NUCLEAR ENERGY CONSUMPTION AND ECONOMIC GROWTH: EVIDENCE FROM STATES LEVEL IN THE UNITED STATES

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ABSTRACT

NUCLEAR ENERGY CONSUMPTION AND ECONOMIC GROWTH: EVIDENCE FROM STATES LEVEL IN THE UNITED STATES

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This study attempts to investigate the causal relationship between nuclear energy consumption and economic growth in 10 selected states of the United States (US) from the period of 1970 to 2008. Tests for unit roots, cointegration, Granger causality and Variance Decomposition are presented. The main conclusion is that the causal relationship between nuclear energy consumption and economic growth is not uniform across states. There exists long run relationship between nuclear energy consumption and economic growth in California, Connecticut, Illinois, Michigan, New Jersey, New York and Washington. In the case of Michigan, there exists bidirectional causality between nuclear energy consumption and economic growth. This means that an increase in nuclear energy consumption directly affects economic growth and that economic growth also stimulates further nuclear energy consumption. The unidirectional causality runs from economic growth to nuclear energy consumption without any feedback effects in New Jersey, Pennsylvania and South Carolina, and from nuclear energy consumption to economic growth in Connecticut and Washington. However, no causality between nuclear energy consumption and economic growth will exist in California, Illinois, New York and Wisconsin.

ABSTRAK

PENGGUNAAN TENAGA NUKLEAR DAN PEMBANGGUNAN EKONOMI: BUKTI DARIPADA PERINGKAT NEGERI DI AMERIKA SYARIKAT

Oleh

Tan Chiang Ching

Kajian ini menyelidik hubungan antara penggunaan tenaga nuklear dengan pertumbuhan ekonomi ke atas 10 negeri dalam Amerika Syarikat dari tahun 1970 ke 2008. Pengujian untuk ujian kepegunan, ujian kopengamiran, ujian penyebab Granger dan ujian penguraian varians telah digunakan. Kesimpulan utama adalah hubungan antara penggunaan tenaga nuklear dan pertumbuhan ekonomi tidak seragam di negeri yang berbeza. Dalam kajian ini, hubungan jangka panjang antara penggunaan tenaga nuklear dan pertumbuhan ekonomi wujud di negeri California, Connecticut, Illinois, Michigan, New Jersey, New York dan Washington. Bagi kes Michigan, wujud hubungan dua hala antara penggunaan tenaga nuklear dan pertumbuhan ekonomi. Ini bererti peningkatan dalam penggunaan tenaga nuklear secara langsung akan mempengaruhi pertumbuhan ekonomi dan pertumbuhan ekonomi juga akan merangsang kepada peningkatan penggunaan tenaga nuklear. Hubungan satu hala dari pertumbuhan ekonomi ke penggunaan tenaga nuklear wujud di negeri-negeri seperti New Jersey, Pennsylvania dan Carolina Selatan, dan wujud hubungan dari penggunaan tenaga nuklear ke pertumbuhan ekonomi di negeri Connecticut dan Washington. Namun, bagi negeri-negeri seperti California, Illinois, New York dan Wisconsin, sebarang hubungan antara penggunaan tenaga nuklear dan pertumbuhan ekonomi tidak dikesan.

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CHAPTER ONE

INTRODUCTION

1.0 Introduction

According to Oxford Dictionaries (2010), energy is the power derived from the utilization of physical or chemical resources, especially to provide light and heat or to work machines. The electricity that we used in our home, office and more was properly generated by burning coal, nuclear reaction, or hydroelectric plant at a dam, which these are called energy sources. Energy sources can be categories into renewable, which is an energy source that can be easily replenished and non-renewable energy, which is an energy source that we are using up and cannot be recreate. Renewable energies are solar energy, wind, geothermal energy, biomass and hydropower whereas non-renewable are oil and petroleum products which includes gasoline, diesel fuel, heating oil and propane, natural gas, coal and nuclear (US Energy Information Administration (EIA), 2010a).

Energy is a crucial factor of production as well as key player in the production process (Stern, 2000). This is because energy can directly be used to manufacture a final product. In addition, Pokrovski (2003) also proposed that energy has been used as an external source to substitute for labour input in technological processes. He also stated that energy is used as a value creating production factor.

Meanwhile, according to Oxford Dictionaries (2010), nuclear energy is defined as the energy released during nuclear fission or fusion. According to World Nuclear Association, the main use of nuclear energy is to generate electricity which drives the turbine generators. This is simply a clean and efficient way of boiling water to make steam as the steam is clean, safe and cost competitive. A nuclear power station works most like coal or gas fired power stations, except for the reactor itself. Moreover, nuclear energy has environment advantages over fossil fuels because the nuclear power stations do not cause any pollution. Since there is abundance of uranium in the earth's crust, the fuel for nuclear power is unlimited unlike oil, coal and gas. Nowadays, many countries have built nuclear power plants not only to reduce dependence on imported oil but also to increase the supply of secured energy and also to minimize the price volatility associated with oil import (Rufael and Menyah, 2010).

1.1 History of Nuclear Energy in the United States[1]

Energy plays an essential role in an economy, so the relationship between energy consumption and economic growth is now well researched in the literature (Hou, 2009). In 1904, a British physicist, Ernest Rutherford found out that enormous energies could be release with controlled fission of heavy elements. This is the central insight for nuclear energy. By 1942, Enrico Fermi's group was the first self-sustaining to achieve the possibility to control chain reaction at the University of Chicago. During the World War II, this progress was postponed, but the theoretical foundation had been established. After World War II, there had several factors that encourage nuclear power's development.

By early 1950, nuclear power was critical to avoid energy dependence because both the United States (US) and Western Europe became net importers of crude oil. However in 1951, an experimental reactor sponsored by the US Atomic Energy Commission generated the first electricity from nuclear power. In 1956, the British completed the first operable commercial reactor at Calder Hall. A year later, the US Shipping Port unit were used based on power plants in nuclear submarines where after US built several demonstration plants in reactor manufactures and made commitments to build additional plants at fixed prices by cooperation with the US electric utility industry. These commitments would help launch commercial nuclear power in US. Between 1966 and 1974, successful in the demonstration plants and the growing awareness of US dependency on imported crude oil would force led to a

[1] Refer to US Energy Information Administration (EIA): History of Energy in the United States: 1635-2000 (Nuclear Energy), and Energy Kids, US Energy Information Administration (EIA): Energy Timeline: Nuclear.

wave of enthusiasm for nuclear electric power that sent orders for reactor units soaring.

The accident at the Three Mile Island Unit-2 (TMI-2) nuclear power plant near Middletown, Pennsylvania on March 1979 was the most serious in the US nuclear power plant industry's operating history. Equipment malfunctions, design related problems and human error led to a partial meltdown of the TMI-2 reactor core but only very minute releases of radioactivity. After the accident at Three Mile Island in 1979, US reinforced growing wariness in safety concerns of nuclear power. As the chief reason of its declining momentum in US was economic, there was a promise that nuclear electric power would have make energy "too cheap to meter". But, nuclear power plants have always been costly to build and led many units were forced to undertake costly design changes and equipment retrofits, partially as a result of the Three Mile Island accident. Meanwhile, US nuclear energy industry created the Institute of Nuclear Power Operations to address issues of safety and performance. Nuclear power plants have also had to compete with conventional coal or natural gas fired plants with declining operating costs. This directly affect the interest in the further orders subsided and many ordered units by nuclear power plants were cancelled before they were built and many ordered units cancelled in that time and many operable units had been shut down permanently. The joint effect of shutdowns and lack of new units coming on line is that the number of US operable units had fallen.

In year 1980 is the first time that nuclear energy generated more electricity than oil in US. Afterwards, the Nuclear Waste Policy Act of 1982 was signed to approving the development of a high level nuclear waste repository. For the moment, nuclear energy was generated more electricity than natural gas. In 1984, nuclear was replaced the hydropower as the second largest source of electricity in US and the largest source at that time is coal. Besides that, the Perry power plant in Ohio became the 100^{th} US nuclear power plant in operation by 1986.

The US nuclear industry dramatically improved its safety and operational performance was achieved as the US industry continued deregulation, begun with passage of the Energy Policy Act in 1992, which the Energy Policy Act 1992 reformed the licensing process for nuclear power plants. Changes accelerated after 1998, including mergers and acquisitions affecting the ownership and management of nuclear power plants. In year 2000, the Nuclear Regulatory Commission (NRC) issued the first ever license renewal to Calvert Cliffs Nuclear Power Plant at Constellation Energy to allowing an additional 20 years of operation. The NRC also approved a 20 years extension to the operating license to Oconee Nuclear Station, owner and operator by Duke Energy in South Carolina.

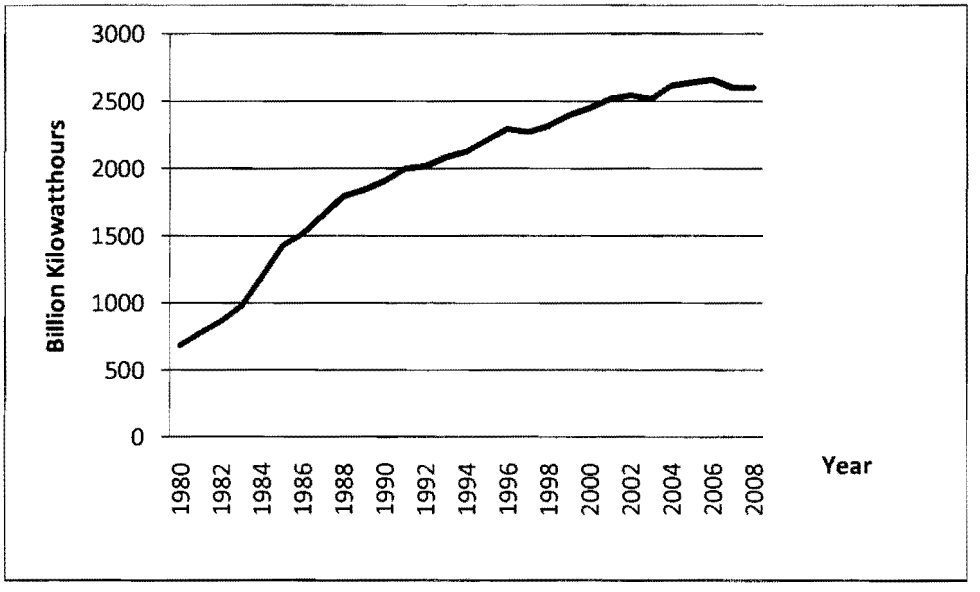
The Nuclear Power 2010 Program was developed in February 2002, which is a joint government or industry cost-shared effort to identify sites for new nuclear power plants, develop and bring to market advanced nuclear plant technologies, evaluate the business case for building new nuclear plant plants and demonstrate untested regulatory processes leading to an industry decision in the next few years to

seek NRC approval to build and operate at least one new advanced nuclear power plant in US. In August 8, 2005, President George W. Bush signed the Energy Policy Act 2005, which included measures to encourage the nuclear industry to built new power plants. A survey in US that done in 2006 found that a high level of support for nuclear energy among the public, with 68 percent favouring nuclear energy as one way to generate electricity and 49 percent stating a need to build more nuclear plants. In 2007, US contribute 31 percent shares of world nuclear electricity generation, which generated 8,458 trillion or 806 billion Kilowatt hours (KWh) energy consumption. In recent years, US had the largest contribution of the world nuclear electricity generation. Such as in 2007, US contribute most in the world nuclear electricity generation[2].

[2] Data of nuclear energy consumption come from US Energy Information Administration (EIA) (2010).

1.2 The Trend of Nuclear Energy Consumption in the United States

Figure 1: The World's Nuclear Energy Consumption, 1980-2008



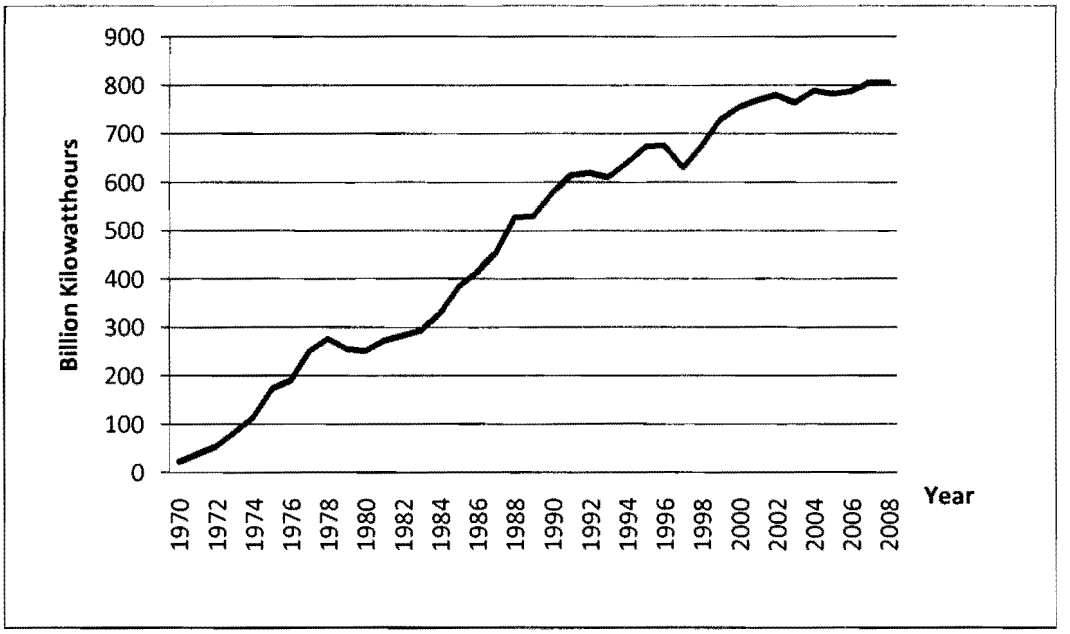
Source: International Energy Statistics, US Energy Information Administration (EIA), Various Issues.

Figure 1 above shows the trend of total world nuclear energy consumption (NEC) from 1980 to 2008. The NEC is measured in billion Kilowatt hours. Overall, the NEC of worldwide has been increasing rapidly by about 280 percent from 1980 to 2008. Besides that, according to International Energy Outlook, published by EIA (2010) the world market in nuclear power generation is projected to increase by 74 percent from 2007 to 2035.

Moreover, nuclear energy share of worldwide electricity generation has been increased from 3.3 percent in 1973 to 14.8 percent in 2006 while the oil share declined from 24.7 percent to 5.8 percent and there were no big changes in other

fuels such as coal and gas over the same period of time (International Energy Agency, 2009). Nuclear power plants are most attractive where energy demand growth is rapid, alternative resources are scarce, energy supply security is a priority, and nuclear power is important for reducing air pollution and greenhouse gas emissions (Yoo and Ku, 2009).

Figure 2: The Nuclear Energy Consumption in the United States, 1970-2008



Source: State Energy Data System, US Energy Information Administration (EIA), Various Issues.

Figure 2 present the trends of NEC in the US from 1970 to 2008. In general, the NEC in US has been increasing rapidly by about 3000 percent from 1970 to 2008. US is the country that contribute the most nuclear energy produced in the world at 2008, which is 30.7 percent of the world total (International Energy Agency, 2010). According to International Energy Agency, the nuclear power generated electricity

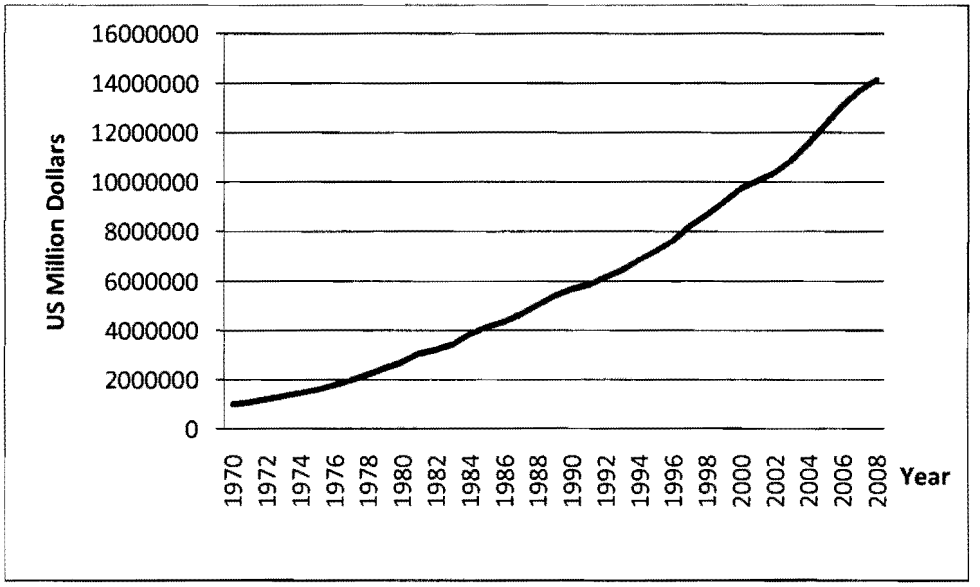
in US is 19 percent of the total production in 2008. In supply side, nuclear also contributed or share 9.6 percent of total primary energy supply in US at 2008.[3]

For the past decades, vast numbers of researchers and policy makers are interest in the relationship between energy resources and economic growth. Most of their studies conducted examined the relationship between energy consumption and economic growth (or GDP). Hence, the relationship between NEC and economic growth are certainly one of the relationships that researchers and policy makers would be interested as well.

[3] The share of total primary energy supply is excludes electricity trade.

1.3 The Trend of Gross Domestic Product in the United States

Figure 3: The Gross Domestic Product in the United States, 1970-2008



Source: International Financial Statistics, International Monetary Fund, Various Issues.

Figure 3 shows that the trends of total gross domestic product (GDP) in US from 1970 to 2008. Overall, the GDP had increase rapidly from 1970 to 2008. Based on the trends, the GDP had increase sharply to US $14,165,565 million in 2008 compared with US $1,011,966 million in 1970. It shows that the GDP in US rose up by about 1300 percent from 1970 to 2008. According to Ho and Siu (2006), a higher level of income and saving stimulates the consumption of durable goods such as vehicles and electricity appliances in household, and the economy becomes wealthier after transitioning into a service based on economy.

Masih and Masih (1996a) provide evidence that high economic growth tends to lead to high energy consumption and vice versa. By comparing Figure 2 and

Figure 3, both of the trends for NEC and GDP are increasing in general. It has proven that recently US is invested in nuclear and renewable energy to increase the supply of secure energy, to minimize the price volatility associated with oil imports and to reduce greenhouse gas emissions (Toth and Rogner, 2006; Vaillancourt *et al.*, 2008; Adamantiades and Kessides, 2009). Consequently, we suggest that increase in NEC is usually accompanied by an increasing in GDP, a point proved by Rufael and Menyah (2010).

1.4 Problem Statement

Since 1973 oil crisis, supply energy security has become a primary concern for many oil importing countries, such as the US, Japan, China and so on. This insecurity has made the search for alternative sources of cheap domestic energy supply to forces behind the energy policy among many energy importing countries (Toth and Rogner, 2006).

Nowadays, there is diversity of the energy sources, but they want to find a stable, safe and clean energy supply to become the main priorities of energy policy. Many believe that nuclear energy is one of the solutions to global warming and energy security, as a virtually carbon free source of energy (Ferguson, 2007). According to Apergis and Payne (2010), nuclear energy is an important energy source in the development of such long term energy and environmental strategies. Nuclear energy can address global energy needs in regions of the world where energy demand growth is rapid. Besides that, the environmental challenge that US and other imported energy dependent countries facing is how to produce more secure and cheap energy and how to reduce green house gas emissions.

Menyah and Rufael (2010a) believed that nuclear energy can provide some solutions to the problems of energy security. Presently, US is to invest in nuclear energy to reduce dependence on imported oil, increase supply of secure energy and to reduce green house gas emissions (Toth and Rogner, 2006; Vaillancourt *et al.*, 2008; Adamantiades and Kessides, 2009). According to International Energy

Agency (IEA) notes, nuclear energy is magnetizing new interest for increasing the diversity of energy supplies and energy security, and for providing a low-carbon alternative to fossil fuels (International Energy Agency, 2008). Nuclear energy has its own disadvantages such as, it can be used to create weapon, expulsing radiation that is very harmful for human body, damaging human body's cell and so on. Thus, proper management of nuclear energy are needed in order to prevent the harms it would bring.

Currently, nuclear energy consumption (NEC) is increasingly been used some state of US. For example, in New York City, nuclear energy consumption rose sharply to 43,209 million Kilowatt hours in 2008 compared with 4,273 million Kilowatt hours in 1970 (US EIA, 2010). The question arise that in the case where since NEC lead to US economic growth in state, then why US government would not implement NEC in each its state? As a part of energy security strategy, many countries have built nuclear power plants with the aim to reduce dependence on imported oil, increasing supply of secured energy and minimize price instability related with oil imports. Building nuclear power plant in US would need manpower or labour both to build as well as to operate it. This would increase in their incomes which consequently raise their purchasing power as well as standard of living. All of this leads to more consumption in US. In other words, building nuclear power plant would also increase government spending and reduce unemployment in US. With increase government spending and reduced unemployment, this would lead to GDP boost in US.

The overall findings of the most empirical studies show that there is a strong relationship between NEC and economic growth in many countries. For example, Schurr (1983) detected a positive relationship between nuclear energy abundance and economic growth, while Rufael and Menyah (2010) found that there has bidirectional relationship between economic growth and NEC in US. However, the relationship between economic growth (or GDP) and NEC in different states are unidentified. Is long run relationship between GDP and NEC in different states in US will exist? What is the causal relationship between GDP and NEC in different states?