective VEC-model estimation: Model 3

```
. vec ln_electricity_consumption ln_population, lags(2)

Vector error-correction model

Sample:  1962 - 2009                            No. of obs      =        48
                                                AIC             = -15.71505
Log likelihood =  386.1612                      HQIC            = -15.58246
Det(Sigma_ml)  =  3.53e-10                      SBIC            =  -15.3642

Equation           Parms      RMSE     R-sq      chi2     P>chi2
----------------------------------------------------------------
D_ln_electrici~n     4     .041498   0.8642   280.0602   0.0000
D_ln_population      4     .000505   0.9997     135299   0.0000
----------------------------------------------------------------

------------------------------------------------------------------------------
             |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
D_ln_elect~n |
        _ce1 |
         L1. |   .0181579   .0231519     0.78   0.433     -.027219    .0635349
ln_electri~n |
         LD. |   .6153834   .1385147     4.44   0.000     .3438995    .8868672
ln_populat~n |
         LD. |   1.058395   3.996647     0.26   0.791    -6.774889    8.891678
       _cons |  -.0005412   .1099849    -0.00   0.996    -.2161077    .2150253
-------------+----------------------------------------------------------------
D_ln_popul~n |
        _ce1 |
         L1. |   .0015917   .0002817     5.65   0.000     .0010395    .0021439
ln_electri~n |
         LD. |  -.0070983   .0016856    -4.21   0.000    -.0104021   -.0037945
ln_populat~n |
         LD. |   .7788075   .0486365    16.01   0.000     .6834816    .8741333
       _cons |   .0061737   .0013384     4.61   0.000     .0035504     .008797
------------------------------------------------------------------------------
```

In short-run perspective we can say that electricity consumption doesn’t significantly depend upon the growth rate of population but significantly depends on the growth rate of electricity consumption from the previous period. But population growth on the other hand significantly depends upon the previous period electricity consumption growth and previous period population growth. 1% increase in electricity consumption from the previous period would decrease current period's population my -0.007%. And 1% increase in population from previous period would add 0.77% in this period's population.

12. Model 4: Electricity Consumption Growth, and Urbanization Growth

a. Hypothesis

Electricity consumption growth is positively significant related to the growth in Urbanization. Due to rapid social changes there has been fast increase in Pakistan's urban population. Today around 32% of the population lives in cities due to natural increase in birth rate, and because of urban migration. As a result of this, conditions in the cities are under tremendous pressure. It is therefore import to analyze how urbanization growth leads to increase in electricity consumption[45].

b. Model Specifications and Variables

Regression model will be used where Y (dependent factor) will be year-on growth in electricity consumption and X (Independent factor) will be my demographic indicator urbanization.

Model 4: Electricity Consumption as a function of Urbanization growth

Years	**Electricity consumption in MW**	Growth in electricity consumption % (Y)	Urbanization growth rate %, X1

(4) Formula for testing electricity consumption with respect to independent variable population growth: Y = α + β*X

(5) -> $\mathrm{Ln}y_t$ = constant+ f { ln (x) }$_t$ + error$_t$

[45] Mr. Ahtesham Babar, Population of Pakistan, (<pap.org.pk/statistics/population.htm>)

Estimation of the above equation econometrically, would leads following testable model:

(6) -> Ln(Electricity Consumption growth)$_t$ = α_t + f { ln(Urbanization growth) }$_t$ + e_t

Where, Y represents growth in Electricity Consumption, X is growth in Urbanization, α and β are coefficients (α is constant, β is elasticity), t denotes time period, e_t is the error term with the usual statistical properties.

c. Data

The study would be based upon historical data spreading over from 1960 to 2009 (t=1…50), which is taken from World Bank Database website. I have obtained natural logarithms prior to conducting statistical tests.

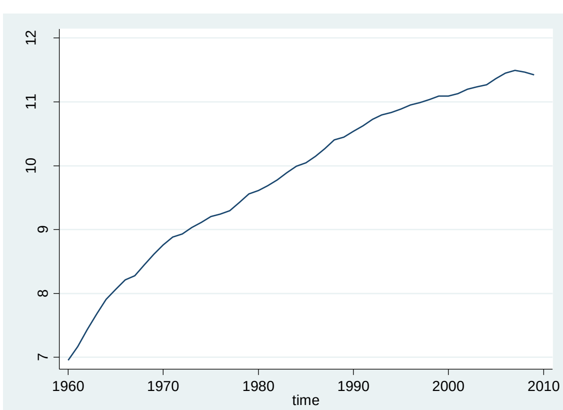
d. Empirical Analysis Model 4: Electricity Consumption Growth, and Urbanization Growth

i. Analysis of the data

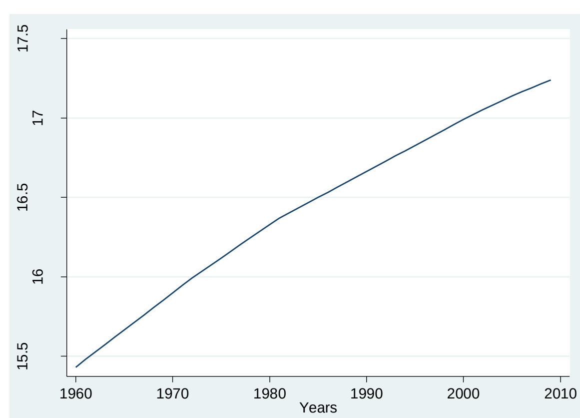
Since I'm using logged values of my original time-series, it is import to create new time series: ln_electricity_consumption ln_urbanization, which are logged (electricity consumption and urbanization)

Graphs showing the behavior of electricity consumption and urbanization time series

Figure 22



h.electricity consumption



i.urbanization

Figure 1 (h,i) exemplifies clear approaching trends for all our time-series. We can articulate something about the character of growth: Electricity Consumption, as well as Urbanization increased smoothly over the span of 50 years.

ii. Testing time-series for stationarity

Augmented Dickey-Fuller unit root test is performed in order to observe stationarity of time series. And to define the number of lags I'll use the Autocorrelogram for logged variables (*Oscar Torres-Reyna,* ver. 1.3, *Draft*, Time Series).

Augmented Dickey-Fuller Unit Root Tests					
Variables	Test statistics Z(t)	5% Critical value	10% Critical value	Deterministic Regressors	Results
ln_electricity_consumption	(2.24)	(3.51)	(3.19)	constant	non-stationary
ln_urbanization	(1.87)	(3.51)	(3.19)	constant	non-stationary
Lagged differenced terms are added in order to produce white noise residuals, which explain any autocorrelation in the time series. The variable which has unit root is non-stationary at the level form, but it become Stationary after taking difference. We refer this type of variable is integrated of order one or two I (1) or I (2). It also depends on the number of times it was differenced. Here the urbanization series become stationary after taking the second difference.					
dln_electricity_consumption	(4.14)	(3.51)	(3.19)	constant + trend	stationary
dln_urbanization	(2.74)	(3.51)	(3.19)	constant + trend	non-stationary
d2ln_urbanization	(4.82)	(3.52)	(3.19)	constant	stationary

iii. Short-Run (VAR) Model Estimation And Testing

To determine the number of lags I will use the selection-order criteria. The information criteria and LR-Test suggests having dln_electricity_consumption d2ln_urbanization: 1 lag

```
. varsoc dln_electricity_consumption d2ln_urbanization

   Selection-order criteria
   Sample:  1966 - 2009                         Number of obs      =        44
  +---------------------------------------------------------------------------+
  |lag |    LL      LR      df    p      FPE       AIC      HQIC      SBIC    |
  |----+----------------------------------------------------------------------|
  |  0 |  303.446                      3.8e-09  -13.7021   -13.672   -13.621  |
  |  1 |  313.686   20.48*   4  0.000  2.9e-09* -13.9857* -13.8955* -13.7424* |
  |  2 |  314.929  2.4864    4  0.647  3.3e-09  -13.8604    -13.71  -13.4549  |
  |  3 |  317.992  6.1254    4  0.190  3.4e-09  -13.8178  -13.6073  -13.2501  |
  |  4 |  322.646  9.3082    4  0.054  3.4e-09  -13.8475  -13.5769  -13.1176  |
  +---------------------------------------------------------------------------+
   Endogenous:  dln_electricity_consumption d2ln_urbanization
    Exogenous:  _cons
```

Now we can proceed directly to estimation of VAR-model. Running the models gives us the following output Tables:

VAR-Model Estimation: Electricity Consumption growth and Population growth

```
. var dln_electricity_consumption d2ln_urbanization, lags(1)

Vector autoregression

Sample:  1963 - 2009                               No. of obs      =        47
Log likelihood =  336.5559                         AIC             = -14.06621
FPE            =  2.67e-09                         HQIC            = -13.97733
Det(Sigma_ml)  =  2.07e-09                         SBIC            = -13.83002

Equation           Parms      RMSE     R-sq      chi2     P>chi2
----------------------------------------------------------------
dln_electricit~n      3     .040549   0.5138   49.66179   0.0000
d2ln_urbanizat~n      3     .001201   0.1295   6.992689   0.0303
----------------------------------------------------------------

------------------------------------------------------------------------------
             |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
dln_electr~n |
dln_electr~n |
         L1. |   .6762672    .097398     6.94   0.000     .4853706    .8671637
d2ln_urban~n |
         L1. |  -3.459147    4.31487    -0.80   0.423    -11.91614    4.997844
       _cons |   .0212296   .0107242     1.98   0.048     .0002106    .0422487
-------------+----------------------------------------------------------------
d2ln_urban~n |
dln_electr~n |
         L1. |   .0053401   .0028854     1.85   0.064    -.0003152    .0109954
d2ln_urban~n |
         L1. |     .25471   .1278286     1.99   0.046     .0041706    .5052494
       _cons |  -.0008096   .0003177    -2.55   0.011    -.0014323   -.0001869
------------------------------------------------------------------------------
```

In the short-run scenario the electricity consumption does not significantly depend on the growth rate of urbanization. The p-values of the estimated coefficients are greater than 0.1, which means that they are not significant at 10% significance level. If we look at the electricity consumption growth, it only depends significantly on the electricity consumption growth from the previous period. 1% increase in the last year’s growth would increase in this year’s electricity consumption’s growth by .67%. On the other hand 1% increase in last period urbanization would add 0.25% in this period’s urbanization, and 1% increase in last year electricity consumption would add .005% in urbanization growth in current year.

iv. Granger Causality Test

Electricity consumption growth is not Granger-caused by changes in the growth rate of urbanization, but urbanization growth is Granger caused by growth in electricity consumption.

```
. vargranger

   Granger causality Wald tests
```

Equation	Excluded	chi2	df	Prob > chi2
dln_electricity~n	d2ln_urbanization	.64269	1	0.423
dln_electricity~n	ALL	.64269	1	0.423
d2ln_urbanization	dln_electricity~n	3.4251	1	0.064
d2ln_urbanization	ALL	3.4251	1	0.064

v. Testing the models Stability

In order to check the stability of the VAR-models we can analyze the eigenvalues for each equation. All the eigenvalues are less than 1 and lie inside the unit circle, which signifies that the models are stable.

```
. varstable

   Eigenvalue stability condition
```

Eigenvalue	Modulus
.6265956	.626596
.3043815	.304382

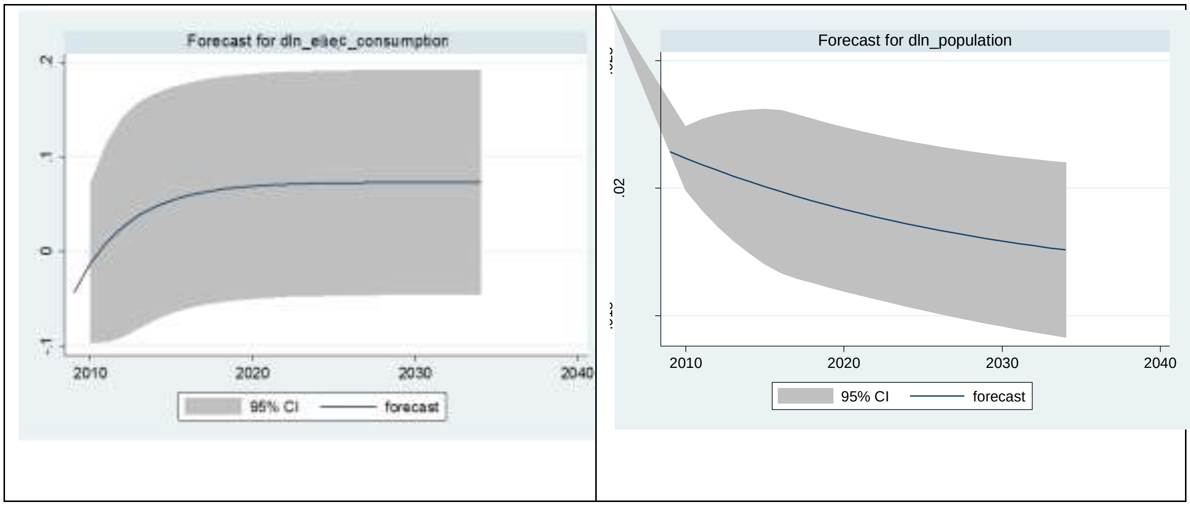
```
   All the eigenvalues lie inside the unit circle.
   VAR satisfies stability condition.
```

vi. Forecasting

By using the estimated VAR-models I'll forecast for the next 25 years, to see the general patterns of future growth.

Looking at the graph below, we can tell that:

- Electricity Consumption is expected to increase at accelerating growth rate, and eventually increasing at around 7% growth.
- Urbanization is going to increase but at a decreasing growth rate.



vii. Long-Run (VEC) Model Estimation And Testing

For the estimation VEC model it is important to define number of cointegrating equations, by performing Johansen test. I would use first difference and logged values for Electricity Consumption and population because in VAR-model we took second difference of these variables earlier.

Johansen test

The trace statistic test result is greater than critical value, so we don't reject the null hypothesis that these two variables are not cointegrated, we will move forward to estimate the VECM model. The null is rejected because the trace statistic is more than the critical value.

```
. vecrank ln_electricity_consumption ln_urbanization, lags(1)

                       Johansen tests for cointegration
Trend: constant                                         Number of obs =      49
Sample:  1961 - 2009                                             Lags =       1
-------------------------------------------------------------------------------
                                                        5%
maximum                                    trace    critical
  rank    parms       LL       eigenvalue  statistic   value
    0       2     251.60374         .       148.3206   15.41
    1       5     320.43993     0.93977      10.6482    3.76
    2       6     325.76402     0.19532
-------------------------------------------------------------------------------
```

Lags for VEC estimation: the number of lags is set at 2 based on the selection order criteria, below.

```
. varsoc ln_electricity_consumption ln_urbanization

   Selection-order criteria
   Sample:  1964 - 2009                        Number of obs      =        46
  +---------------------------------------------------------------------------+
  |lag |    LL      LR      df    p      FPE       AIC      HQIC      SBIC    |
  |----+----------------------------------------------------------------------|
  |  0 |  10.3527                      .002384   -.36316  -.333377  -.283654  |
  |  1 |  305.453   590.2    4  0.000  7.6e-09  -13.0197  -12.9303  -12.7812  |
  |  2 |  336.433  61.961*   4  0.000  2.4e-09  -14.1928  -14.0438* -13.7952* |
  |  3 |  340.978  9.0897    4  0.059  2.3e-09* -14.2164*  -14.008  -13.6599  |
  |  4 |  343.842  5.7281    4  0.220  2.4e-09  -14.1671   -13.899  -13.4515  |
  +---------------------------------------------------------------------------+
   Endogenous:  ln_electricity_consumption ln_urbanization
    Exogenous:  _cons
```

Results of estimated VEC-model (Cointegration Equations)

Model 4

Normalized cointegrating equation coefficients (Appendix 6.)		
ln_electricity_consumption	ln_urbanization	Constant
1	-1.94	21.74
.28	1.74	

$\ln y_t$ = constant + f { ln (X) $\}_t$+ error_t

The equation is the following:

Coequation_{1t} = ln(electricity_consumption$_t$) -1.94 ln(urbanization$_t$)

This implies that in long-term equilibrium (when cointegration equations are equal to 0):

ln_electricity_consumption$_t$ = + 1.94 ln_urbanization$_t$

Long-run: The growth in electricity consumption is significantly correlated with the growth in urbanization. In the VAR-model test analysis we observed that in short-run electricity consumption growth is not influenced by urbanization growth, but in the long-run scenario we can see a positive relation. 1% increase in urbanization growth would result in 1.94% growth in electricity consumption. So we accept the hypothesis of research that growth in electricity consumption significantly and positively depends on the growth in urbanization.

Now we need to study, what happens if long-term equilibrium is broken, there is a positive cointegrating error, which means that cointegration equation is not equal to 0, but is greater than 0):

$ln\_electricity\_consumption_t$ -1.94 $ln\_urbanization_t > 0$

By examining the ce1 values we can say error correction for ln_electricity_consumption is statistically significant at 5% level and is -0.12. This is yearly negative adjustment of $ln\_electricity\_consumption_t$ will be -.12% of deviation of in $ln\_electricity\_consumption_{t-1}$ from its cointergrating values. And yearly positive adjustment of $ln\_urbanization_t$ would be .002 of $ln\_urbanization_{t-1}$ from its cointegrating value.

Short run perspective VEC-model estimation: Model4

```
. vec ln_electricity_consumption ln_urbanization, lags(2)

Vector error-correction model

Sample:  1962 - 2009                              No. of obs      =        48
                                                  AIC             = -14.08468
Log likelihood =  347.0323                        HQIC            = -13.95209
Det(Sigma_ml)  =  1.80e-09                        SBIC            = -13.73383

Equation           Parms      RMSE     R-sq      chi2     P>chi2
----------------------------------------------------------------
D_ln_electrici~n     4      .036596   0.8944   372.7074   0.0000
D_ln_urbanizat~n     4      .001265   0.9989   41758.21   0.0000
----------------------------------------------------------------

------------------------------------------------------------------------------
             |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
D_ln_elect~n |
        _ce1 |
         L1. |   -.125859   .0394648    -3.19   0.001    -.2032087   -.0485094
ln_electri~n |
         LD. |   .3757021   .1264144     2.97   0.003     .1279345    .6234697
ln_urbaniz~n |
         LD. |   .1900523   1.203579     0.16   0.875    -2.168919    2.549024
       _cons |  -5.87e-06   .0354456    -0.00   1.000    -.0694779    .0694662
-------------+----------------------------------------------------------------
D_ln_urban~n |
        _ce1 |
         L1. |   .0027919   .0013645     2.05   0.041     .0001176    .0054662
ln_electri~n |
         LD. |   .0108026   .0043707     2.47   0.013     .0022363     .019369
ln_urbaniz~n |
         LD. |   .9933481   .0416127    23.87   0.000     .9117887    1.074907
       _cons |  -.0002647   .0012255    -0.22   0.829    -.0026666    .0021372
------------------------------------------------------------------------------
```

In short-run perspective we can say that electricity consumption doesn't significantly depend upon the growth rate of population but significantly depends on the growth rate of electricity consumption from the previous period. But urbanization growth significantly depends upon the previous period electricity consumption growth and previous period urbanization growth. 1% increase in electricity consumption from the previous period would increase current period's urbanization my 0.011%. And 1%

increase in urbanization from previous period would add 0.99% in this period's urbanization.

13. Conclusion: Summary of Results, Analysis & Policy Implications

a. Summary

i. Short-run:

Results for Time-series studies based on Granger causality, VAR, VECM short-run					
Research	**Country**	**Variables**	**Data Span**	**Cointegration**	**Result**
M. Abubakr Khan Daha	Pakistan	Electricity Consumption, GDP	1960-2009	Yes	ECG→GDP (VAR)
M. Abubakr Khan Daha	Pakistan	Electricity Consumption, Manufacturing	1960-2009	No	MSG◊ECG
		Electricity Consumption, Agriculture		Yes	ASG→ECG↑
		Electricity Consumption, Services		Yes	SSG→ECG↓
M. Abubakr Khan Daha	Pakistan Pakistan	Electricity Consumption, Population	1960-2009	Yes	PG→ECG↑
	Pakistan Pakistan	Electricity Consumption, Urbanization	1960-2009	Yes	ECG →UG↑

Electricity Consumption and GDP: In short-run electricity consumption growth is not influenced by GDP growth, ***thus we reject the hypothesis***

Electricity Consumption, GDP, Agriculture, Manufacturing, and Service*:* We can say that Electricity consumption significantly depends upon the previous period's growth rate of Agriculture sector, and Service sector, but not the Manufacturing sector.

- 1% increase in Agriculture growth from the previous period would add 0.43% in Electricity consumption in this period.
- 1% increase in Service sector growth from the previous period would decrease Electricity consumption in this period by 0.56%.

We accept the hypothesis that Agriculture sector growth influences Electricity consumption, but we reject the hypothesis that Services growth, Manufacturing growth influences Electricity consumption in Short-run.

Electricity Consumption and Population: In short-run scenario electricity consumption growth is influenced by population growth.

- 1% increase in population growth would lead to 5.8% increase in electricity consumption.

Thus we accept the hypothesis

Electricity Consumption and Urbanization: In short-run electricity consumption growth is not influenced by urbanization growth, ***thus we reject the hypothesis***

ii. Long-run:

Results for Time-series studies based on VECM Long-run					
Research	**Country**	**Variables**	**Data Span**	**Cointegration**	**Result**
M. Abubakr Khan Daha	Pakistan	Electricity Consumption, GDP	1960-2009	Yes	GDP→ECG↑
M. Abubakr Khan Daha	Pakistan	Electricity Consumption, Manufacturing	1960-2009	Yes	MSG◊ECG↓
		Electricity Consumption, Agriculture		Yes	ASG→ECG↓
		Electricity Consumption, Services		Yes	SSG→ECG↑
M. Abubakr Khan Daha	Pakistan Pakistan	Electricity Consumption, Population	1960-2009	Yes	PG→ECG↑
	Pakistan Pakistan	Electricity Consumption, Urbanization		Yes	UG→ECG↑

Note: ECG refers to Electricity Consumption growth, MSG refers to Manufacturing sector growth, ASG refers to Agriculture sector growth, SSG refers to services sector growth, PG refers to population growth, UG refers to Urbanization growth, → refers to from one to another, ↑refers to increase, ↓refers to decrease

Electricity Consumption and GDP:

- 1% increase in GDP growth would result in .831% increase in the growth of Electricity Consumption.

<u>We accept the hypothesis of research that growth in electricity consumption significantly and positively depends on the growth in GDP.</u>

Electricity Consumption, GDP, Agriculture, Manufacturing, and Service:

- 1% growth in Service sector leads to 7.77% growth in Electricity Consumption.
- 1% increase in Manufacturing growth leads to 4.21% decrease in Electricity Consumption.
- 1% increase in Agriculture sector results in 4.09% decrease in Electricity Consumption.

<u>So we accept the hypothesis that electricity consumption depends on services sector growth, but reject the hypothesis of that its positively dependent on agriculture, and manufacturing in the long-run.</u>

Electricity Consumption and Population:

1% growth in Population leads to 4.69% increase in electricity consumption growth

<u>We can accept the hypothesis that population growth leads to growth in electricity consumption.</u>

Electricity Consumption and Urbanization:

1% increase in urbanization growth leads to 1.94% increase in electricity consumption growth.

<u>We can accept the hypothesis that urbanization growth leads to growth in electricity consumption.</u>

b. Analysis & Interpretation

Pakistan is 6th most populous country and 25th largest economy *in nominal terms*, in the world. Despite having enormous potentiality for energy resources unfortunately it remains energy deficient, and the power generation capacity has only grown at the rate .81% from 2007 to 2010. The widening gap between the supply and demand for electricity has serious implications for the nation, and the current situation warrants extensive research.

In this paper I have investigated the relationship and direction between the growth of different economic indicators and the growth of electricity consumption. In addition to this I have also looked at the population and urbanization growth with respect to electricity consumption. The empirical results are based upon data from 1960 to 2010, taken from World Bank Database, and State Bank of Pakistan.

I have used statistical analysis approach which involved Granger causality test, to look at causality between my variables, as well as VAR-model estimation and VEC-model estimation to look at short-run and long-run growth scenarios.

Running the Granger causality test and short-run VAR, I found out that changes in growth of electricity consumption are granger caused by the agriculture and services sector, but not by the manufacturing sector. An increase in agriculture growth increases electricity consumption, this could be due to seasonal changes in crops demands, and weather conditions effecting the water requirements in short-run, e.g. there is high demand for cotton this year, because of last year's high prices; much more land is used cotton irrigation resulting in increased use of tube-wells and pesticides spraying leading to increase in electricity consumption in the sector. Although agriculture sector is very labor intensive and employs 44% of the total labor force, but for irrigational activities there is usage of electricity e.g. tube-wells for watering, thrashers, and other machinery, which can lead to increase in electricity consumption in short-run.

On the hand my short-run results also suggest that growth in services lead to decrease in electricity consumption. Services sector accounts for 53% of the GDP[46]. This decrease

[46] Real Economy (<ecosecretariat.org/countries/Pakistan/tab_text_report.htm>)

in consumption could link to advancement in technology, as well as increase in telecommunication industry. After deregulation of telecommunication industry, this sector has grown at an extraordinary rate. In 2010 there were 105million cell phone subscribers in the country[47], ranked ninth in the world. Thus increase in service sector could be linked to shifting to more advance methods, which are less energy intensive. In my demographic indicators increase in population would lead to increase in electricity consumption in the short-run. Pakistan's increase in population is attributed to natural increase, so this indicates requirements for healthcare facilities, and schools would increase leading to increase in electricity consumption.

In the long-run GDP growth upshots growth in electricity consumption; this goes hand-in-hand with the previous studies that as economies prosper, people tend to send more money on goods and services which are electricity consuming, e.g. healthcare, fitness centers, electronic appliances, cinemas, theme parks, expanded transportation networks, etc.

Long-run scenario: an increase in manufacturing sector leads to decrease in electricity consumption. The reason behind this result is that large scale manufacturing industries have setup their own private electricity generation units for example in the sugar industry companies have their own electricity production units, which run on ethanol, and bagasse, and heavy industries such as metal, and textile have their own thermal based electricity power units[48]. PPIB (private Power and Infrastructure Board) was created in 1994, to promote private sector participation in electricity generation[49], since then many companies have opted for this (more expensive) option rather relying on unstable electric supply from government. Another reason why growth in manufacturing sector leads to reduction in electricity consumption could be somewhat of a structural shit within the manufacturing sector, from heavy industry towards more

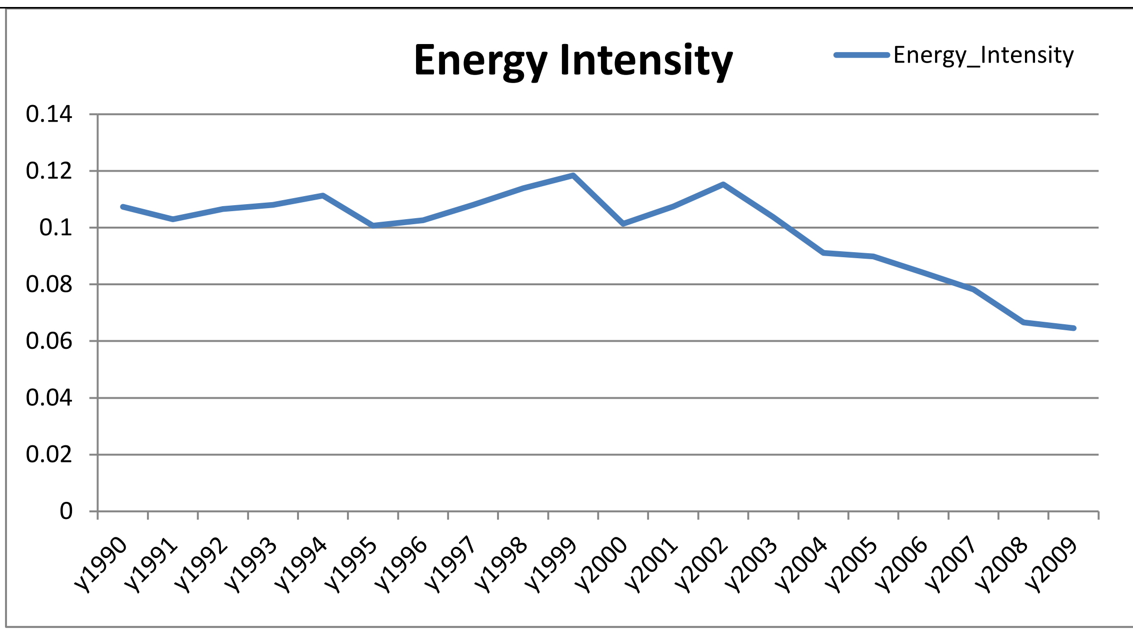
[47] pta.gov.pk/index.php?cur_t=vtext&option=com_content&task=view&id=583&Itemid=1&catid=95
[48] ppib.gov.pk/N_commissioned_ipps.htm
[49] ppib.gov.pk/N_about_ppib.htm

labor intensive industries such as leather and sports goods; where craftsmanship and human skills are more important than machinery[50].

An increase agriculture sector leads to reduction in electricity consumption in long term, because of the fact that it is the most labor intensive sector of the economy. It accounts for 21% in GDP share but employs 45% of the country labor force[51]. So a growth in sector indicates increase in employment and decrease in electricity consumption. This can be due to distrusted electricity supply especially in the rural areas, farmers has shifted towards manpower rather than machinery.

Long-run results for services sector tells us that 1% growth would lead to 7.77% increase in electricity consumption. State Bank of Pakistan handbook tells us that in 1990 the share of Agriculture sector, Manufacturing sector, and Services sector was 26.0%, 25.2%, and 48.8%, but in 2010 the share was 21.8%, 33.6% and 54.6% respectively[52]. This indicate structural shift, as the share of agriculture sector has been decreasing over time, and service sector has been increasing.

Figure 20.



Note: I have calculated energy intensity based on the ratio between energy consumption and GDP.

[50] Sectoral Share in Gross Domestic Product Handbook of Statistics on Pakistan Economy 2010, P-2,10
[51] Agriculture, Economic Survey of Pakistan 2010, P-1
[52] Sectoral Share in Gross Domestic Product Handbook of Statistics on Pakistan Economy 2010, P-3-5

Energy consumption was given in years terms so I have change it in hrs, and also convert into watts from mega watts, in order to use to calculate energy intensity. I used the following 2 formulas to calculate Energy Intensity.

1 MW*h /yr / GDP or Btus / GDP => ((MW * 1,000,000 Watts h)/ (365.25·24)h) / GDP => MW * 114.077116 Watt / GDP

Example for year 1960

=> (37,659,000 * 1,000,000) / (365.25 * 24) / 40,010,425,587.14

*Using energy consumption and GDP data from World Bank Database

We can also relate this shift towards services sector and change in energy intensity over the years (Figure 20.). Those countries where services sector play major role in the economy tend to be more efficient in terms of using energy.

The population of 1% leads to 4.96% increase in electricity consumption. About two thirds of the population lives in the rural areas, and for last few years' government has introduced special plans for rural electrification. This step was taken to reduce the burden on the metropolitan cities, as well as to facilitate small cottage industries like embroidery, rugs, sports, etc. With the increase in rural electrification, no doubt increase in population would lead to further increase in electricity consumption. And with the declining death rate and persistently high birth rate, the role of population is a main factor behind electricity consumption.

As for my last model I can conclude that 1% increase in urbanization causes 1.94% increase in growth rate of electricity consumption. The causality is unidirectional. It can be enunciated that as the economy activity increases and businesses expand it attracts more people to urban centers from rural areas for having better access to healthcare facilities, schooling, jobs, thus also leading to increase in electricity consumption.

To conclude we accept the hypothesis that economic growth leads to increase electricity consumption in the long-run. The results are en bloc supported by the modern research, and growth theories that economic growth does lead to growth in the electricity consumption of a country at an aggregate level. In Pakistan's case it is observed that the consumption of electricity is linked with the economic prosperity of the country. A unidirectional causal relationship from real economic activity in services sectors, and growth in urbanization to electricity consumption shows that economic development accelerates greater demand for electricity in the long-run.

c. Policy implication

It is evident that lack of coherent investment strategy regarding key sectors results in grievous energy crisis (based on electricity shortage), as the one Pakistan is facing today. The policy entailments of this paper are: On the demand side government need to introduce electricity conservation policies, this can reduce the electricity deficit by 10-25%[53]. Clocks should advanced by 1hr (GMT+6) for day light saving, shops, markets should be opened early and closed at 9pm. Currently the bazaars are open till midnight for the shoppers. Additionally Saturday and Sunday should be declared public holiday, instead of just Sunday. On the supply side supply side the government of Pakistan needs to investment in the energy sector for electricity production, especially hydropower, coal, nuclear, and natural gas. Oil-fired power generation plants can also play an important role in the short-term, because oil-based IPPs (Independent Power Plants) are likeable solution in the near future, though in the long-run government needs to reduce its dependency on oil, as it reduces foreign exchange reserves, and increases trade deficit. Hydropower is the cheapest and most reliable source, and there exist enormous untapped hydropower potential to be exploited, but its takes 5-10 years to come online[54]. That's why it is the most attractive long-run option. Addition to this Pakistan huge coal reserves can also play an important part in future, but would require huge investments and technical ability. This can be done through safe political environment, and secured returns on investment to foreign and local investors form government of Pakistan. Country can also build on its nuclear capacity to meet its future energy requirement; nonetheless this option is an unlikely answer for now, because of international pressure, especially after recent Japanese nuclear meltdown crisis. Negotiations are underway for Iran and Turkmenistan Gas pipeline projects, but due to the current politically instability in Pakistan and increasing sanctions on Iran for its

[53] Asif Ali (2008), Industry Focus, Pakistan Power, Asia Pacific Pakistan Power & Natural Gas (Citi), P-53
[54] Abid Jamal and Edmond Lee (2007), Asia Pacific Equity Research, Pakistan Power Space, JPMorgan, P,22-23,

nuclear program, gas power generation is feasible solution, but only in medium or long-run.

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15.Appendix *

Appendix 1.

```
. sum ln_electricity_consumption ln_gdp ln_manufacturing ln_agriculture
> ln_service ln_population ln_urbanization
```

Variable	Obs	Mean	Std. Dev.	Min	Max
ln_electri~n	50	9.841407	1.278942	6.953684	11.49489
ln_gdp	50	23.97686	1.096146	22.0335	25.82247
ln_manufac~g	50	22.05133	1.161783	19.8647	24.16399
ln_agricul~e	50	22.67384	.8806039	21.20524	24.22309
ln_service	50	23.12098	1.198893	21.0142	25.1534
ln_populat~n	50	18.32775	.3960637	17.64091	18.94959
ln_urbaniz~n	50	16.43006	.5370656	15.42967	17.23927

Appendix 2.

```
. reg electricity_consumption manufacturing agriculture service
```

Source	SS	df	MS
Model	4.3594e+10	3	1.4531e+10
Residual	2.5477e+09	46	55384388.7
Total	4.6142e+10	49	941665744

Number of obs	=	50
F(3, 46)	=	262.37
Prob > F	=	0.0000
R-squared	=	0.9448
Adj R-squared	=	0.9412
Root MSE	=	7442.1

electricit~n	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
manufactur~g	-5.50e-07	1.63e-06	-0.34	0.737	-3.83e-06	2.73e-06
agriculture	5.82e-06	1.13e-06	5.16	0.000	3.55e-06	8.09e-06
service	-6.47e-07	8.66e-07	-0.75	0.459	-2.39e-06	1.10e-06
_cons	-7104.59	2913.043	-2.44	0.019	-12968.24	-1240.938

Appendix 3. Electricity consumption and GDP

```
. vec  ln_electricity_consumption ln_gdp, lags(2)

Vector error-correction model

Sample:  1962 - 2009                              No. of obs      =        48
                                                  AIC             = -5.249256
Log likelihood =  134.9821                        HQIC            = -5.116669
Det(Sigma_ml)  =  .0000124                        SBIC            = -4.898406

Equation           Parms      RMSE     R-sq      chi2     P>chi2
----------------------------------------------------------------
D_ln_electrici~n      4     .037203   0.8909   359.2027   0.0000
D_ln_gdp              4     .103199   0.4297   33.14841   0.0000
----------------------------------------------------------------

------------------------------------------------------------------------------
             |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
D_ln_elect~n |
        _ce1 |
         L1. |  -.0829191   .0214533    -3.87   0.000    -.1249668   -.0408714
ln_electri~n |
         LD. |   .3506388   .1351201     2.60   0.009     .0858082    .6154694
      ln_gdp |
         LD. |  -.0663883   .0531579    -1.25   0.212    -.1705759    .0377993
       _cons |   .0317573    .011164     2.84   0.004     .0098762    .0536383
-------------+----------------------------------------------------------------
D_ln_gdp     |
        _ce1 |
         L1. |   .1230996   .0595099     2.07   0.039     .0064624    .2397369
ln_electri~n |
         LD. |   .8566517   .3748134     2.29   0.022     .1220309    1.591272
      ln_gdp |
         LD. |   .2303863   .1474562     1.56   0.118    -.0586224    .5193951
       _cons |   .0213915   .0309681     0.69   0.490    -.039305     .0820879
------------------------------------------------------------------------------

Cointegrating equations

Equation           Parms    chi2     P>chi2
-------------------------------------------
_ce1                 1   111.9692   0.0000
-------------------------------------------

Identification:  beta is exactly identified
                 Johansen normalization restriction imposed
------------------------------------------------------------------------------
        beta |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
_ce1         |
ln_electri~n |          1          .        .       .            .           .
      ln_gdp |  -.8310628   .0785389   -10.58   0.000    -.9849962   -.6771295
       _cons |   9.707635          .        .       .            .           .
------------------------------------------------------------------------------
```

Appendix 4. Electricity consumption, manufacturing, agriculture, services

```
. var  dln_electricity_consumption dln_manufacturing dln_agriculture dln_service , lags(1)

Vector autoregression

Sample:  1962 - 2009                              No. of obs      =        48
Log likelihood =  292.4948                        AIC             = -11.35395
FPE            =  1.38e-10                        HQIC            = -11.05931
Det(Sigma_ml)  =  5.99e-11                        SBIC            = -10.57428

Equation           Parms      RMSE     R-sq      chi2     P>chi2
----------------------------------------------------------------
dln_electricit~n      5     .040133   0.6164   77.14381   0.0000
dln_manufactur~g      5     .118513   0.0902   4.761488   0.3127
dln_agriculture       5     .108873   0.0604   3.084625   0.5438
dln_service           5     .111682   0.0531   2.693935   0.6103
----------------------------------------------------------------

------------------------------------------------------------------------------
             |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
dln_electr~n |
dln_electr~n |
         L1. |   .8207932   .0985899     8.33   0.000     .6275605    1.014026
dln_manufa~g |
         L1. |  -.0521365   .1342441    -0.39   0.698    -.3152502    .2109771
dln_agricu~e |
         L1. |   .3444965   .1221627     2.82   0.005      .105062    .5839311
 dln_service |
         L1. |  -.2924606   .1728029    -1.69   0.091    -.6311481    .0462269
       _cons |   .0198926   .0112351     1.77   0.077    -.0021278    .0419131
-------------+----------------------------------------------------------------
dln_manufa~g |
dln_electr~n |
         L1. |   .3759935    .291139     1.29   0.197    -.1946286    .9466155
dln_manufa~g |
         L1. |    .330382   .3964269     0.83   0.405    -.4466005    1.107365
dln_agricu~e |
         L1. |  -.1377039   .3607501    -0.38   0.703    -.8447611    .5693533
 dln_service |
         L1. |  -.0686604   .5102922    -0.13   0.893    -1.068815    .9314939
       _cons |    .033201   .0331777     1.00   0.317     -.031826    .0982281
-------------+----------------------------------------------------------------
dln_agricu~e |
dln_electr~n |
         L1. |  -.0449681   .2674556    -0.17   0.866    -.5691713    .4792352
dln_manufa~g |
         L1. |   .4746642   .3641785     1.30   0.192    -.2391125    1.188441
dln_agricu~e |
         L1. |  -.2454535   .3314039    -0.74   0.459    -.8949933    .4040862
 dln_service |
         L1. |  -.1218886   .4687811    -0.26   0.795    -1.040683    .7969055
       _cons |   .0491588   .0304787     1.61   0.107    -.0105785     .108896
-------------+----------------------------------------------------------------
dln_service  |
dln_electr~n |
         L1. |   .1554469   .2743567     0.57   0.571    -.3822824    .6931762
dln_manufa~g |
         L1. |   .2529904   .3735754     0.68   0.498     -.479204    .9851847
dln_agricu~e |
         L1. |  -.2464891   .3399551    -0.73   0.468     -.912789    .4198107
 dln_service |
         L1. |   .0920902   .4808771     0.19   0.848    -.8504116    1.034592
       _cons |   .0544327   .0312652     1.74   0.082    -.0068459    .1157113
------------------------------------------------------------------------------
```

```
Cointegrating equations

Equation           Parms    chi2     P>chi2
_ce1                   3   91.53741   0.0000

Identification:  beta is exactly identified
                 Johansen normalization restriction imposed

        beta |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
_ce1         |
ln_electri~n |          1          .       .       .            .           .
ln_manufac~g |   4.209759   1.013857    4.15   0.000     2.222635    6.196883
ln_agricul~e |   4.092231   1.239242    3.30   0.001     1.663361    6.521102
  ln_service |  -7.776617    1.44724   -5.37   0.000    -10.61316   -4.940078
       _cons |  -16.88895          .       .       .            .           .
```

Appendix 5. Electricity and Population

```
. vec ln_electricity_consumption ln_population, lags(2)

Vector error-correction model

Sample:  1962 - 2009                              No. of obs      =        48
                                                  AIC             = -15.71505
Log likelihood =  386.1612                        HQIC            = -15.58246
Det(Sigma_ml)  =  3.53e-10                        SBIC            =  -15.3642

Equation           Parms      RMSE     R-sq      chi2     P>chi2
D_ln_electrici~n     4      .041498   0.8642   280.0602   0.0000
D_ln_population      4      .000505   0.9997     135299   0.0000

             |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
D_ln_elect~n |
        _ce1 |
         L1. |   .0181579   .0231519     0.78   0.433     -.027219    .0635349
ln_electri~n |
         LD. |   .6153834   .1385147     4.44   0.000     .3438995    .8868672
ln_populat~n |
         LD. |   1.058395   3.996647     0.26   0.791    -6.774889    8.891678
       _cons |  -.0005412   .1099849    -0.00   0.996    -.2161077    .2150253
-------------+----------------------------------------------------------------
D_ln_popul~n |
        _ce1 |
         L1. |   .0015917   .0002817     5.65   0.000     .0010395    .0021439
ln_electri~n |
         LD. |  -.0070983   .0016856    -4.21   0.000    -.0104021   -.0037945
ln_populat~n |
         LD. |   .7788075   .0486365    16.01   0.000     .6834816    .8741333
       _cons |   .0061737   .0013384     4.61   0.000     .0035504     .008797

Cointegrating equations

Equation           Parms    chi2     P>chi2
_ce1                   1   283.7009   0.0000

Identification:  beta is exactly identified
                 Johansen normalization restriction imposed

        beta |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
_ce1         |
ln_electri~n |          1          .       .       .            .           .
ln_populat~n |  -4.690784   .2784935   -16.84   0.000    -5.236621   -4.144947
       _cons |   76.27215          .       .       .            .           .
```

Appendix6.

```
. vec ln_electricity_consumption ln_urbanization, lags(2)

Vector error-correction model

Sample:  1962 - 2009                              No. of obs      =        48
                                                  AIC             = -14.08468
Log likelihood =  347.0323                        HQIC            = -13.95209
Det(Sigma_ml)  =  1.80e-09                        SBIC            = -13.73383

Equation           Parms      RMSE     R-sq      chi2     P>chi2
----------------------------------------------------------------
D_ln_electrici~n     4     .036596   0.8944   372.7074   0.0000
D_ln_urbanizat~n     4     .001265   0.9989   41758.21   0.0000
----------------------------------------------------------------

------------------------------------------------------------------------------
             |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
D_ln_elect~n |
        _ce1 |
         L1. |   -.125859   .0394648    -3.19   0.001    -.2032087   -.0485094
ln_electri~n |
         LD. |   .3757021   .1264144     2.97   0.003     .1279345    .6234697
ln_urbaniz~n |
         LD. |   .1900523   1.203579     0.16   0.875    -2.168919    2.549024
       _cons |  -5.87e-06   .0354456    -0.00   1.000    -.0694779    .0694662
-------------+----------------------------------------------------------------
D_ln_urban~n |
        _ce1 |
         L1. |   .0027919   .0013645     2.05   0.041     .0001176    .0054662
ln_electri~n |
         LD. |   .0108026   .0043707     2.47   0.013     .0022363     .019369
ln_urbaniz~n |
         LD. |   .9933481   .0416127    23.87   0.000     .9117887    1.074907
       _cons |  -.0002647   .0012255    -0.22   0.829    -.0026666    .0021372
------------------------------------------------------------------------------

Cointegrating equations

Equation           Parms    chi2     P>chi2
-------------------------------------------
_ce1                 1   48.29522   0.0000
-------------------------------------------

Identification:  beta is exactly identified
                 Johansen normalization restriction imposed

------------------------------------------------------------------------------
        beta |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
_ce1         |
ln_electri~n |          1          .        .       .            .           .
ln_urbaniz~n |   -1.94622   .2800528    -6.95   0.000    -2.495114   -1.397327
       _cons |   21.74796          .        .       .            .           .
------------------------------------------------------------------------------
```