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能源消耗、出口及經濟成長關聯性之多變量 Granger 因果分析-以中國及印度為例

Multivariate Granger Causality between Energy Consumption, Exports and Economic Growth: Evidence from China and India

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ABSTRACT

This paper investigates the causal relationship between energy consumption, economic growth and exports for China and India employing dynamic econometric models with annual data for the period 1980-2011. Unit root test, lag length selection, co-integration test, and Granger causality test are conducted to reveal the relationships. The results indicate that there is a unidirectional causality running from energy consumption to exports and also from energy consumption to economic growth in China. Therefore, energy should be fulfilled to the production sectors to support exports in terms of economic growth. Moreover, investments on alternative energy production should be improved. VAT reduction, tax incentives and R&D subsidies are form of government support in renewable energy investment.

Additionally, this research reveals that there is a unidirectional causality flowing from exports to energy consumption, economic growth to energy consumption, and export to economic growth in India. Hence, the evidences seem to support the growth-led-export hypothesis in India for the period analyzed. The implication based on the results is to implement energy conservation policies, including efficiency improvement and energy mix policies, which are designed to reduce energy consumption without sacrificing the country's economic growth.

Key words: Energy consumption, Economic growth, Exports, Granger causality

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CHAPTER ONE

INTRODUCTION

1.1 Research Background

Current global economic activities are internationalization. Energy is an important component required in all production processes and also an engine of economic growth for most countries (Zhang and Lahr, 2011). Moreover, energy is an essential composition in modern industrial production (Mulegeta et al. 2010). Energy can be used to produce goods and services through both direct and indirect energy consumption. Direct energy consumption is the energy that is used directly in goods production process and services production function. Indirect energy consumption is the energy used during a production process to produce intermediate goods and services (Kahrl and Holst, 2008).

In the past two decades, the economic development of China and India has experienced rapid growth. Goldman Sach (2003) stated that BRIC (Brazil, Russia, India and China) economy could become much more powerful in the world than the G6 (United States, Japan, Germany, France, Italy and the United Kingdom) in less than 40 years. The impact of economic growth not only affects the economic development process but also energy consumption patterns which have significantly changed.

The rapid economic growth and population usually requires more energy consumption, and generally energy use is faster than GDP growth especially in developing countries (Lin, 1992). He indicated that due to several major changes associated with development process such as industrialization, increase in labor and capital intensive, specialize infrastructure construction, and growth of urban areas, all of which usually lead to growth in energy consumption.

Among economists, they claim that there is a strong relation between energy consumption and economic activity. Economic growth improves the standard of living in which it is associated with energy consumption; as economic growth, both total and energy consumption per capita tends to increase (Kaufmann and Kuhl, 2006). Firms and households usually use energy along with factors of production (capital, labor, raw materials and land) to consume and produce goods and services. Households own factors of production. The firms purchased these factors and use them in production process to process goods and services. Firms sell these finish goods and services to households. This cycle is consistent with the second law of thermodynamics which implies that energy is required in the creation of goods and services. All economic processes require energy, so that energy is always an important element of production (Stern, 1997).

The results of the Centre for Climate Economics and Policy (2010) show that energy consumption is a necessary input for economic development and economic growth. To support such rapid economic growth, the consumption of primary energy in China and India has grown rapidly, especially coal and oil, such that together they consume 56 percent of the world's coal (British Petroleum statistic (BP), 2011). According to the U.S. Energy Information Administration (EIA) 2011, by 2035 world energy consumption will increase by 53 percent in which China and India will account for half of the increase in energy consumption. Currently, China's energy consumption becomes the largest in the world, even with the annual growth rate of 6.18 percent whereas India is the fourth largest energy consumer in the world behind China, the

United States and Russian Federation with the annual growth rate of 5.66 percent during the 1980-2011. Furthermore, China and India also play a significant role in the world coal production sector. Since China is the world's largest coal producer and India is the fourth largest coal producer in the world. In 2011, China's coal production reached the equivalent of 1956 Million tons oil of coal, the highest in the world. While India reached 222.4 Million tons oil equivalent (BP, 2012).

In 1978, after years of a major economic reform program, China has experienced rapid growth and development in its economic. A closed economy at the end of 1970s, China's trade (as percentage of GDP), by the mid-1990s increased from 17 percent in 1978 to about 40 percent in the mid-1990s (IMF, 2011). This success of China's economy is explained by the formation of state-owned enterprises and private businesses, foreign trade and foreign direct investment (FDI) and by the opening of the country's policy so called Open Door policy, especially after the entrance to the World Trade Organization (WTO) in 2001.

For India, the government implemented Structural Adjustment Program (SAP) in 1991. This SAP had concentrated on the economic development which led to decrease of poverty level and improving the Indian people's life standards. By beginning the SAP, economy experienced the 7 percent growth rate for three consecutive years (Trading Economics.com, India Central Statistical Organization). Having followed up the trend, India's trade to GDP ratio has increased from 15 percent to 54 percent of GDP between 1990 and 2011 (World Bank, 2012), and India's economy is now one of the fastest growing in the world. Nonetheless, in recent years, India is assertive pushing for more liberal global trade systems, as well as its investment policy reformation by loosen quantitative restriction and foreign investments norm, reducing tariff barriers and devaluing the currency.

Goldman Sachs (2003) stated that China will overtake the U.S., as the world's largest economy by 2027 and one of the fastest growing major economy, India, is likely to become the world's third largest economy in year 2034 and the world's largest economy in year 2050 (Frank and Citi Private Bank, 2012). Meanwhile, the two countries rely heavily on its exports. About 31 percent of China's GDP and 25 percent of GDP of India in 2011 are contributed by exports (World Bank, 2012). In other words, the exports have a great power to drive economic development (Li, 2010). Obviously, both energy and exports have a significant role in China and India economic growth. However, exports not only effect on economic growth (Narayan and Smyth, 2009) but also on energy consumption (Halicioglu, 2011). Shortage of energy is expected to create serious side effects to both China and India's economies. On the other hand, when energy is deficient it is possible that the economic growth rate will slow down but when energy is available the effect on economic growth is much less (Stern, 2011). Not surprisingly, the relationship between energy consumption and gross domestic product (GDP) has attracted much attention in the economic fields and has become one of the most researched topics in recent years comparing to the other developing countries (Calvani and Alderman, 2010).

An increasing number of companies are taking part in the global investment, and many countries embolden the use of foreign investment and exports to promote their economic growth (Shahbaz, 2011). Furthermore, export expansion is expected to support economic development through the positive channel from exports to economic growth (Balassa, 1978; Esfahani, 1991; Rodrik, 1999). Many studies believed that the rapid growth of China and India economy is mainly due to exports expansion (Stiglitz, 2007). During recent years a numerous empirical studies have conducted to examine the relationship between country's exports and economic growth or the export-led growth hypothesis with ambiguous and mixed results. The mixed results are due to be used in the analysis either time-series or cross-sectional data.

After World War II, some developing countries started to use export-led growth strategy (Export oriented or Outward oriented) which is a trade policy and economic strategy aiming to promote the industrial sector of a country by exporting goods for which the nation has a comparative advantage. An export-led growth scheme is that exports are the major factor to support economic (Medina-Smith, 2001). Exports are the most important source of foreign capital and funds, which can be used to promote and create employment opportunities (Chuang, 1998). According to Abou-Stait (2005), an export-led growth strategy offers several incentives to producers to support their export goods through different governmental policies. The tactic also aims at increasing the capability of producing goods that can compete in the international market using advanced technology (Grossman and Helpman 1991). Exports can help the country compete in the world economy and to reduce the effect of external shocks on the domestic market (Shahbaz and Leitao, 2010). Exports allow domestic production to achieve economies of scale (Helpman and Krugman 1985). Tsen (2006) found evidence in East Asian countries' economies that provide good samples of the importance of the industrial sector and exports to economic growth and development. In the past few years, a growing of empirical research has found strong positive linkages between exports and economic growth (World Bank, 1993; Hsiao and Hsiao, 2006; Pistoresi and Rinaldi, 2011).

This study examines the relationship between energy consumption, economic growth and exports in China and India. These countries such as BRICs were chosen because they are newly advanced economic development along with Brazil and Russia whose economies are growing very fast especially exports. Furthermore, they are energy-dependent nations which are ongoing industrialization. According to The Energy Outlook 2030 published by British Petroleum, by 2030 China and India will be the world's largest and 3rd largest economy and energy consumers, jointly accounting for about 35 percent of global population, GDP and energy demand. Moreover, they share so many things in common such as they are among the world's fastest growing developing countries with high foreign investment rate and even in terms of population, both the nations stand close by (CIA, 2012). Currently, China is India's largest trading partner (Department of Commerce of India, 2012).

1.1.1 Economic growth in China and India

China and India are expected to be the dominant world economic growth for the next 30 years (Voigt, 2012). China and India economies have great importance to the rest of the world not just for over 40 percent of the world's population living in China and India but also for the future of Asia and the broader world economy. China was the world's second largest economy after the United States in 2011, whereas India's economy is the tenth largest in the world (IMF, 2012).

Before 1991 China and India's economies developed steadily at similar levels. Today China's GDP is over 397 percent of India's, with China's GDP hitting 731 billion US$ in 2011 versus a little over 184 billion US$ in India. The two nations have difference development approach. China has implemented a manufacturing-led growth strategy whereas India has implemented services-based development strategy. China used FDI and focused on building industrial skill, while India focused on the services front (Jayanthakumaran et al., 2012). While each approach has its pros and cons, over the past 15 years China's excellent performance in the economic reforms makes it a very attractive model for the other Asia countries.

1.1.2 Energy Consumption in China and India

The rapid growth of economic development and industrialization, energy consumption from Asia has been one of the main reasons for the rises in energy prices. In 2011, China and India accounted for about 25 percent of the world energy consumption. Strong economic growth leads China and India to double their combined energy demand by 2035 according to U.S. Energy Information Administration (EIA) in 2011. China's industrial development is broad-based and therefore requires many different types of energy. China's energy consumption expanded both in volume and growth rate terms after 2002, while India's energy consumption has had a constant growth rate of 5 percent over the past years. The global shares of primary energy consumption were only 4.6 percent for India and as high as 21.3 percent for China in 2011.

1.1.3 Exports in China and India

Since India and China took part of globalization trend, this proved to be a key trigger for their exports to rise – in the early 1990s for India and late 1970s for China. Currently, China was the largest exporter country in the world in 2011 while India ranks 19th largest exporter country in the world, according to Central Intelligence Agency (CIA) in 2012. The interaction among demographics, reforms and globalization is a crucial element of faster growth in job opportunities, income and investments. India and China with their high economic growth rates have bettered their rankings as the most attractive investment destinations. India integrated with the global economy started to expedite in the early 1990s while the integration of China began in the early 1980s. Indeed, India is following China’s path which makes India the fastest growing exporter just after China. From 2003 to 2011, China’s exports rose from $485 billion to $2296 billion, up to 23.72 percent per year in average. While India’s exports increased from US$90 billion in 2003 to about $455 billion in 2011. However, China's exports value decreased 15.7 percent year by year until reach $1333 billion in 2009 because of the United States recession in 2008. Since the United States is China’s largest trade partner, the economic recession in the U.S. had an affect on demand of goods from China. India's exports in 2009 also fell by 5.15 percent to US$274 billion from the same period a year earlier due to demand weakened in Europe and the United States.

1.2 Research Motivation and Contribution

There is an enormous amount of studies explaining the causal relationship between energy consumption and economic growth over the past thirty years following the seminal study of Kraft and Kraft (1978). In economics, there are the hypotheses that indicate the existence of the relationship between energy consumption and economic growth. The directions of the relationship between energy consumption and GDP have a significant role in energy policy implication. For instance, if there is unidirectional causality running from energy use to GDP, reducing energy consumption could lead to a decline in GDP and increase of national unemployment, while increase in energy consumption might lead to economic growth. On the other hand, if unidirectional causality runs from GDP to energy use, it may state that decreasing energy consumption may have little effect on economic growth. The finding of no causality in either direction is, the so-called ‘neutrality hypothesis’ which imply that energy conservation policies do not have effect on economic growth (Asafu-Adjaye, 2000). However, outcomes are differences due to a number of reasons including different data sets, different countries, different time periods, and different measurement methodologies.

Few studies investigate the relationship between energy-GDP nexus for China and India applied a multivariate framework. Jayanthakumaran, Verma and Liu (2011) include real income in addition to energy consumption and trade intensity (Total of exports and imports divided by GDP), Zhang and Ren (2011) include fixed asset investment and employee in addition to energy consumption and economic growth, Zhang and Cheng (2009) include fixed capital and urban population in addition to energy consumption and economic growth. To reduce the previous literature limitation of omitted relevant variables, this study employs a trivariate framework in which, in addition to GDP and energy consumption, we incorporate exports data for both goods and services. This extends the Granger causality literature on the energy–GDP nexus and exports–GDP nexus that was initiated by Narayan and Smyth in 2009 and followed by Lean and Smyth in 2010. These models lead to examine the existence of two competing hypotheses simultaneously: energy-GDP nexus and exports-GDP nexus in addition to an auxiliary hypothesis between exports and energy consumption. It is important to consider exports in the study since exports have served as a primary driver for economic growth of China and India over the last two decades (Chandra 2000, 2002; Love and Chandra, 2004; Chandra, 2003b; Ekanayake, 1999; Lin and Li, 2001). If China and India improve theirs exports performance, we need to know if this will increase in energy use and lead to economic growth or not. Moreover, the most important thing to be questioned here is whether energy consumption contributed to economic development and exports expansion. While China's exports, particularly manufacturing goods have increased very fast and the proportion of exports to GDP has considerably increased, this figure suggests an important relationship among exports, energy consumption and economic development that is worth to studying. Consequently, this research seeks to bridge the previous literature gap in which there are few studies that examine the causal relationship between energy consumption, exports and GDP within the one multivariate model in both China and India at the same time. The interrelationship between energy-economic and growth-export is analyzed using cointegration technique and a causality link in the short-run and long-run.

The purpose of this study is to examine the causal relationship among energy consumption, economic growth and, exports for China and India using procedures like unit root tests, cointegration and Granger causality techniques. It is expected that such knowledge could help the government in policies making development and the study results could provide valuable information to practitioners and academicians for future studies in the related field.

1.3 Research Objectives

Based upon the above research background and motivation, the research objectives of this study are shown as follows:

1. Investigate the causal relationship among economic growth, energy consumption and exports using the concept of Granger causality in China.

2. Investigate the causal relationship among economic growth, energy consumption and exports using the concept of Granger causality in India.

3. To suggest energy and economic policy to policy maker in order to create positive effect on the economy.

1.4 Research Scope

At first, the relevant literature will be collected and reviewed for the understanding of the relevance between energy consumption, economic growth, and exports. The study employs annual time series data for China and India from 1980 to 2011. The variables employed; energy consumption, GDP, and exports were used in natural logarithm and were obtained from World Bank database and BP Statistical Review of World Energy. All variables were deflated to million. The time-series econometric analyses were conducted with Eviews (version 5.0) software. After collecting the data, they will be analyzed by the following techniques:

1. Unit root test
2. Cointegration test
3. Granger causality test

A detailed description of research methods and data analysis is shown in Chapter 3 to 4. To sum up, the flow chart of this study is illustrated in Figure 1-1.

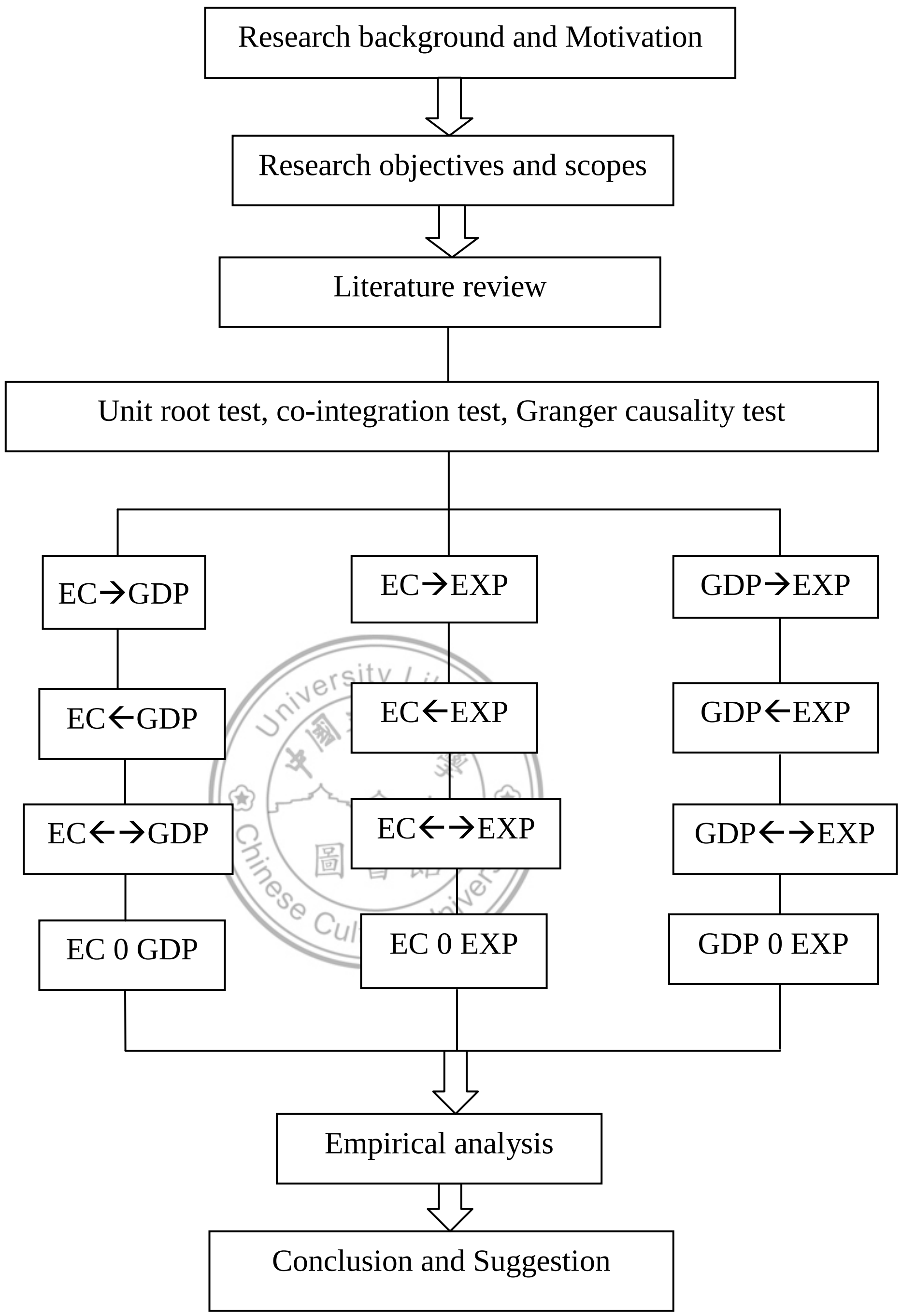

Figure 1-1. Research Flow Charts in this Study

1.5 The Structure of this Study

This paper contains five chapters, and the summary for each is as follows:

Chapter one outlines the research background, motivation, objective, procedures, and the structure of this study.

Chapter two outlines briefly the literature on the inter-relationships among economic growth, energy consumption and exports.

Chapter three describes data used hypotheses, and the study’s model and methodology.

Chapter four presents the descriptive results the empirical analysis results of this study. The results of several analyzes include: unit root test results; cointegration test results; and Granger causality results.

Chapter five is a summary of the significant findings and conclusions of this study. The first section summarizes the significant research findings of this study. The second section outlines suggestions and practical implications of the results for future research.

CHAPTER TWO

LITERATURE REVIEW

2.1. Definition of Research Constructs

2.1.1. Energy Consumption

Primary energy consumption refers to the direct use at the source, or supply to users without transformation to secondary or tertiary forms of energy, of natural resources such as crude oil, hard coal, natural gas, that is, energy that has not been subjected to any conversion or transformation process (OECD, 1997). Primary energy is sources that only involve extraction or capture, and through this extraction and capture, the physical and chemical characteristics of the energy is not changed (Overgaard, 2008). Primary energy includes losses from transportation, friction, heat loss and other inefficiencies. Specifically, consumption equals indigenous production plus imports and stock changes, minus exports and fuels supplied to ships and aircraft engaged in international transport (International Energy Agency, 2012). Moreover, the raw fuel that is burned to create heat and electricity, such as natural gas or fuel oil used in onsite generation can be consider as a primary energy.

2.1.2 Economic growth

Economic growth or Gross domestic product (GDP) which is the second variable in this study is the measure of total market value of all goods and services produced by labor and property located within a country in a specific time period (Schiller, 2012). It’s equal to total consumer, investment and government spending, plus the value of exports, minus the value of imports that occur within a defined territory (CIA, 2012). GDP is commonly used as an indicator of the economic health of a country, as well as to gauge a country's standard of living. According to World Bank (2012), GDP is the sum of the gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products.

2.1.3 Exports

The last variable is exports, based on the World Bank (2012), exports refer to exports of goods and services represent the value of all goods and other market services produced in one country are shipped to another country. They include the value of merchandise, transport, travel, freight, insurance, royalties, license fees, and other services, such as communication, financial, information, construction, personal, business, and government services. They exclude compensation of employees and investment income and transfer payments. The ability to export goods helps an economy to grow by selling more overall goods and services (Shahbaz, Azim and Ahmad, 2012).

2.2 Interrelationship among Research Variables

2.2.1 Relationship between Energy Consumption and Economic Growth

In the past two decades, there is a sizeable literature that analysis Granger causality between GDP and energy consumption assuming that higher economic growth requires more energy use. In fact, a more efficient use of energy is required to achieve a higher level economic growth. However, the direction of causality may be difference. Following Kraft and Kraft (1978), a pioneering research in this area, an extended number of empirical studies (Narayan and Singh, 2007; Wolde-Rufael 2006; Pao and Tsai 2010; Lee and Chang 2007; Fei et al. 2011; Lee 2005) used panel data to test the economic growth–energy consumption nexus across countries and found mixed results (Halicioglu, 2009). These studies have tested four major hypotheses namely growth hypothesis, conservation hypothesis, feedback hypothesis, and neutrality hypothesis, in which Payne (2010) concluded that the results are inconclusive since results from the competing hypotheses are fairly divided. In the energy-GDP nexus, the most revealing argument is that energy is a crucial component for production (Halicioglu, 2011). Therefore, energy consumption is considered to be an important factor to economic growth. The second strand is based on neutrality hypothesis, in which energy consumption and economic growth have no relationship in either direction, means that energy conservation policies can be adopted without adverse effect on GDP. The third strand is based on conservation hypothesis, in which there is a unidirectional causality running from GDP to energy consumption, it may be implied that energy conservation policies have little or no impact on economic growth. The conclusions from energy consumption and economic growth literature are often ambiguous. As Ozturk (2010) noted: the diverse results arise due to different countries' characteristics, different time periods, different variables, and different econometric methodologies employed and Mehrara (2007) also has the same conclusion.

The existing Granger causality studies of the energy-GDP nexus for China generally apply a bivariate (Yuan et al., 2008; Zhang and Cheng, 2009; Chang, 2010; Wang et al., 2011; Bloch, Rafiq and Salim, 2012). The results from studies are inconclusive. Some studies find unidirectional causality running from GDP to energy consumption. Yuan et al. (2008) found a unidirectional causality from GDP to energy consumption from 1963 to 2005. A unidirectional causality flowing from GDP to energy is also found in studies of Zhang and Cheng (2009) and Chang (2010) who analyses China's data on carbon emission, GDP and energy consumption. Unidirectional causality from GDP to energy consumption is also found in Narayan and Smyth (2005) who analyze Australia's data on electricity, GDP and employment; Lise and Montfort (2007) who examine the energy consumption and economic growth data of Turkey from 1970 to 2003; Chen et al. (2007) who examine electricity consumption and GDP data of 10 Asian countries over the period from 1971 to 2001.

There are also studies that find a unidirectional causal relationship that running from energy consumption to GDP. Wolde-Rufael (2004) finds that over the period from 1952 to 1999 energy consumption causes GDP in Shanghai. Wang et al. (2011) find that energy consumption causes economic growth in China from 1978 to 2009, while Shiu and Lam (2002) find similar results using GDP and electricity consumption data of China over the period from 1971 to 2000. Other studies that find unidirectional causality from electricity consumption to economic growth by Yuan et al.(2007) and Xiao et al. (2012).

Bi-directional causality has also been found in some studies. For example, Zhang and Li (2007) investigate the relationship between coal consumption and GDP for China over the period from 1980 to 2004 and find that there is a bidirectional causal relationship between these two variables. Lee (2006) examines data for G-11 countries. They find bi-directional causal relationship between energy consumption and GDP in the United States. However, in the same study they find two different results for other countries. In the case of Canada, Belgium, the Netherlands and Switzerland, they find unidirectional running from energy consumption to GDP, whereas the causality relationship appears to be uni-directional running from GDP to energy consumption for Japan, Italy and France. Other studies that find bi-directional causality in China are Yuan et al. (2008), Chang (2010), Wang et al. (2011), see Table 2-1.

Although most studies find a significant relationship between energy and GDP, some studies, such as, Soytas and Sari (2006) study on China from 1971 to 2002, Altinay and Karagol (2004) study on Turkey from 1950 to 2000 conclude that there is no causal relationship between these two variables. There are also studies that find mixed results for various countries. Chen et al. (2006) study 10 newly industrializing Asian countries using Granger causality from 1971 to 2000, they find that there is uni-directional long-run causality running from real GDP to electricity consumption for Hong Kong and Korea. In contrast, in Indonesia, there is a uni-directional long-run causality from electricity consumption to real GDP. However, electricity consumption and GDP are not significant in India, Singapore, Taiwan and Thailand, which implies that there is no relationship between real GDP and electricity consumption in these countries.

Table 2-1 *Summary Empirical Results on Energy-Growth Nexus for China*

Author(s)	**Study period**	**Variables**	**Method**	**Causal relationship**
Wolde-Rufael (2004)	1952-1999	EC, GDP	VAR, TY	EC → GDP
Soytas and Sari (2006)	1971-2002	EC, GDP	VAR, TY	None
Zou and Chau (2006)	1953-2002	OC, GDP	ECM, GC	OC →GDP
Zhang and Li (2007)	1980-2004	CC, GDP	ECM, GC	CC ↔ GDP
Yuan et al. (2007)	1978-2004	ELC, GDP	ECM, GC	ELC → GDP
Yuan et al. (2008)	1963-2005	EC, GDP, ELC, OC, CC	ECM, GC	GDP →EC ELC →GDP GDP ↔ OC GDP →CC
Zhang and Cheng (2009)	1960-2007	GDP, EC, CO_2	VAR, TY	GDP →EC
Chang (2010)	1981-2006	CO_2, EC, GDP	ECM, JC, GC	GDP → CO_2 EC ↔ GDP
Wang et al. (2011)	1972-2006	EC, GDP, Capital, Labor	ARDL, GC	EC → GDP Capital → GDP Labor →GDP EC ↔ GDP (Short run)
Bloch, Rafiq and Salim (2012)	1953-2002	Supply side - Labor, Capital, CC Demand side - GDP, CP, CO_2, CC	ECM, JC, GC	Supply side: CC → GDP Capital → GDP Labor → CC (Short run) CC → Capital Demand side: GDP → CC CC ↔ CO_2 GDP → CO_2
Yalta and Cakar (2012)	1971-2007	EC,GDP	VAR, Meboot DGP	None

Keys: EC (energy consumption), GDP (Gross domestic product), OC (Oil consumption), CC (Coal consumption), ELC (Electricity consumption), CP (Coal price), TY (Toda and Yamamoto), GC (Granger causality), VAR (Vector autoregressive regression), EG (Engle-Granger), JC (Johansen Cointegration), ARDL (Autoregressive Distributed Lag), ECM (Error correction model)

Table 2-2 *Summary Empirical Results on Energy-Growth Nexus for India*

Author(s)	**Study period**	**Variables**	**Method**	**Causal relationship**
Asafu-Adjaye (2000)	1973-1995	EC, GDP, EP	EG	EC → GDP
Ghosh (2002)	1950-1997	ELC, GDP	VAR, TY	GDP → ELC
Paul and Bhattacharya (2004)	1950-1996	GDP, EC	ECM, GC	EC ↔ GDP
Ghosh (2009)	1970-2006	GDP, Electricity supply, Employment	ARDL, ECM	GDP → Electricity supply
Pradhan (2010)	1970-2006	EC (oil and electricity), GDP	ECM, GC	GDP → EC
Alam et al. (2011)	1971-2006	EC, GDP, CO_2	VAR, TY	EC ↔ CO_2

Keys: EC (energy consumption), GDP (Gross domestic product), OC (Oil consumption), CC (Coal consumption), ELC (Electricity consumption), EP (Energy price), CP (Coal price), TY (Toda and Yamamoto), GC (Granger causality), VAR (Vector autoregressive regression), EG (Engle-Granger), JC (Johansen Cointegration), ARDL (Autoregressive Distributed Lag), ECM (Error correction model)

On the other hand, the existing literature in India shows mixed results. Most of the studies study the causality relationship between energy consumption and GDP (see Table 2-2). However, results from the literature can be categorized into three different strands i.e., a unidirectional causality, a bi-directional causality and no causality. Asafu-Adjaye (2000) has examined the causality relationship between energy consumption and economic growth and included energy price as an additional variable. Ghosh (2002) employed Toda and Yamamoto (1995) (TY) procedure and found unidirectional granger causality running from GDP to electricity consumption between 1950 to 1997. Using an error correction model approach for the period 1950-1996, Paul and Bhattacharya (2004) found bi-directional causality. Pradhan (2010) employed an ECM approach for the period 1970 to 2006, and finds unidirectional Granger causality running from GDP to energy consumption. Alam et al. (2011), using a VAR model for the period 1971-2006 and found bidirectional causality flowing between energy consumption and carbon emission.

Recently, some studies (for example, Soytas and Sari, 2006; Soytas and Sari, 2009; Zhang and Cheng, 2009; Alam et al., 2011) have investigated causality relationships among multiple variables applying the multivariate model of TY, multivariate Johansen and Juselius (1990) multivariate ECM (Ang, 2008; Ghosh, 2009) and panel cointegration (Apergis and Payne, 2010; Belke et al., 2010; Chang, 2010). Asafu-Adjaye (2000) has examined the causality relationship between energy consumption and economic growth and included energy price as an additional variable, for the period 1973-1995 and found unidirectional Granger causality running from energy consumption to economic growth both in the short run and in the long run. Although it has been recognized that the interrelationships among income, environmental pollutions and other growth parameters are the key variables in the growth theory (Xepapadeas, 2005), but there is a number of studies examining relationship between GDP, energy consumption, and CO2 emissions using additional variables under the same framework, specifically for India.

2.2.2 Relationship between Exports and Economic Growth

As for the second competing hypothesis study the relationship between exports and GDP or exports-GDP nexus, the remarkable view is that exports are seen as a stimulator of economic growth. The role of exports as one of the most important factors of economic growth is not new. It goes back to the classical economic theories by Adam Smith (The Wealth of Nation, 1776) and David Ricardo (The Principles of Political Economy, 1817), who argued that the country can achieve economic gains through international trade. The argument of the neo-classical economists is that competition in international market promotes economies of scale and increases efficiency by concentrating resources in sectors in which the country is more efficient.

The export led hypothesis states that there is causality runs from exports to GDP. There are number of possible reasons why Granger causality might runs from exports to GDP. First, exports increase GDP because exports are a component of GDP in accounting formulation. Second, according to the neo-classical economic growth theory, exports are a factor that can affect technological progress that is related to economic efficiency, which are a major source of economic growth (Abou-Stait, 2005). Third, countries with high exports to GDP ratio are more open to outside markets and generate externalities, such as the incentive to innovate (Ahmad, 2001). Fourth, increasing in export leads to an increase in demand for the country's output in exports may promote specialization, which eliminates overvaluation of the domestic currency (Awokuse, 2008; Andraz and Rodrigues, 2010; Soukiasis and Antunes, 2011; Lorde, 2011). On the other hand, the competing hypothesis that Granger causality runs from GDP to exports should be considered as a handmaiden theories (Kravis, 1970). There is also potential for growth-led exports. For example, Lancaster (1981), Krugman (1984) and Bhagwati (1988) suggest that economic growth enhances skills and technology which create the country's comparative advantage. Jung (1985) argued that growth of export can be explain by economic growth.

Ahmed (2001) assumed that economic growth is caused by technological improvements which evolve with exports expansion. It is possible that there is feedback relationship between exports and GDP. According to Helpman and Krugman (1985) exports may rise from achieves economies of scale due to productivity gains; the rise in exports may reduce cost per unit, which may result in productivity gains in the export sector. It is thus argued that an expansion of exports will have a positive effect on the rest of the economy. A similar argument was established by Bhagwati (1988) stating that increase trade generates more income, which leads to more trade.

Jordaan and Eita (2007) examined the causality between exports and GDP of Namibia for the period 1970 to 2005. The results found evidence in support of the ELG hypothesis, and suggested that the export has a positive effect on economic growth.

Rangasamy (2008) analyzed the exports and economic growth relationship for South Africa, and provides evidence support the export-led growth hypothesis. Their results indicate that the unidirectional Granger causality runs from exports to economic growth.

Pazim (2009) tested the validity of export-led growth hypothesis in Indonesia, Malaysia, and the Philippines for period 1985-2002 by using panel data analysis. And, it is concluded that there exists no relationship between the size on national income and amount of exports for these countries on the basis of one-way random effect model. The panel unit root test shows that both GDP and exports is not stationary at their level, while the panel co-integration test implying that there is no co-integration relationship between the exports and economic growth. As a conclusion, the empirical findings did not provide evident to support the “export-led hypothesis for these countries.

Elbeydi, Hamuda and Gazda (2010) investigated the relationship between exports and economic growth for Libya cover the period of 1980 to 2007. The findings indicate that there exists a long-run bi-directional causality between exports and economic growth, and thus, the export promotion policy contributes to Libya’s economic growth.

Lean and Smyth (2010) studied the short-run and long-run relationship among economic growth, electricity generation, exports and prices in a multivariate model for Malaysia from 1970 to 2008. This study further show neither the export-led nor handmaiden theories of trade are supported and it did not find any significant causality between prices and economic growth.

The study of the dynamics of the relation between expansion of exports and economic growth has been addressed by a number of researchers in the context of India. The empirical results generally support the export-led hypothesis. However, there are some inconclusive results in addition to the support for the growth-led hypothesis. In the case of India data, the results appear to be varied. The summary results of the exports- GDP studies are shown in Table 2-3.

Table 2-3 *Summary Empirical Results on Export-Growth Nexus for India*

Author(s)	**Study period**	**Variables**	**Method**	**Causal relationship**
Ekanayake (1999)	1960-1996	EX, GDP	JC, EG	EX ↔ GDP (long run) GDP → EX (short run)
Anwar and Sampath (2000)	1960-1992	EX, GDP	JC, GC	No causality
Nidugala (2001)	1980s	EX, GDP	JC, GC	EX → GDP
Kemal et al. (2002)	1960-1998	EX, GDP	VAR, GC	EX → GDP (long run) GDP → EX (short run)
Chandra (2002)	1950-1996	EX, GDP	JC, GC	EX ↔ GDP
Sharma and Panagiotidis (2005)	1971-2001	EX, IM, GDP	JC, GC	EX → GDP
Raju and Kurien (2005)	1960-1992	EX, GDP	ECM, GC	EX → GDP
Pandey (2006)	1950-2002	EX, GDP	ECM, EG	GDP → EX
Pradhan (2007)	1971-2005	EX, GDP, IM, INV, Employment	JC, GC, ECM	INV → EX GDP →EX
Dash (2009)	1992-2007	EX, GDP	ECM, GC	EX → GDP
Pradhan (2010)	1970-2010	EX, GDP, Capital, Exchange rate, World GDP	JC, ECM, GC	EX → GDP
Mishra (2011)	1970-2009	EX, GDP	ECM, GC	GDP → EX
Ray (2011)	1972-2011	EX, GDP	ECM, JC, GC	EX ↔ GDP

Keys: EX (Export), GDP (Gross domestic product), IM (Import), INV (Investment), TY (Toda and Yamamoto), GC (Granger causality), VAR (Vector autoregressive regression), EG (Engle-Granger), JC (Johansen Cointegration), ARDL (Autoregressive Distributed Lag), ECM (Error correction model)

There is fair amount of literature on export led growth hypothesis (ELG) that study Chinese economy (Table 2-4). Most of the empirical studies found uni-directional causality between variables. Lin (2003) stated that 10 percent increase in exports caused percent increase in GDP in the 1990s in China on the basis of new proposed estimation method, when both direct and indirect contributions are considered. In a similar framework,

Mah (2005) studied the long-run causality between export and growth for the period 1979-2001 with the help of significance of error correction model (ECM). The result of the Granger causality test shows that there is a two-way causality between economic growth and exports.

Tang (2006) considered three variables: exports, GDP and imports for the period 1979-2001. He found that there is no long run relationship among export, GDP and imports. This study indicates no long-run and short-run causality between export expansion and economic growth in China on the basis of Granger causality while economic growth does Granger-cause imports in the short run.

Hsiao and Hsiao (2006) investigate the ELG hypothesis using a vector autoregressive (VAR) model by considering the relationship between real GDP, real exports and FDI during 1986-2004, see Table 2-4. They conclude that there is a unidirectional causality from GDP to FDI and a unidirectional causality from exports to FDI. These unidirectional causalities indicate that, during the past two decades, China attracted a large amount of FDI because of its low wage, the fast growing economic, and the potentially larhe market. China's inward FDI investment has also been attracted by its possibility of exporting commodities to developed countries like the United States, Japan, and European Union. However, the test results here show that China's inward FDI and exports do not cause economic growth, and the export-led-growth and the FDI-led-growth hypotheses do not seem to be suitable for China.

Table 2-4 *Summary Empirical Results on Export-Growth Nexus for China*

Author(s)	**Study period**	**Variables**	**Method**	**Causal relationship**
Mah (2005)	1979-2001	EX, GDP	ECM, GC	EX ↔ GDP
Tang (2006)	1979-2001	EX, GDP, IM	ECM, GC	GDP →IM (Short run)
Hsiao and Hsiao (2006)	1986-2004	GDP, EX, FDI	VAR, GC, TY	GDP → FDI Export → FDI

Keys: EX (Export), GDP (Gross domestic product), IM (Import), TY (Toda and Yamamoto), GC (Granger causality), VAR (Vector autoregressive regression), EG (Engle-Granger), ECM (Error correction model)

From the review of empirical literature on exports and growth, it is clear that the exports do not necessarily cause growth.

2.2.3 Relationship between Exports and Energy Consumption

The third set of competing hypothesis base on the relationship between exports and energy consumption. However, these hypotheses are not supported by economic theories. If Granger causality runs from exports to energy consumption or no Granger causality running in either direction, it follows that energy saving policies can be expected to have no adverse impact on export growth. On the other hand, if energy consumption causes export, reducing energy use could limit expansion in exports which are an engine of economic growth. There is few literatures study the relationship between exports and energy consumption. Erkan et al. (2010), for instance, based on the standard Granger causality tests, analyze the impact of domestic energy consumption on exports in Turkey using annual data from 1970 to 2006, and find evidence of the relationship between domestic energy consumption and exports in long term. Granger causality test reveals that there is a unidirectional causality running from energy consumption to exports. Therefore, energy consumption has a positive impact on exports. Li (2010) finds unidirectional causality running from exports to energy consumption in Shandong province. On the other hand, exports growth is a cause of increase of the energy consumption. Therefore the increase of Shandong's export promotes energy consumption.

CHAPTER THREE

RESEARCH METHODOLOGY

The objective of this paper is to investigate the dynamics relationship among energy consumption, exports and economic growth in China and India using the annual data for the period 1980 to 2011. In this study, the variables are Primary Energy Consumption (EC), Total Exports (EXP) and Economic Growth (GDP). Total Exports are the sum product and service exports expressed in the United States dollars. And, the Gross Domestic Product (GDP) is used as the proxy for economic growth. All necessary data for the sample period are obtained from World Bank database. All the variables are taken in their natural logarithms to avoid the problems of heteroscedasticity.

3.1 Research Hypotheses

Based upon the literature reviewed in the previous chapter, three sets of hypotheses, as listed below, were formulated and evaluated through empirical validation in this study.

The first set of competing hypotheses concerns the relationship between energy consumption and GDP. These hypotheses, which have been considered in the energy consumption-GDP nexus literature, have important policy implications.

The second set of competing hypotheses concerns the causal relationship between exports and GDP. These hypotheses have been considered in the exports-GDP nexus literature. The export-led hypothesis states that Granger causality runs from exports to GDP.

The third set of competing hypotheses concerns the relationship between energy consumption and exports whether the growth of the export is the cause of an increase in energy consumption.

In this paper, four common steps of time series analysis were followed to test for the relationship among energy consumption and GDP, energy consumption and export and exports and GDP in both the short-run and long-run. The four steps approached in time series studied were: (1) unit root test (stationary test), (2) lag length selection, (3) cointegration, and (4) Granger causality test. This paper followed these steps to ensure that all variables included were stationary – either in levels or in first differences, and models and lag order were properly specified – to observe the likelihood for short-run or long-run relationships between integrated variables and to determine the direction of causalities among energy consumption, exports and economic growth. The flow chart of empirical process in the study is shown in Figure 3-1.

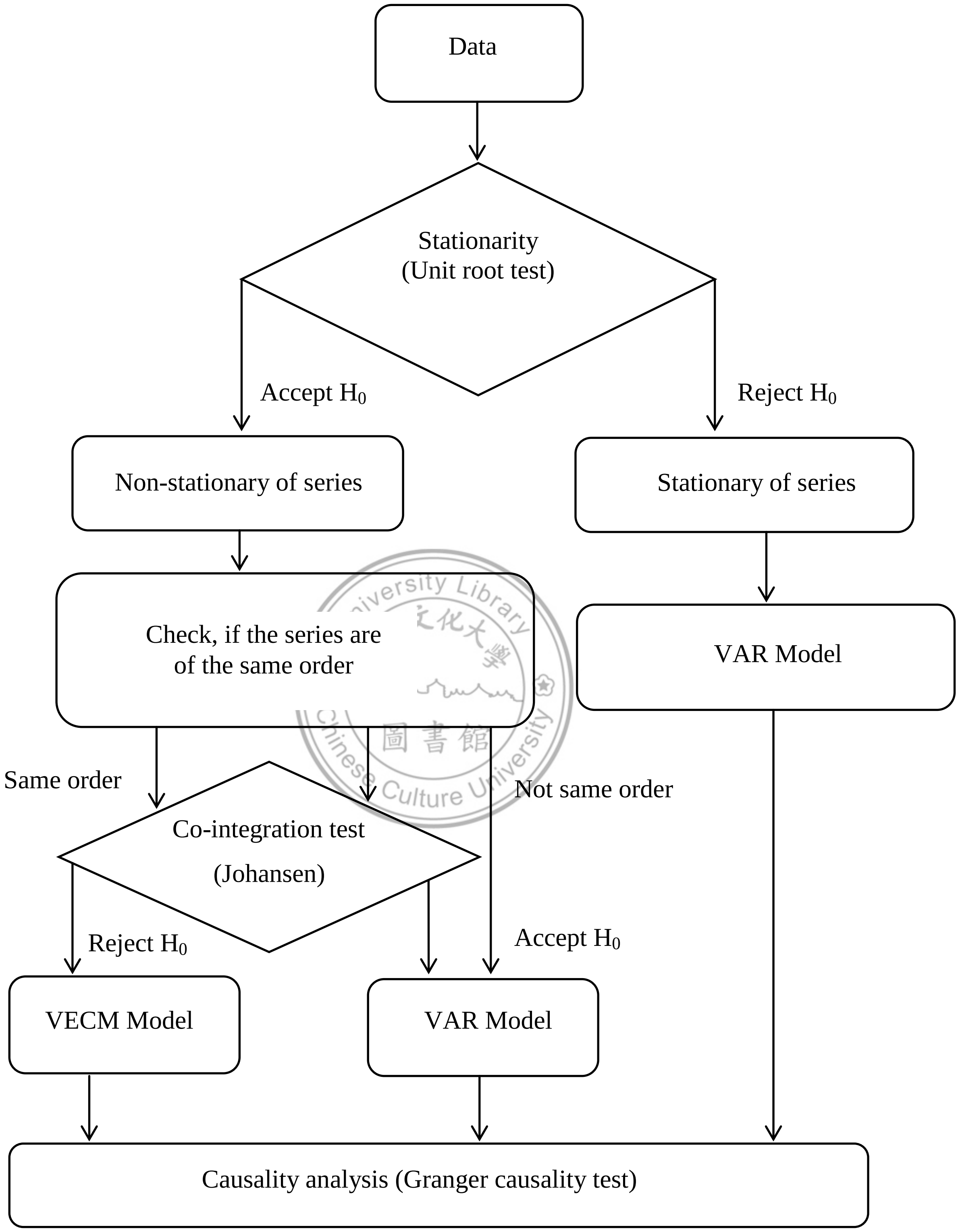

Figure 3-1. Flow Chart of Empirical Process in the Study

3.2 Econometrics Methods

3.2.1 Unit Root Test

Although a conventional model should be estimated using a system estimator or single equation approach, it is important to consider the underlying properties of the processes that generate time-series variables because the presence of unit roots in the series normally behave with stochastic trends. If a series contains a unit root test or is non-stationary, then the problem of spurious regression may occur in that they may indicate a relationship between two variables where one does not exist. However, a linear combination of two or more non-stationary series (with the same order of integration) may be stationary. If it combined with other non-stationary series' to form a cointegrated stationary relationship, then the series are considered to be cointegrated and have long-run relationships. Engle and Granger (1987) showed that if the two series X and Y (say) are individually I(1) (i.e. integrated of order one) and cointegrated then there would be a causal relationship at least in one direction. The presence of cointegration among the variables rules out the possibility of ''spurious'' correlation. However, although cointegration indicates the presence or absence of Granger causality, it does not indicate in which direction causality runs between the variables. This direction of Granger's causality can be detected through the Vector Error Correction model (VECM) of long-run cointegrating vectors. Furthermore, Granger's Representation Theorem demonstrates how to model a cointegrated I(1) series in a vector autoregression (VAR) format. VAR can be constructed either in terms of the level of the data or in terms of their first differences, i.e. I(0) variables, with the addition of an error correction term to capture the short-run dynamics.

Accordingly, these unit root tests are used to check the robustness of the results. It consists of running a regression of the first difference of the series against the series lagged, lagged difference terms and optionally, a constant and a time trend. A series is said to be nonstationary (or stationary) if it has nonconstant (or constant) mean, variance, and autocovariance (at various lags) over time. If a nonstationary series has to be differenced d times to become stationary, then it is said to be integrated of order d: i.e. I(d). To test for the existence of stationary of the data series and determine the order of integration of the three variables, we conduct the unit root tests employing the augmented Dickey–Fuller (ADF) and Phillips– Perron (PP) methods (Dickey and Fuller, 1981; Kwiatkowski et al., 1992; Phillips and Perron, 1988) to examine unit root test and the stationarity of the data series in this paper. As Enders (1995) indicated, the Dickey–Fuller tests assume the errors to be independent and have constant variance, while the Phillips–Perron test allows for fairly mild assumptions about the distribution of errors.

The ADF test considered three different regression equations including pure random walk, random walk with drift or intercept term, and both a drift and linear time trend. The ADF test regression is represented below (Chimobi and Uche, 2010):

$$\Delta\mathbf{Y}_t = \boldsymbol{\alpha} + \boldsymbol{\rho}\mathbf{Y}_{t-1} + \boldsymbol{\rho}_i \sum_{i=1}^{p} \Delta\mathrm{Y}_{t-1} + \boldsymbol{\varepsilon}_t \tag{3-1}$$

Where $\Delta Y_{t-1} = (Y_{t-1} - Y_{t-2})$, $\Delta Y_{t-2} = (Y_{t-2} - Y_{t-3})$,..., and ε_t is a pure white noise error term. In this equation, the main parameter was ρ. If ρ was not significantly different from zero or less than critical values, the series indicate that there is a unit root or the time series is nonstationary.

In this paper, two of the three-noted equations were used: one with a drift or intercept and another with both intercept and trend. The null hypothesis (H_0) is that $\rho_0=$

0 was tested for equation with intercept and with both trend and intercept against the alternative hypothesis of H_1 ($\rho_0 < 0$). Once values for the test are computed, they can be compared to the relevant critical value. If the calculated value of ADF statistic is greater than McKinnon's critical values, then the null hypothesis (H_0) is not rejected and the series are nonstationary or not integrated of order zero, I(0). Alternatively, rejected of the null hypothesis implies stationary or integrated of order zero. Failure to reject the null hypothesis leads to conducting the test on the difference of the series by differencing (subtracting Y_{t-1} from Y_t, taking the difference $Y_t - Y_{t-1}$) correspondingly to $Y_t - Y_{t-1} = \varepsilon_t$ or $Y_t - Y_{t-1} = \alpha + \varepsilon_t$ [$Yt \sim I(d); d > 0$] and then the process becomes difference-stationary. If the time series (variables) are non-stationary in their levels, they can be integrated with I(1), when their first differences are stationary. Two equations regarding stationary of time series of EC, GDP, and EXP are examined as follow (Ahmad et al., 2008):

Equation (1) one with a drift or intercept

$$\Delta\mathbf{Y}_t = \boldsymbol{\alpha} + \boldsymbol{\rho}_0\mathbf{Y}_{t-1} + \sum_{t=1}^{p} \rho\Delta\mathbf{Y}_{t-1} + \boldsymbol{\varepsilon}_t \tag{3-2}$$

Equations (2) both intercept and trend

$$\Delta\mathbf{Y}_t = \boldsymbol{\alpha} + \boldsymbol{\rho}_0\mathbf{Y}_{t-1} + \eta\mathbf{T} + \sum_{t=1}^{p}{}_{t}\Delta\mathbf{Y}_{t-1} + \boldsymbol{\varepsilon}_t \tag{3-3}$$

Where Y_t is EC, GDP and EXP,ΔY_t is the first difference of the variable Y_t, α is the intercept, T is time trend, p is optimum lag length for which the lagged value of variable is significant, and εt is residual of time series.

The PP test entailed less stringent restrictions on the error process and used nonparametric statistical method for serial correlation in the error term without adding lagged difference terms (Greece, 1997). PP test allows the error term to be weakly dependent and heterogeneously distributed. In contrast, the ADF test accounted for possible serial correlation in the error term by adding lagged difference terms in the regression (Gujarati, 2003). Furthermore, ADF test assumed that the expected value of the error term was equal to zero, independent and has a constant variance, however PP tests did not require the error term be serially uncorrelated or homogeneous, therefore PP test was more flexible in term of serial correlation between disturbances. Monte Carlo studies find that PP test has greater power to reject a false null hypothesis of a unit root. However, it is preferable to use the ADF test when the true model contains negative moving average terms and the PP test when the true model contains positive moving average terms.

3.2.2 Lag Length Selection

A critical element in the specification of appropriate VAR models is the consideration of the lag length of the VAR. Enders (1995) stated that one approach to select the appropriate lag length is to start with a relatively long lag length and pare down the model by the usual t-test and/or F-tests. If the t-statistic on lag p* is insignificant at some specified critical value, re-estimate the regression using a lag length of p* **-** 1**.** Repeat the process until the lag is significantly different from zero. There are several criteria used for selecting and appropriate lag length in the model. The optimum lag length is frequently determined using an explicit statistical criterion such as the Akaike's information criterion (AIC), Schwarz's information criterion (SIC) or Bayesian Information Criterion (BIC), log-likelihood ratio test (LR) Criterion, and the Hannan-Quin information criterion (HQ). In all alternatives, the model that best fits the data is the one that minimizes the overall sum residuals of squared (RSS) or maximizes the likelihood ratio. For the short-lag models, both symmetric and asymmetric, the SIC, PIC, KAIC, and KSIC slightly outperform the AIC, but the difference is small. For the longer-lag models, the AIC-specified lag length models outperforms the other criterion, especially the SIC and PIC.

Gideon E. Schwarz (1978) developed BIC, who gave a Bayesian argument for adopting it. BIC widely applied to any set of maximum likelihood-based models. The optimal lag length of the pairwise VAR models in this study was determined by the SIC criterion. Although both AIC and SIC are commonly used models for selection criteria, SIC was perceived to have some advantages for this study. SIC's construction allows it to select a more parsimonious model than the AIC. The SIC also has superior large sample properties (Enders, 1995). When the sample size approaches infinity, the SIC is asymptotically consistent while the AIC is biased toward selecting an over parameterized model. In this study, AIC, SIC, HQ, and LR are used to determine optimum lag length of ADF model. AIC, SIC, HQ, and LR values are presented as follows (Usman and Sarpong, 2009):

$$\text{Schwarz: SIC} = \mathbf{T} \ln |\boldsymbol{\Sigma}| + \mathbf{N} \ln \mathbf{T} \qquad (3\text{-}4)$$

$$\text{Akaike: AIC} = \mathbf{T} \ln |\boldsymbol{\Sigma}| + \mathbf{2\ N} \qquad (3\text{-}5)$$

$$\text{Hannan-Quin: HQ} = \mathbf{T} \ln |\boldsymbol{\Sigma}| + \mathbf{2N} \ln \ln \mathbf{T} \qquad (3\text{-}6)$$

Where $|\Sigma|$ is determinant of the variance/covariance matrix of the residuals, N is total number of parameters estimated in all equations, and T is number of usable observations.

$$\text{Log-likelihood ratio: LR} = (\mathbf{T - m})(\ln |\boldsymbol{\Sigma}_{\mathbf{r}}| \ln |\boldsymbol{\Sigma}_{\mathbf{u}}|) \qquad (3\text{-}7)$$

Where T is number of usable observations, m is number of parameters estimated in each equation of the unrestricted system, including the constant, $\ln|\Sigma_r|$ is natural logarithm of the determinant of the covariance matrix of residuals of the restricted system, and $\ln|\Sigma_u|$ is natural logarithm of the determinant of the covariance matrix of residuals of the unrestricted system.

If the results of AIC, SIC, HQ, and LR are the optimum lag length of time series, the result of SIC is chosen because the Schwarz (1978) information criteria is the most parsimonious correct model.

3.2.3 Cointegration test

Once the unit roots are confirmed for data series, the next step is to examine whether there exists a long-run equilibrium relationship among the variables. This calls for cointegration analysis, which is significant so as to avoid the risk of spurious regression. Engle and Granger (1987) introduce the cointegration test method to overcome non-stationary time-series due to unit roots intrinsic problem. They found that a linear combination of two or more non-stationary variables might be stationary, so that, if this stationary linear combination exists then the non-stationary time-series are said to be cointegrated. They show that if independent series are integrated of the same order d, denoted by I(d), and if the residuals of the linear regression among these series are integrated of the order d–b, I(d–b), then the series are said to be cointegrated of the order d, b, denoted as CI(d,b). Thus, the stationary linear combination may be interpreted as a long-run equilibrium relationship among the variables.

The concept of this long-run relationship was extended by Johansen (1988). The Johansen method applies the maximum likelihood procedure to determine the presence of cointegrated vectors in non-stationary time series using autoregressive processes, such as, ADF and PP test. The testing hypothesis is the null hypothesis in consideration ($H_{0)}$, where there are a different number of cointegration relations, against the alternative hypothesis (H_1), that all series are stationary.

In the Johansen's procedure, the first step is the estimation of a unrestricted, closed p^{th} order VAR in k variables. The VAR based co-integration test using the methodology developed in Johansen (1992, 1995) is:

$$\mathbf{y}_t = \mathbf{A}_1\mathbf{y}_{t-1} + \mathbf{A}_2\mathbf{y}_{t-2} + \ldots + \mathbf{A}_p\mathbf{y}_{t-p} + \boldsymbol{\beta}x_t + \boldsymbol{\varepsilon}_t \tag{3-8}$$

Where y_t is a k -vector of non-stationary I(1) endogenous variables, X_t is a d –vector of exogenous deterministic variables, A_1 , ..., A_p *and* β are coefficients to be estimated, and ε_t is an independent and identically distributed n-dimensional vector.

Since most economic time series are non-stationary, the above stated VAR model is generally estimated in its first-difference form. Then, this VAR could be rewritten as (Mishra, 2011; Pratomo, 2007):

$$\Delta\mathbf{y}_t = \prod \mathbf{y}_{t-1} + \sum_{i=1}^{p-1} \Gamma\, \Delta\mathbf{y}_{t-i} + \boldsymbol{\beta}x_t + \boldsymbol{\varepsilon}_t \tag{3-9}$$

Where

$$\prod = \sum_{i=1}^{p} A_i - \mathrm{I} \text{ and } \Gamma_i = -\sum_{j=i+1}^{p} A_j \tag{3-10}$$

and $\prod$ is the long-term matrix containing whether the condition of y_t is either cointegrated or not-cointegrated. p denotes the lag length, Γi is the number of cointegrated vectors (cointegrated rank) and ε_t is the residual matrix. Granger's representation theorem suggests that if the coefficient matrix $\prod$ has reduced rank r < k, then there exists k x r matrices α and β each rank r such that $\prod = \alpha\beta'$ and $\beta' y_t$ is I(0). r is the number of cointegrating vectors (the co-integrating rank) and each column of β is the vector of cointegrating parameters while α is the vector error correction coefficient that measures the speed of convergence in Δy_t.

The main point of conducting Johansen's cointegration test is to determine the rank (r) of the p x p $\prod$ matrix. In the present application, there are three possible ranks. First, it can be full rank, which would imply that the variables are given by a stationary process, which are difference from the earlier finding that the two variables are non-stationary. Second, the rank of $\prod$ can be zero, in which case it indicates that there is no long run relationship between research variables. In instances when $\prod$ is of either full rank or zero rank, the model should be estimate using either levels or first differences, respectively. Finally, in the intermediate case when $0 < r < p$ (reduced rank), there are r cointegrating vectors among the elements of y_t and p-r common stochastic trends. The Johansen approach to cointegration test is based on two tests statistics, including trace test and the maximum eigenvalue test.

3.2.3.1 Trace test

The trace test attempts to determine the number of cointegrating vectors between the variables by testing the null hypothesis that r = 0 against the alternative hypothesis that r > 0 or r≤ 1 where r is the number of cointegrating vectors. The trace test statistic can be specified as: $\boldsymbol{\tau}_{\text{trace}} = \mathbf{-T}\sum_{i=r+1}^{k}\log(1 - \lambda_i)$, where λ_i is the ith largest canonical correlation and T is the number of observations.

3.2.3.2 Maximum Eigenvalue Test

The maximum eigenvalue tests the null hypothesis that the number of cointegrating vectors is equal to r against the alternative of r + 1 cointegrating vectors relation with the test statistic: $\tau_{max} = -T\log(1-\boldsymbol{\lambda}_{r+1})$, where $\boldsymbol{\lambda}_{r+1}$ is the $(r + 1)^{th}$ largest canonical correlation. In the trace test, the null hypothesis of $r = 0$ is tested against the alternative of $r + 1$ cointegrating relations. Thus, if the value of the Likelihood Ratio (LR) was greater than the critical values, the null hypothesis of zero cointegrating vectors was rejected.

It is well known that Johansen's cointegration test is very sensitive to the choice of lag length. So, at first a VAR model is fitted to the time series data in order to find an appropriate lag length. The Schwarz Information Criterion (SIC) is used to select the optimal lag length required in the cointegration test.

The trace test and maximum eigenvalue test are used to determine the existence of co-integration, and whether the method of estimation used is the ordinary least squares (OLS) or maximum likelihood, both provide the same results. If the results show evidence of a co-integrating relationship between the variables, this indicates that the research variables interact a systematic co-movement in the long run. Such a long run causality relationship requires testing by VECM. However, if there is no long-run equilibrium relation among time series, VAR model is applied to examine Granger causality test.

3.2.4 Granger causality

Next, we examine the direction of causality between the variables based on Granger causality test. The concept of Granger causality as defined by Granger (1969) is as follows; A time series variable, say X, is causal for another time series variable Y, if the past value of X (x_{t-1}, x_{t-2},..., x_0) helps explain Y (y_t) with greater accuracy. In other words, X is causing Y if X temporarily precedes Y, so changes in X take place before changes in Y. Similarly, variable Y is said to cause variable X if the past helps improve the forecasts of the latter. Granger's notion of causality asserts that X causes Y if the history lagged values of X contribute to the explanation of series Y more accurately than merely by using the history lagged values of Y. Granger causality has been extensively used in empirical economics studies. This study examines the direction of causalities between energy consumption, GDP, and exports in the final stage with Granger causality test. To test for causality, two Granger causality alternative models were stipulated: VAR in first differences and the error correction model (ECM).

3.2.4.1 Vector Autoregressive Model

The VAR model is used if results of unit root test indicated that the variables were integrated of order one I(1) but not cointegrated. In the present study linear combinations of non-stationary variables are found not stationary, that is, the variables are not cointegrated. In absence of co-integration the unrestricted VAR in first difference is estimated, which take the following form (Chimobi and Uche, 2010):

$$LEC_t = \mathbf{b}_{1t}LEC_{t-i} + \mathbf{c}_{1t}LGDP_{t-i} + \mathbf{d}_{1t}LEXP_{t-i} + \boldsymbol{\varepsilon}_{1t} \tag{3-11}$$

$$LGDP_t = \mathbf{b}_{2t}LEC_{t-i} + \mathbf{c}_{2t}LGDP_{t-i} + \mathbf{d}_{2t}LEXP_{t-i} + \boldsymbol{\varepsilon}_{2t} \tag{3-12}$$

$$LEXP_t = \mathbf{b}_{3t}LEC_{t-i} + \mathbf{c}_{3t}LGDP_{t-i} + \mathbf{d}_{3t}LEXP_{t-i} + \boldsymbol{\varepsilon}_{3t} \tag{3-13}$$

Where b, c and d are the coefficients of variables and ε_t is random disturbances. For EC_t to be unaffected by GDP_t and EXP_t, c_{1t} and d_{1t} must not be significantly different from zero and so on for the other variables.

Granger causality is particularly easy to deal with in VAR models. Assume that our data can be described by the following matrix form:

$$\begin{bmatrix} \mathbf{LEC_t} \\ \mathbf{LGDP_t} \\ \mathbf{LEXP_t} \end{bmatrix} = \begin{bmatrix} \alpha 1 \\ \alpha 2 \\ \alpha 3 \end{bmatrix} + \begin{bmatrix} A_{11}^1 & A_{12}^1 & A_{13}^1 \\ A_{21}^1 & A_{22}^1 & A_{23}^1 \\ A_{31}^1 & A_{32}^1 & A_{33}^1 \end{bmatrix} \begin{bmatrix} \mathbf{LEC_{t-1}} \\ \mathbf{LGDP_{t-1}} \\ \mathbf{LEXP_{t-1}} \end{bmatrix} + \dots + \begin{bmatrix} A_{11}^k & A_{12}^k & A_{13}^k \\ A_{21}^k & A_{22}^k & A_{23}^k \\ A_{31}^k & A_{32}^k & A_{33}^k \end{bmatrix} \begin{bmatrix} \mathbf{LEC_{t-k}} \\ \mathbf{LGDP_{t-k}} \\ \mathbf{LEXP_{t-k}} \end{bmatrix} + \begin{bmatrix} \boldsymbol{\varepsilon}_{1t} \\ \boldsymbol{\varepsilon}_{2t} \\ \boldsymbol{\varepsilon}_{3t} \end{bmatrix} \tag{3-14}$$

Where k is the optimal lag length.

3.2.4.2 Vector Error Correction Model

If the cointegration is confirmed the existence between variables, then the third step entails the construction of error correction mechanism to model dynamic relationship. The purpose of the error correction model is to indicate the dynamic of adjustment from the short run equilibrium to the long-run equilibrium state.

The VECM was introduced by Sargan (1964), and later popularized by Engle and Granger (1987) and Granger (1988), respectively. Granger (1988) argued that if variables are non-stationary, but become stationary after the difference, and are co-integrated, it becomes necessary to estimate a VECM for the multivariate causality test. The Vector Error Correction Model (VECM) is a restricted VAR applied to nonstationary series that are known to be cointegrated. The VECM is based on the behavioral assumption that two or more time series exhibit an equilibrium relationship that determines both short- and long-run behavior. Once the equilibrium conditions are imposed, the VECM describes how the examined model is adjusting in each time period towards its long-run equilibrium state. Since the variables are supposed to be cointegrated, in the short-run, deviations from this long-run equilibrium will react on the changes in the dependent variables in order to impose their movements towards the long-run equilibrium state. Hence, the cointegrated vectors from which the error correction terms are derived indicate an independent direction where a stable meaningful long-run relationship exists.

The VECM has cointegration relations built into the specification so that it restricts the long-run behavior of the endogenous variables to converge on their cointegrating relationship while allowing for short-run adjustment dynamics. The VECM is used to see if long-run equilibrium will gradually achieve, and contemporaneous changes in the variables that determine equilibrium, are adjusted. In sum, VECM has both long-run and short-run properties built in. The long-run properties embedded in error term while short-run properties are partially captured by the equilibrium error term. The size of the error correction term indicates the speed of adjustment of any disequilibrium towards a long-run equilibrium state. In this study the error correction model, as suggested by Hendry (1996), has been used. The general form of the VECM is as follows:

$$\Delta LEC_t = \boldsymbol{\alpha}_0 + \boldsymbol{\lambda}_{1i}EC1_{t-1} + \sum_{i=1}^{p} \boldsymbol{\alpha}_{1,i}\, \Delta LEC_{t-i} + \sum_{i=1}^{p} \boldsymbol{\alpha}_{2,i}\, \Delta LGDP_{t-i} + \sum_{i=1}^{p} \boldsymbol{\alpha}_{3,i}\, \Delta LEXP_{t-i} + \boldsymbol{\mu}_{1t} \tag{3-15}$$

$$\Delta LGDP_t = \boldsymbol{\beta}_0 + \boldsymbol{\lambda}_{2i}EC2_{t-1} + \sum_{i=1}^{p} \boldsymbol{\beta}_{1,i}\, \Delta LGDP_{t-i} + \sum_{i=1}^{p} \boldsymbol{\beta}_{2,i}\, \Delta LEC_{t-i} + \sum_{i=1}^{p} \boldsymbol{\beta}_{3,i}\, \Delta LEXP_{t-i} + \boldsymbol{\mu}_{2t} \tag{3-16}$$

$$\Delta LEXP_t = \boldsymbol{\delta}_0 + \boldsymbol{\lambda}_{3i}EC3_{t-1} + \sum_{i=1}^{p} \boldsymbol{\delta}_{1,i}\, \Delta LEXP_{t-i} + \sum_{i=1}^{p} \boldsymbol{\delta}_{2,i}\, \Delta LEC_{t-i} + \sum_{i=1}^{p} \boldsymbol{\delta}_{3,i}\, \Delta LGDP_{t-i} + \boldsymbol{\mu}_{3t} \tag{3-17}$$

Where Δ is the first difference operator; EC_{t-1} is the error correction term lagged value, α's, β's and δ's are parameters to be estimated, μ's are the serially uncorrelated error terms and λ is the short-run coefficient of the error correction term ($-1 < \lambda < 0$). The error correction coefficient (λ) is very important in this error correction estimation as the greater co-efficient indicates higher speed of adjustment of the model from the short-run to the long-run.

The error correction term represents the long-run relationship. A negative and significant coefficient of the error correction term indicates the presence of long-run causal relationship. If both the coefficients of error correction terms in both the equations are significant, this will suggest the bi-directional causality or a two-way feedback relationship. If only the set of estimated coefficients on the lagged Y (λ_1) is non-zero and the error correction term coefficient (ECT1) is significant, this will suggest a unidirectional causality from Y to X, implying that Y drives X towards long-run equilibrium, but not the other way around. Similarly, if λ_2 is non-zero and the error correction term coefficient (ECT2) is significant, this will suggest a unidirectional causality from X to Y, implying that X drives Y towards long-run equilibrium but not the other way around.

On the other hand, the lagged terms of ΔX_t and ΔY_t represented as explanatory variables, indicating a short-run cause and effect relationship between the two variables. Thus, if the lagged coefficients of ΔX_t appear to be significant in the regression of ΔY_t, this will mean that X predicts Y. Similarly, if the lagged coefficients of ΔY_t appear to be significant in the regression of ΔX_t, this will mean that Y predicts X.

CHAPTER FOUR

EMPIRICAL RESULTS

4.1 Descriptive Statistic Analysis

The focus of this study is to explore the relationship among GDP, energy consumption and exports in China and India. The annual data for energy consumption are obtained from BP Statistical Review of World Energy (BP) and GDP and exports are obtained from the World Bank Development Indicators (WDI) from 1980 to 2011. Energy consumption is measured in Million tons oil equivalent (Mtoe). GDP and exports are measured in current US$ Million.

Table 4-1 provides a statistical summary associated with the actual value of three variables for each country. The highest means of energy consumption, GDP and exports are found in China, with China having the higher real GDP mean (1505467.41), higher energy consumption mean (1066.64) and higher exports mean (436201.47). Additionally, China displays the greater variation in energy consumption (617.06), GDP (1802774.30) and exports (595826.41) since China is the world's largest energy consumer and the world leading exporter. Over the past few years China has relied heavily on the success of its manufacturing sector and exports to encourage its economic growth. And China is the world's second largest gross domestic product which is approximately equivalent to 11.77 percent of the world economy (World Bank, 2012).

Table 4-1 *Summary Statistics (before taking logarithm), 1980-2011.*

Country	**Energy Consumption**		**GDP**		**Exports**	
	Mean	*S.D.*	*Mean*	*S.D.*	*Mean*	*S.D.*
China	1,066.64	617.06	1,505,467.41	1,802,774.30	436,201.47	595,826.41
India	261.96	124.18	561,520.21	440,700.73	91,345.90	115,726.32

Three macroeconomic indicators (GDP, exports and energy consumption) were analyzed in this study to express China and India's economic performance. Since 1980, all three macroeconomic indicators trended upward. However, the impact of 2008 financial crisis resulted in a declining trend for exports in India and China during certain periods.

GDP, exports and energy consumption from 1980-2011 in China and India are shown in Figure 4-1 to Figure 4-6 respectively.

GDP of China and India have increased rapidly since 1994. The average 17 percent and 11 percent per year economic growth rate for China and India caused significant changes in GDP value. However, in 2008, the crisis contracted India's GDP by 2 percent. Subsequently, economic growth started to rise again in 2009 and expected to continue rising in the future, see Figure 4-2. As a matter of fact, the global economic slowdown caused the growth rate of GDP in China to drop from 29.41 percent in 2008 to 10.38 percent in 2009. In 2010, the downward trend has stopped as the GDP growth rate in that year was 18.82 percent, see Figure 4-1.

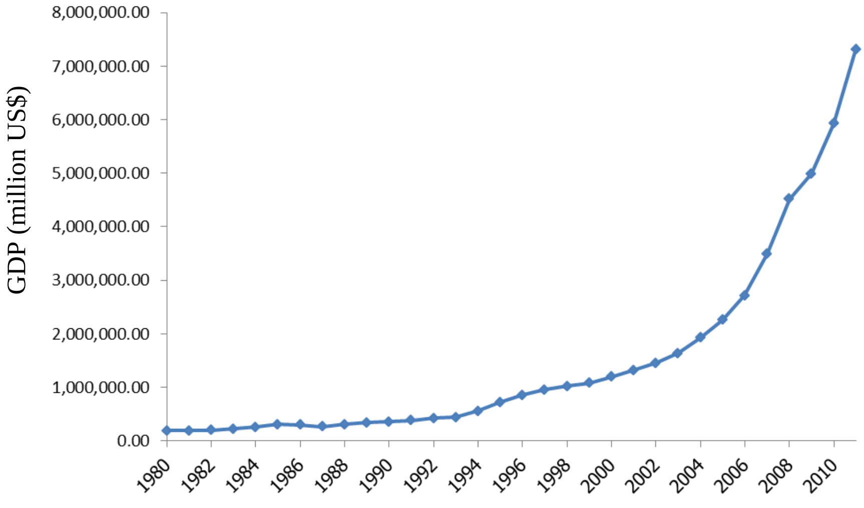

Figure 4-1. China's GDP from 1980-2011
Source: Compiled from World Bank (2012).

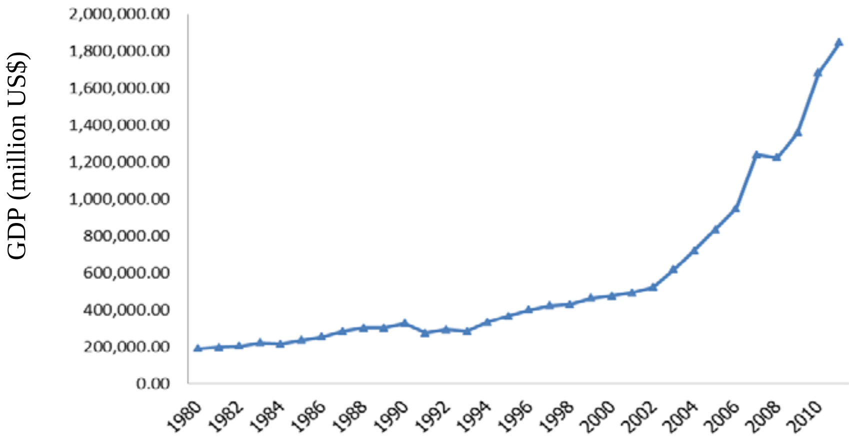

Figure. 4-2 India's GDP from 1980-2011
Source: Compiled from World Bank (2012).

In China in the early 1970s, the export rate was not stable due to the strengthened economic policies and China continued suffering from inadequate transportation, communication, and energy resources. The value of exports, which relied mainly on office equipment and electrical machinery, were also affected. Signs of change began to appear in late the 1980s after the government reformed several economic policies including the fiscal, monetary, and trade openness that diversified exports so that they were not so highly dependent on domestic market. The years between 2000 to 2007 were transitional for exports sector. Unfortunately, the disastrous 2008 financial crisis had huge impact on exports. In 2009 the value of exports plunged more than 15 percent compared with the previous year. The unstable macroeconomic condition was presumed as major causes in the decline of exports. However, beginning in 2010, the exports sector started to rise again with growth of 31 percent see Figure 4-3.

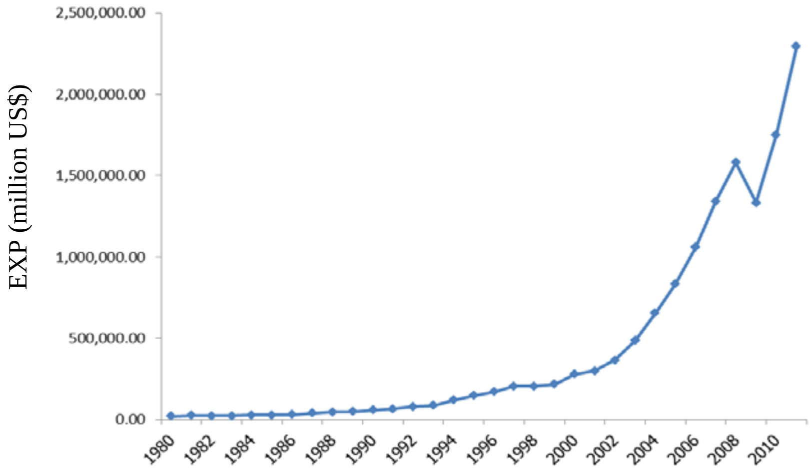

Figure 4-3. China's exports from 1980-2011
Source: Compiled from World Bank (2012).

India's exports have increased much faster than GDP over the past few decades. Exports have increased even faster since 1972. Several factors appear to have contributed to this event including foreign direct investment (FDI) which has been rising consistently especially from the early 1990s. The sign of change in exports trend appeared in 1991 after India opened its market by lowering tariff and non-tariff barriers (NTBs), and liberalizing investment policy, India exports have grown average 14 percent per year. However, India's exports were also affected by financial crisis in 2008. In 2009, the value of exports dropped 5 percent from previous year. Nevertheless, in 2010, India's exports began to increase again with growth rate of 39 percent per year, see Figure 4-4.

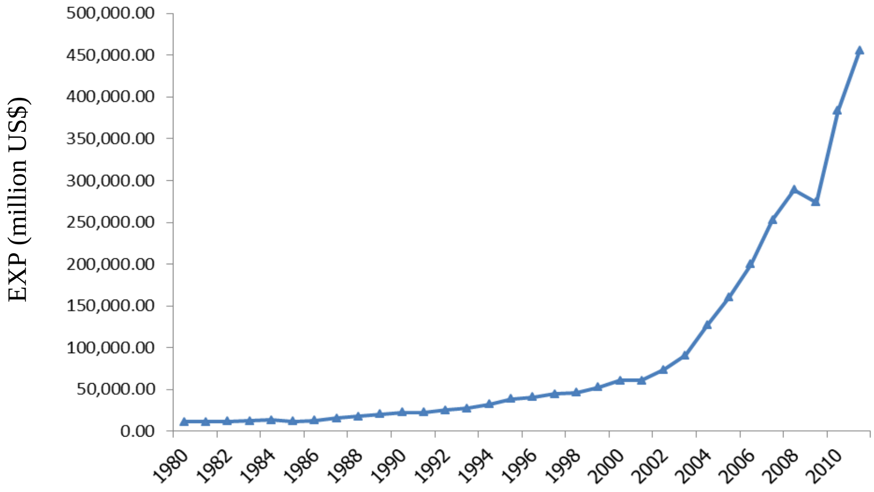

Figure. 4-4 India’s exports from 1980-2011
Source: Compiled from World Bank (2012).

China is the world's largest populated country, its energy consumption has been steadily increasing, nearly doubling in the 10 years from 2000 to 2011 (from 1010 Mtoe to 2613 Mtoe), accounting for 21 percent of the world's energy consumption. Nonetheless, Chinese demand for energy has rapidly increased since 1969. It relies heavily on natural gas, coal, hydroelectric power, oil and electric power; all which have contributed to the energy shortages in the country. Due to a high population, China's power output is in short supply especially in 2002, there was a shortage of electricity in China and 21 provinces had to initiate energy policy to limit the energy use. As China continues the development process, its energy use is expected to continue rise in the next decades, see Figure 4-5.

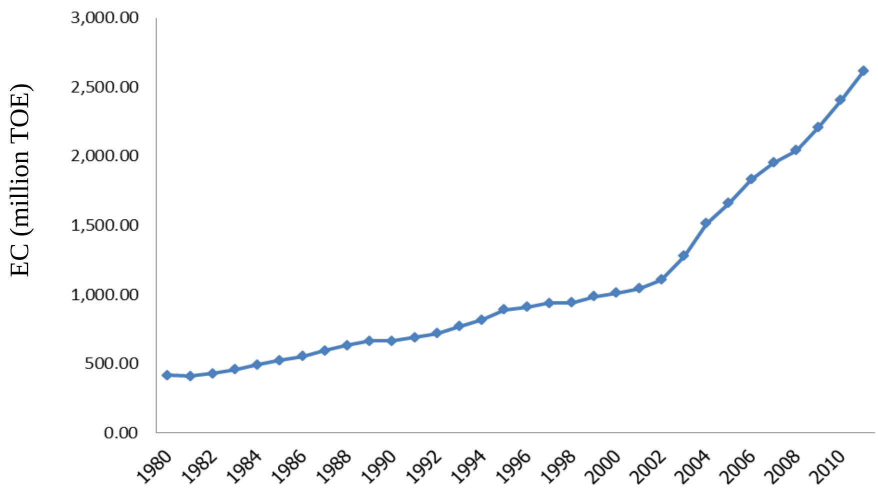

Figure 4-5. China's energy consumption from 1980-2011
Source: Compiled from World Bank (2012).

In the recent years, India's energy consumption has been growing at one of the fastest rates in the world due to an increase of population and economic development. The energy consumption in India increased at a steady rate. On average, the energy consumption was 5.4 percent per year from 1980 to 2011. Without exception, energy use in India is expected to grow along with economic growth since the level of economic development has been observed to be dependent on the energy demand during the next twenty years, see Figure 4-6.

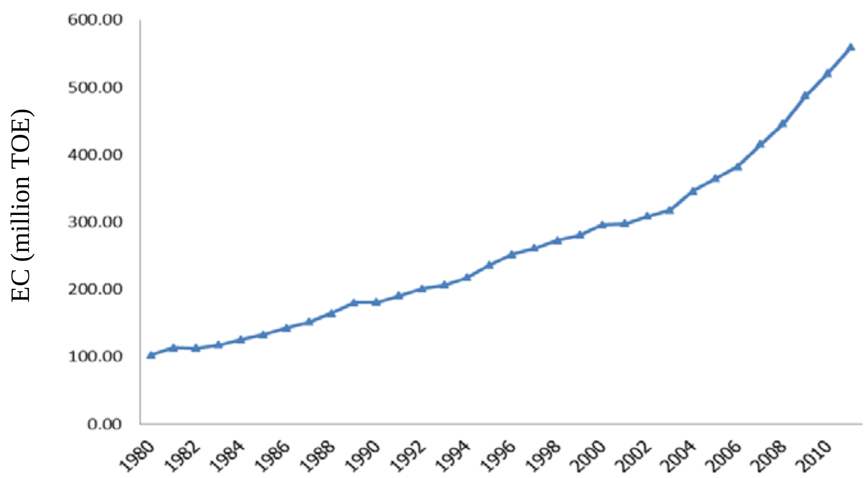

Figure 4-6. India's energy consumption from 1980-2011
Source: Compiled from World Bank (2012).

In the following section, this study examined the three methods commonly employed in time-series analysis. Econometrics techniques such as unit root test, cointegration test and Granger causality test are used to find short-run and long-run relationship and direction of causality between energy consumption, exports and GDP.

4.2 Econometric Analysis

Before process the econometric model, we need to test their reasonableness. That is to test whether there is a causal relationship between GDP, exports and energy consumption. The model strategy applied in this article is Johansen cointegration test and the Granger causality test. Since both of the two tests require that the time series is stationary series, while most of the time series are non-stationary series. Hence, we need to test the stability of data. To begin with, this paper runs the unit root test on logarithm of energy consumption, exports and GDP, if they are stationary series, then we can directly test for causality; if they are nonstationary series, then we have to test for co-integration, thus test the causal relationship of energy consumption, exports and GDP. Till now and we can create models for estimate according to a causal relationship between them. The data that were tested are in logarithm form, which is conducive to the model estimation and parameter analysis.

4.2.1 Unit Root Tests

In the first stage, unit root tests were conducted, with GDP, exports of goods and services and energy consumption as the time-series variables in this study. These variables must be stationary or cointegrated in order to avoid a spurious problem and to affirm whether they are stationary or not.

The time series properties of the variables are checked through two types of unit root tests: ADF and PP test with critical values 5 percent. For these tests, the null hypothesis is that there is a unit root, while the alternative hypothesis is that there is no unit root. The results of the ADF and PP tests are shown in Table 4-2 and Table 4-3.

Table 4-2 *Augmented Dickey-Fuller and Phillips-Perron Unit Root Tests on Energy Consumption, GDP and Exports for China (1980-2011)*

	Unit Root Tests in Levels		**Unit Root Tests in First Difference**		**Model**
Variable	*ADF*	*PP*	*ADF*	*PP*	
LEC	3.0407	6.6140	-3.191752**	-3.27838**	Intercept
	(0.9989)	(1.0000)	(0.0305)	(0.0251)	
LGDP	3.0695	6.7327	-3.290744**	-3.290744**	Intercept
	(0.9990)	(1.0000)	(0.0244)	(0.0244)	
LEXP	7.6014	7.3942	-4.748859***	-4.733324***	Intercept
	(1.0000)	(1.0000)	(0.0006)	(0.0007)	

Note: *** represent 1% of significant level.
** represent 5% of significant level.
* represent 10% of significant level.
: The lag lengths are selected using SIC criteria

For China, the ADF and PP tests results demonstrate that all of the series are non-stationary in levels or the results failed to reject the null-hypothesis in their level. Thus, to correct for the presence of unit root in all series, first difference measures are taken. The result of the unit roots tests in first difference based on ADF tests and PP tests show that GDP (p-value 0.0244), exports (p-value 0.0006) and energy consumption (p-value 0.0305) are stationary in their first difference. Therefore, all variables are found to be integrated in order 1 in the models with trend or without trend.

Table 4-3 *Augmented Dickey-Fuller and Phillips-Perron Unit Root Tests on Energy Consumption, GDP and Exports for India (1980-2011)*

	Unit Root Tests in Levels		**Unit Root Tests in First Difference**		**Model**
Variable	*ADF*	*PP*	*ADF*	*PP*	
LEC	11.7340	11.5855	-5.500473***	-5.50494***	Intercept
	(1.0000)	(1.0000)	(0.0001)	(0.0001)	
LGDP	5.1253	4.4028	-6.063922***	-6.063922***	Trend and
	(1.0000)	(1.0000)	(0.0001)	(0.0001)	Intercept
LEXP	6.8319	5.5556	-4.961726***	-4.941928***	Trend and
	(1.0000)	(1.0000)	(0.0020)	(0.0021)	Intercept

Note: *** represent 1% of significant level.
** represent 5% of significant level.
* represent 10% of significant level.
: The lag lengths are selected using SIC criteria

For India, the results of two tests indicate that the two series are found to be non-stationary in their level or the null hypothesis of a unit root cannot be rejected. However, first differences, GDP (p-value 0.0001), exports (p-value 0.0020) and energy consumption (p-value 0.0001) lead to stationary. These indicate that the integration of GDP, exports and energy consumption for India is of order one, i.e.

I(1).

4.2.2 Lag length selection

There are several statistical criteria which might be used to determine appropriate number of lags. There are the Akaike information criterion (AIC), the Schwarz information criterion (SIC), the Hannan-Quinn information criterion (HQ), and the LR test. The appropriate optimum lag length model must be determined to capture autoregressive time series and a residual in the process of ADF unit root test (Schwert, 1987). The number of lags in the model is determined according to the SIC. The result of lag length for China that minimizes the SIC was 1 (-7.5331) which is reported in Table 4-4.

Table 4-4 *Lag Length Selection for China*

Criterion	**Lag length**						
	0	1	2	3	4	5	6
AIC	-0.4461	-8.1138	-8.3115	-8.3620	-8.0840	-7.7868	-8.7401*
SIC	-0.3009	-7.5331*	-7.2954	-6.9104	-6.1969	-5.4642	-5.9819
HQ	-0.4043	-7.9466	-8.0189*	-7.9440	-7.5406	-7.1180	-7.9458
LR	NA	183.9204*	16.9108	11.8853	5.3857	3.9509	11.5190

Note: * indicates lag order selected by the criterion

The results of lag length selection showed that the optimum number of lags in the specified model for India is 1 when the SIC is minimum (-8.59529), see Table 4-5. These models are used to test for cointegration between GDP, exports and energy consumption in China and India.

Table 4-5 *Lag Length Selection for India*

Criterion	**Lag length**					
	0	1	2	3	4	5
AIC	-1.54335	-9.17122	-9.07258	-9.38327*	9.29637	-9.34593
SIC	-1.39937	-8.59529*	-8.06471	-7.94345	-7.42460	-7.01222
HQ	-1.50053	-8.99997*	-8.77289	-8.95514	-8.73979	-8.66092
LR	NA	190.7744*	11.36059	16.61506	8.11665	7.87851

Note: * indicates lag order selected by the criterion

4.2.3 Cointegration and Model Residual Analysis

In the next step, Johansen's Trace and Maximum Eigenvalue tests procedure are applied to detect cointegration. Johansen's cointegration test is used to find long-run equilibrium between variables. In other words, to find out whether the variable is related to each other in the long-run. This provides a unified framework for estimation and testing of cointegrating relations. The cointegration rank, r, of the time series is tested using two test statistics. Denoting the number of cointegrating vectors by r_0; the maximum eigenvalue (λmax) test is calculated under the null hypothesis that $r_0 = r$, against the alternative of $r_0 > r$. The trace test is calculated under the null hypothesis that $r_0 \leq r$, against $r_0 > r$. Trace test and maximum eigenvalue test were used to determine the rank of cointegration. Next, we determine the appropriate model for Johansen-Juselius cointegration test through the Pantula's (1989) principle suggested in Johansen (1992) and Hansen and Juselius (1995). The question of which of the five models would be chosen can be decided on the basis of the Pantula principle. We compared the trace statistic with the critical value. If the model is rejected, we continue to next model. This procedure is continued till the null is accepted for the first time. Trace test statistics suggests that Model 2 will be the most appropriate model for both countries because the first time null hypothesis cannot be rejected is located at Model 2. Therefore, the Johansen-Juselius cointegration test results are presented in below table.

Table 4-6 *Results of Johansen's Cointegration Test for China*

Hypothesized Number of Cointegrating Equations	Eigen Value	Trace Statistic	5% Critical Value (p-value)	Max-Eigen value	5% Critical Value (p-value)
R=0	0.4554	34.3439	35.1928 (0.0615)	17.6238	22.2996 (0.1981)
R≤1	0.2711	16.7201	20.2618 (0.1433)	9.1720	15.8921 (0.4156)
R≤2	0.2292	7.5481	0.1004 (0.1004)	7.5481	9.1645 (0.1004)

* denotes rejection of the hypothesis at the 0.05 level

Table 4-7 *Results of Johansen's Cointegration Test for India*

Hypothesized Number of Cointegrating Equations	Eigen Value	Trace Statistic	5% Critical Value (p-value)	Max-Eigen Value	5% Critical Value (p-value)
R=0	0.4922	33.0289	35.1928 (0.0840)	19.6511	22.2996 (0.1125)
R≤1	0.2577	13.3778	20.2618 (0.3344)	8.6413	15.8921 (0.4732)
R≤2	0.1507	4.7365	9.1645 (0.3136)	4.7365	9.1645 (0.3136)

* denotes rejection of the hypothesis at the 0.05 level

Trace and maximum eigen value tests are applied to determine the rank of cointegration. If both tests' results indicated greater value than the critical value then null hypothesis was rejected, and failed to reject null hypothesis if otherwise. Table 4-6 and 4-7 demonstrated the summary of Johansen's cointegration test. Column 1 corresponds to the null hypothesis of both trace and maximum eigen value test. Columns 2 to 6 indicate the computed values of trace and maximum eigen value. For the trace test, the critical value at 5 percent was 35.1928 at $r = 0$ and 20.2618 at $r = 1$ for China and India, the null hypothesis of no cointegration is not rejected at 5 per cent level of significance. For maximum eigen value tests, maximal eigenvalue statistic was 17.6238 for China and 19.6511 for India at $r = 0$, which are below the 95 per cent critical value. Hence the null hypothesis of $r = 0$ cannot be rejected at 5 per cent level of significance. Therefore, both eigenvalue (λmax) and trace test indicate that there is no cointegration relationship between these variables; this implies that export, energy consumption and GDP have no long run relationship.

4.2.4 Granger causality test

The concepts of standard Granger causality are often used to study causal relationships between time series variables in vector autoregressive (VAR) models. Let X_t, Y_t be realizations of two stochastic time series X, Y at time point t, then Granger defines X to be causal for Y if X provide significant information in the past and present at time t helps to improve forecast of Y_t. Based on results from VAR model, the coefficient of independent variables and dependent variables CHI_EC and CHI_EXP are 1.7858 (p-value 0.0014) (Table 4-8). The positive coefficient between CHI_EC and CHI_EXP means that change in energy consumption is significant in explain export growth. The coefficient of independent variables and dependent variables CHI_EC and CHI_GDP is 0.6694 (p-value 0.0741), which expresses a positive relationship between EC and GDP at 10% level of significant. The positive effect coefficient between CHI_EC and CHI_GDP implies that change in energy consumption is significantly influence economic growth.

Table 4-8 *Results of Estimation VAR Model in China*

dependent / independent	CHI_EC	CHI_EXP	CHI_GDP
CHI_EC	0.5594***	1.7858***	0.6694*
CHI_EXP	0.0262	-0.0141	0.1407
CHI_GDP	-0.0701	-0.4000	0.2899*
F-test	4.7682	4.0191	4.6088
S.E.	0.0303	0.1016	0.0699

Note: *** represent 1% level of significant
** represent 5% level of significant
* represent 10 % level of significant

From the results in Table 4-9, the coefficient of independent variables and dependent variables IND_GDP and IND_EXP is 0.5138 (p-value 0.0507), which expresses a positive relationship between GDP and EXP at 10 % level of significant.

The positive effect coefficient between IND_GDP and IND_EXP implies that change in GDP is significant influencing change in export.

Table 4-9 *Results of Estimation VAR Model in India*

dependent / independent	IND_EC	IND_EXP	IND_GDP
IND_EC	-0.0548	-0.2853	0.4903
IND_EXP	0.0112	0.0590	0.1570
IND_GDP	0.1084	0.5138*	-0.0856
F-test	1.4412	2.2470	0.5296
S.E.	0.0247	0.0943	0.0844

Note: *** represent 1% level of significant
** represent 5% level of significant
* represent 10 % level of significant

In order to confirm the relationship between the variables based on VAR estimates, a standard Granger causality test has been examined. Granger causality test is applied to study the forerunner-lag relationship between the variables such as EXP, GDP and EC. The results of Granger causality China and India are presented in Tables 4-10 and 4-11 respectively.

Table 4-10 *Granger Causality Test Results for China*

Dependent Variable	Independent variable	F-value	p-value	Causality
LEC	LEXP	0.0907	0.7656	No causality
	LGDP	0.7693	0.3882	No causality
LEXP	LEC	8.6273	0.0067***	LEC → LEXP
	LGDP	0.5229	0.4758	No causality
LGDP	LEC	4.6371	0.0404**	LEC → LGDP
	LEXP	2.5256	0.1237	No causality

Note: lag order is 1.
: *,** and *** indicate statistical significance at 10%, 5% and 1% level, respectively

Table 4-10 shows null hypothesis that energy consumption does not Granger cause exports is rejected at 5 percent significant level. These findings suggest that energy consumption is Granger cause export (p-value 0.0067). The result supports the previous result obtained from VAR model that there is positive relationship between energy consumption and exports at 10 per cent level of significance. This result reflects the fact that the effective and productive usage of energy sources creates positive effect on exports. That is, energy saving policies could limit expansion in exports. Another important result is that energy consumption cause GDP (p-value 0.0404), implies that the use of large amount of energy in industrial sectors may have directly pushed up the economic growth (Lu, 2011). Therefore, reduce energy consumption is not viable at this time in China. The results in Table 4-10 also indicate that export does not Granger-cause energy consumption, GDP does not Granger-cause energy consumption, GDP does not Granger-cause exports, and exports does not Granger-cause GDP for China at 5 per cent level of significance.

Table 4-11 *Granger Causality Test Results for India*

Dependent Variable	Independent variable	F-value	p-value	Causality
LEC	LEXP	1.6585	0.2087	No causality
	LGDP	4.4386	0.0446**	LGDP → LEC
LEXP	LEC	0.0814	0.7776	No causality
	LGDP	3.9737	0.0564*	LGDP → LEXP
LGDP	LEC	0.8358	0.3687	No causality
	LEXP	0.8804	0.3564	No causality

Note: lag order is 1.
: *,** and *** indicate statistical significance at 10%, 5% and 1% level, respectively

For India, from the result of the second equation, there existed a uni-directional causality running from GDP to energy consumption (p-value 0.0446), meaning that increase or growth in the economy of India may have been caused an increase in the level of energy consumption. Therefore, the Government of India can conduct energy saving policies without an adverse impact on economic growth. For the fourth equation, the causality test results showed unidirectional causality between GDP and exports (p-value 0.0564). This means that any increase in GDP would have a positive impact on the growth of exports. This result is possible that there are some industries are expanding quickly. It is unlikely that domestic market will rise as quickly as output from these industries. Therefore, these domestic producers will expand to foreign markets. Therefore, increased in production output are the causes of an increased in export. Also, higher output growth can stimulate investor to invest in these industries, part of which can be for increasing the capacity to export (Kemal et al., 2002). Moreover, Table 4-11 shows that at 10 percent critical value, the results of the causality test showed that exports does not cause energy consumption, energy consumption does not cause exports, energy consumption does not cause GDP, and exports does not cause GDP for India.

CHAPTER FIVE

CONCLUSIONS AND POLICY IMPLICATIONS

5.1 Conclusions

The aim of this study is to investigate the relationship between energy consumption, exports, and economic growth in a developing country like China and India and to suggest some policy implications for the futures studies. In the past three decades, there are a large number of literatures that examines the causality relationship between energy consumption, economic growth and exports. Most of this literature focuses on developing, developed and emerging countries. It is important for policymakers to understand the relationship between these variables in order to design effective policies.

This paper examined the relationship between energy consumption, exports, and GDP for China and India using annual data for the period 1980-2011. Time-series techniques such as unit root tests (ADF and PP tests), cointegration test (Johansen's procedure), and Granger causality tests were applied to test the causal relationship. Below is the summary of important findings of econometric analysis.

The unit roots test from the Augmented Dickey-Fuller (ADF) test and Phillips-Perron (PP) test indicate that all of the series is non-stationary in levels but integrated of the order one I(1) at first difference for both countries. Johansen and Juselius Cointegration test is used to determine the presence of a cointegrating vector in the variables. Both Trace and Maximum Eigen test for both countries indicate no cointegration at 5 percent level of significance pointing to the fact that the variables do not have a long-run relationship. For China, the results indicate the existence of a unidirectional causality running from energy consumption to exports so the growth of the energy consumption is cause of increase of the exports. Furthermore, the result indicates that there is unidirectional causality running from energy consumption to GDP, meaning that the massive consumption of energy may have stimulated the economic growth. However, there is no long-run equilibrium relationship between these variables. Our results are consistent with the findings of Wolde-Rufael (2004) and Wang et al. (2011) who found evidence of unidirectional causality between energy consumption and GDP for china.

Furthermore, the Granger Causality indicates the existence of a uni-directional causality running from GDP to energy consumption in India. An increase in economic growth stimulates a further increase in energy consumption in India. Model estimation results further confirm that economic growth plays a greater role in energy consumption. In a word, rapid economic growth in India will cause high energy consumption. The results are consistent with the findings of Pradhan (2010) who indicate that there is a uni-directional causality flowing from GDP to energy consumption in India. With the advances taking place in many Asian countries, economic growth is causing the industrial and commercial sectors where energy has been used as a primary input resource to expand. Hence, the expansion in GDP also increases the need for energy, which implies that production activities in the industrial sector such as construction, manufacturing and transportation require an energy supply.

Moreover, the Granger causality test indicates that there is a causal relationship running from GDP to exports. This means that any increase in GDP would have a positive impact on exports expansion. In other words, India provides an evidence to support the growth-led-exports over the sample period. This finding, thus, confirms the result of Ekanayake (1999), Pandey (2006), Pradhan (2007) and Mishra (2010); that any increase in GDP has promoted exports. Hence, policy maker should place more emphasis on higher economic growth to incite exports. After we tested the data, we do not find any causal relationship running from exports to energy consumption, GDP to export, energy consumption to GDP, GDP to energy consumption and exports to GDP for China. For India, there is no evidence of causality running from exports to energy consumption, energy consumption to exports, energy consumption to GDP and exports to GDP.

5.2 Policy Implications

Energy is among today important element in economic and social development (Abdulnasser and Manuchehr, 2005). Economic growth in India has depended mostly on energy. Our major result is that economic growth has increased energy consumption. There are several reasons why this has happened. For instance, economic growth has resulted in an expansion in the manufacturing sectors, in which energy is a basic input. As discussed in this paper, the manufacturing sector is a major consumer of energy. This has created concern that India doesn't have enough energy resources to maintain theirs economic growth. Therefore, there are number of previous studies suggested that energy conservation policies could reduce energy consumption in the industrial sector.

In the recent years, the consumption of energy in India increased extremely fast due to increase in population and economic growth. India's energy policy, since 1980s, was mainly based on availability of domestics' resources. Therefore, in the presence of uni-directional causality between GDP and energy consumption, energy conservation measures will not have negative impact on economic growth in India. Therefore, we conclude by suggesting that conservation policies could be implemented to find ways of reducing consumer demand in India, but such policies must be carefully made with continuous support and encouragement from the governments' side to develop energy-efficient technology that minimizes pollution. Investments in pipelines, railways, ports and power transmission are also needed to attract private sector investments and to enable efficient energy choices. Nowadays India's power sector has been suffering from the dual responsibility of the states and the federal government. In the absence of a single institution responsible for the energy sector, India has suffered from poor operational and difficulties in energy decision-making. Hence, the government of India must improve its decision-making process. Moreover, energy policies must be adjusted through reforming the tariff structure to meet with the energy demand and energy mix policies may be used to reduce the reliance on coal. The authorities should encourage the utilization of cleaner energy sources (sunlight, nuclear power, wind, natural gas, biofuel etc.) and improve energy-efficient technologies in order to alleviate the environmental problem. These include increasing public awareness by creating mass awareness of energy conservation topics via media and exhibitions.

Furthermore, we find evidence indicated that there is a positive relationship between energy consumption and exports and energy consumption and GDP in China. This finding is significant for a country like China which has current energy deficiency that would cause economic crisis. Energy should be fulfilled to the production sectors to support exports in terms of economic growth and trade balance. Hence, energy prices should be kept low with price and taxing policies. Since the foreign dependency in oil is very high, investments on alternative energy production should be improved as well. VAT reduction, tax incentives and R&D subsidies are form of government support in renewable energy investment. These would not only bring down China’s energy demand, but also would reduce GHG emissions.

Over the years the Chinese government has had a series of energy policies including the 11th Five-year Plan (2006), White paper on energy "China's Energy Conditions and Policies" (2007) and the Clean Development Mechanism (2009). More recently, under the 12th five-year plan on greenhouse emission control, implemented on March 2011. These plans focus on reducing carbon emissions and energy consumption, renewable energy, improve energy efficiency and developing clean energy. It is estimated that China’s carbon intensity could be mitigated by 17 percent and energy consumption intensity by GDP will also be reduced by 16 percent by following these policies. It is encouraging to see China not only focused on economic growth alone, but also on the need to deal with environment problem. We suggest that the government continue popularize clear coal technology, improve the power structure and diversify its energy supply by encourage the development of renewable energy and support for energy efficiency projects.

Moreover, the results of the empirical analysis conclude that there is no causal relationship between export and GDP in China. This result is inconsistent with Mah (2005) who found bi-directional causality between economic growth and exports. The best place to start explains this phenomenon is the 2001 global IT industry bubbles. The reason we use this event is that the events of 2001 represented the impact of an export fall down on the region. Not only this event was the single largest negative trade shock that Asia had experienced in the last 30 years, it was also spread across the entire world. And China was no exception. However, even though China’s export growth decreases from 27 percent in 2000 to 7 percent in 2001 but actual GDP performance was almost perfectly in line with expectations: large, domestically-oriented countries like China, India, Indonesia and Japan escaped with relatively little damage, while small export economies such as Hong Kong, Malaysia, Singapore and Taiwan swayed into sharp recession. Again, the Chinese economy did slow – but hardly, less than one percentage point (Anderson, 2007). This can implies that over the past decades China’s exports and trade performance have been very inconsistent, but overall GDP growth has been more stable. According to these data, Chinese economic growth is very domestic-led growth.

Another important result shows that economic growth has been instrumental in accelerating exports growth in India. There are several ways in which economic growth can have a positive effect on exports. For example, regarding to the Growth Led Export hypothesis, export development is set off through benefits of efficiency caused by increase in labor skill and technology advancement (Krugman, 1984 and Bhagwati 1988). In this model, economic growth allows a country to produce more varieties, and demand for a country's exports is directly tied to the number of varieties it produces.

Our result is different from the finding of Nidugala (2001), Sharma and Panagiotidis (2005), Raju and Kurien (2005), Dash (2009), and Pradhan (2010) who found evidence support export led growth hypothesis. The fact is that India’s economy is mostly dependent on its large domestic market with external trade accounting for only 20 per cent of the country’s GDP (Mishra, 2011). In 2011, India accounted for 1.67 per cent of world merchandise trade and 3.28 per cent of world commercial services export (WTO, 2012). This supports the finding that the trend in India is not exports led growth but rather growth-led exports. In 2008-09, global financial crisis in developed countries was the major contributors of economic slowdown in India. Due to this, India’s merchandise exports declined of 33.2 per cent in April 2009 as against an increase of

46.8 per cent registered in April 2008. This steep decrease was primarily due to demand decline faced by India’s major markets after global recession. The later part of 2009 to April 2010, there has been a remarkable rise in India’s exports. In April 2010, exports by India reported an increase by 30.4 per cent higher than the level in April 2009 (Department of Commerce of India, 2012). Recently it is further reported that India’s export increased by 36.24 per cent year-on-year basis in 2010. All these support the empirical evidence that the long-term trend may not be exports-led growth in India may not exist. On the basis of empirical results some policy implications are recommended.

First, in order to improve exports efficiency, the policy maker should liberal export policy by reducing barriers to trade in order to create a favorable business environment. Consequently, adjust trade and investment financing structure and improve the structure of export products like provide adequate credit to private sector is highly recommended. Improve export infrastructure is also needed to support export commodities distribution. Furthermore, policy maker should design and implement specific assistance and trade promotion efforts for services industry since service sector is an important part of India’s economy.

Secondly, in the past, India did not tap into its manufacturing exports potential to the fullest; therefore prioritizing technology-intensive manufactured exports commodities seems to be a good way to boost India exports performance since manufactured products such as chemical products, basic metals, general machinery and equipment, and electrical machinery are easier to trade and less price fluctuated than agricultural and mineral products. Furthermore, manufactured commodities will strengthen the competitiveness levels of aggregate exports by reducing the dependence on low value added primary commodities because the price of primary products tends to be highly volatile on world markets. Therefore, government should introduce special incentives to high value added manufactured industries. The incentives may be in the form of tax support, cash grant, full support for research, and development, and tariff reduction. Moreover, governments should establish a good regulatory and institutional framework to promote FDI by set up new special economic zone, offer tax holiday, and open a tax free exporting zone.

Thirdly, full efforts should be made to increase market diversification with the goal of expanding new market access. The strategies could be implemented in trade negotiation and promotion as parts of expansion toward potential markets. Government should actively advancing multilateral and bilateral negotiations with major emerging markets, such as Mexico, South Africa, and others, this include increased free trade agreement with those countries. Moreover, the government should provide assistance to exporters for exhibiting their products in various international exhibitions.

Lastly, the most important is that the Government of India and other policy makers should create economic policies that make the country's macro-economic fundamentals strong enough to survive from the external shocks created by a fast growth of economic and to ensure a noticeable rise in the country's exports. Policy maker should also sacrifice some resources that are not for export sector in order to increase exports.

Generally, it could be noted that there is existence of dynamic relationship existing among energy consumption, export and GDP. In modern industrial economies the connection between energy used directly in production processes and the total energy incorporated in final goods and services are often spread out over extensive supply chains. The differences in results between China and India appear to arise predominantly from differences between approached on the development process.

China has pursued a manufacturing-led growth strategy whereas India is less manufacturing intensive in its export business than China. India's service industry accounts for 57.2 percent of the country's GDP while the industrial and agricultural sectors contribute 28.6 percent and 14.6 percent respectively (Ministry of Finance of India, 2011).

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