Development, Growth, and Electricity in East Asia

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By

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Abstract

This paper examines the relationship between electricity consumption growth and GDP growth using an endogenous growth model. The countries of East Asia have industrialized in a remarkably short time. Some countries in the region have surpassed advanced industrials such as Australia and New Zealand as well as several European states in the value of their economies measured in GDP per capita. These countries have been able to adopt and tailor policies, institutions, market structure, and technology to suit the individual needs of their state. Electricity is necessary to many aspects of modern development. Lack access to cheap, reliable electricity will limit growth. The sample compares three classes of countries in the Pacific Rim referenced against the United States for GDP per capita, Electricity Consumption per capita, and Gross Capital Formation. By applying these components to an endogenous growth model to isolate the effects or implications of increasing electricity generation on GDP growth, this study looks at policy ramifications for the countries still lagging economically in the region as well as extrapolating the results to other under-developed nations. The study addresses historical trends, colonial and cold war legacies, economic and political institutions as well as the role of corruption involved in economic growth. The development of distributed generation and rural electrification programs seem to support overall economic activity and lessen the effects of strongly centralized economic infrastructure. Lastly, the deployment of renewable energy does not positively affect GDP growth from the findings of this study although the amount of data was limited and/or did not measure the relevant aspect. Reducing resource costs should have a positive affect of economic development as well as reducing the fixed capital costs of large scale energy generation by transitioning to smaller decentralized systems.
ACKNOWLEDGEMENT

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LIST OF ABBREVIATIONS

ADB -- ASIAN DEVELOPMENT BANK
AUD -- AUSTRALIAN DOLLARS
AUS -- AUSTRALIA
CHN -- PEOPLE’S REPUBLIC OF CHINA
CNY -- CHINESE YUAN
EC -- ELECTRICITY CONSUMPTION
EP -- ELECTRICITY PRODUCTION
GDP -- GROSS DOMESTIC PRODUCT
GCF -- GROSS CAPITAL FORMATION
HKG -- HONG KONG
HKD -- HONG KONG DOLLAR
IDN -- INDONESIA
IDR -- INDONESIAN RUPIAH
IEA -- INTERNATIONAL ENERGY AGENCY
IMF -- INTERNATIONAL MONETARY FUND
JPN -- JAPAN
JPY -- JAPANESE YEN
KOR -- REPUBLIC OF KOREA (SOUTH)
KRW -- KOREAN WON
kWh -- KILOWATT-HOUR
LDC -- LEAST DEVELOPED COUNTRY
LCU -- LOCAL CURRENCY UNIT
MYR -- MALAYSIA RINGGIT
MYS -- MALAYSIA
NZD -- NEW ZEALAND DOLLAR
NZL -- NEW ZEALAND
OECD -- ORGANIZATION OF ECONOMIC COOPERATION & DEVELOPMENT
PHL -- PHILIPPINES
PHP -- PHILIPPINE PESO
SGD -- SINGAPOREAN DOLLAR
SGP -- SINGAPORE
THA -- THAILAND
THB -- THAI BAHT
USA -- UNITED STATES OF AMERICA
USD -- UNITED STATES DOLLAR
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Chapter 1. Introduction

Electricity is often considered a prerequisite to industrialization and growth. However, it is unclear whether electrification is a condition or a result of growth. More than likely, growth in electrification and in overall electricity demand has a bidirectional relationship with economic growth. It is likely that the shift from other forms of energy (thermal heat, steam, human and animal labor, etc.) to electricity results in freeing up resource inputs for other productive activity enhancing overall growth. As the economy expands and more resources are available, financial assets are directed at the energy sector, to eliminate the binding constraint presented by insufficient energy generation capacity. Kim and Smith (1989) suggest that the energy sector has become a favored instrument of development policy, since electricity generation is viewed as a natural monopoly and therefore must be regulated. Governments are able to influence growth in the overall economy by investing in the energy sector or encouraging private investment by adjusting mechanisms such as pricing and rate of return.

This study addresses the role of electricity demand in Gross Domestic Product (GDP) growth. There is a strong correlation between growth in electricity demand and GDP growth over much the period 1971 – 2003. Political and economic events affect
the countries in cross-section differently over the period. The oil embargo of 1973 – 74 has greater impact on heavily dependent oil importing nations such as Japan and Hong Kong, rather than exporting nations such as Indonesia and Malaysia. By looking at the mix of political and economic institutions and their role in expanding (or retarding) electricity generation during the 32 years of this panel, one can formulate sound policies for those countries in the region that are lagging behind. The challenges presented by the rapid development of China and India must be addressed now while there is time to amend the lessons learned and institutions borrowed from abroad.

The countries of East Asia offer interesting lessons in development as some have transitioned into modern industrial states while others continue to languish. The region as a whole has experienced GDP growth in the later half of the 20th century of around 5% per annum (p.a.). This is significantly higher than the rates experienced in the US and Western Europe. What factors contributed to the successful transition or limited growth of the respective countries of the Pacific Rim? Countries such as Hong Kong, Singapore, Republic of Korea (South Korea), and Republic of China (Taiwan) have effectively transitioned to modern industrial nations with high GDP per capita, have sustained growth rates of approximately 7% p.a. for the last 30 years, and have stabilized population growth to approximately 1.7% p.a.. These countries have managed the transition in an amazing 30 years, with low population and high economic
growth. Why did these countries develop when initial pre-conditions were similar for most of the nations in the region? Why did Malaysia, Thailand, Indonesia and others in the region lag so far behind?

The level of growth experienced in the region is much higher than elsewhere in the world over this period. By comparing development in East Asia against advanced industrials, it is possible to extract lessons for use in policy implementation for developing nations. Technology, adapted policies, and borrowed institutions have played a major role in the accelerated level of GDP growth. The countries of the region, for the most part, underwent policies of population stabilization over the period, with the notable exception of the Philippines and Malaysia. Table 1 shows selected annual population growth rates where the populations of Malaysia and the Philippines have grown more than 4 times as fast as the population of Japan.

Population growth is one component of an endogenous growth model that determines

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<th>CHN</th>
<th>IDN</th>
<th>JPN</th>
<th>KOR</th>
<th>MYS</th>
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<tr>
<td>1971</td>
<td>1.33</td>
<td>1.81</td>
<td>0.59</td>
<td>1.20</td>
<td>2.46</td>
<td>2.37</td>
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</table>
the rate of growth experienced the macro economy. Yet, Malaysia and the Philippines have had very mixed results on growth, with Malaysia growing significantly better than the Philippines. This study will use Paul Romer’s endogenous growth model as a foundation for testing the role of electricity in overall GDP growth (Romer 1986).

By using electricity generation as a proxy for the technology variable, this study attempts to isolate some of the factors that have lead to the sustained high level of GDP growth and be able to extrapolate the findings and implications to development policy for least developed countries (LDC). Modern industrialization is made possible by increasing the level of productivity per unit of labor. By using substituting capital, in the form of electricity, for human labor and by increasing the general knowledge base, countries in the region have been able to increase productivity and expand operations into higher-value outputs such as textiles, light manufacture, computers, microchips, etc. Is it possible for the economic development seen in East Asia to be duplicated elsewhere or are the conditions unique to the region?

It is important to understand the mix of political and economic institutions in each country, so that these elements can be controlled for and the effect of technology on GDP growth can be teased out. Internal political instability, poor institutions, corruption, and international interference alter the conditions for each country involved. This study is primarily concerned with the uneven economic growth
performance of the capitalist nations in the region contrasted with the phenomenal economic growth of mainland China. The lack of reliable data for the communist countries of East Asia (Cambodia, Laos, Vietnam, and North Korea) has resulted in their omission from this study.

Modern industrialization is dependant on energy generation, principally electricity. Growth in electrification of the countryside and increased urbanization seem to correlate to increased GDP growth. Programs carried out in Taiwan and South Korea support the role of mass access to reliable energy as a precursor to reaching developed status. Currently, countries in South and Southeast Asia are constrained by their limited electricity infrastructure, depriving whole areas of India, Indonesia, Vietnam, and others, from realizing the full potential of their economic reforms and growth. Additionally, many of the smaller nations do not have access to internal supplies of fuel stock (coal, natural gas, or petroleum) and therefore must import the majority of their energy needs. Even in countries with fossil fuel resources (such as China, Indonesia, Malaysia, etc.) large quantities of processed fuel is still imported due to lack of local capacity to suitably refine the raw materials.

For the countries of this region that are still transitioning to developed status (Cambodia, Laos, Indonesia, Malaysia, Philippines, Thailand, and Vietnam), would the adoption of renewable energy generation enhance their economic growth? By
employing smaller, local systems these countries would be able to deploy new
generation capacity in a quicker, timelier, manner. Additionally, by using local
generation loss of electricity due to transmission and distribution would be reduced or
eliminated. Reducing the amount of imported feed stock would enable investment
decisions that add value to the domestic market by either the reduction of imports or
through the creation of higher value exports e.g. microchips instead of jute bags, or
both.

For both Indonesia and the Philippines, the large archipelagos over which they
control present unique challenges and opportunities. By decentralizing energy
generation capacity, the outer regions of these countries would be able to experience
some of the benefits currently enjoyed in the densely populated central regions of Java
in Indonesia and Luzon in the Philippines. In remote areas of Thailand, Malaysia,
Vietnam and elsewhere, renewable energy can be implemented in single or multi-
village systems taking advantage of local conditions and providing a platform for
development in these communities.

Electricity is a principal binding constraint for many developing countries. The
World Bank has consistently advocated for the use of coal in domestic markets. In
1982, the World Bank provide the Indonesian Government with USD 185 million to
build new coal thermal facilities with the expectation of Indonesia increasing oil
exports to support the world market (World Bank, 2001). Large scale infrastructure projects, useful and necessary when large urban populations are present but due to the cost and time involved in construction, are often not completed due to changes in political climate or rampant corruption.
Chapter 2. Historical Context of Region Economic Development

Growth in the region has been robust, but has produced uneven results across and within various countries. A brief history and understanding of the economic and political changes that have affected the region is necessary to comprehend the dramatic and robust growth experienced in the later half of the 20th Century. The mix of institutions, market structures, and colonial legacies set the foundation for individual nations to adapt and transform themselves into modern industrial nation-states. The Cold War alignment of nations in the region furthers the complexity of understanding why East Asia grew so rapidly compared to other regions of the world. One element this paper will look at the historic mix of institutions as well as the role of technology, specifically electrification, in predicting GDP growth.

Precursors to Robust Growth

From the beginning of the 19th century the countries of the world have diverged greatly in terms of material well-being, their abilities to seize the advantages of development and expand the wealth of their citizens. The countries of Western Europe

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1 For more information on the economic and political development of the countries in this study, please refer to the reference section found on page 42.
and its offshoots (notably the USA, Canada, Australia and New Zealand) accomplished the transition from traditional subsistence societies to modern industrial nations by the early part of the 20th century. The only non-European country to effectively modernize was Japan, which was able to adopt western institutions and policies and effectively reduce the time needed to industrialize to about 50 years.

Colonization up to the 1870s had been associated with the exploitation of a material resource (gold, iron, furs, etc.), the resettlement of population (either dissent or loyalist), and/or the expansion and monopolization of trading routes. This colonization pattern left much of Africa, most of Asia, most of the Pacific, and parts of southern South America unsettled or administratively incorporated into one of the European empires or into either the Chinese or Japanese sphere of influence. For the most part, the areas left unsettled where either heavily populated with limited trade goods desired by the Europeans, unpopulated with limited resources for extraction, or remote with highly adverse climatic conditions and diseases making them inaccessible to the Europeans.

Changes in European politics created the conditions for rapid acquisition of colonial territory for prestige rather than direct economic benefit. Vast swaths of heavily populated areas were incorporated into the European empires through a mixture of coercive economic and military means. At the same time, Japan began to
industrialize borrowing heavily from European and American institutions and technologies. To fuel its burgeoning industries Japan began trading extensively with the British, Dutch and French colonies of Southeast Asia. The changing world order and the pressures exerted during World War I, allowed many of the dependant colonies to agitate for more autonomy or even independence. Japanese industrialization was scene as a model to emulate.

Japan began to resent its place in the world order, controlled and dictated by the Europeans, and yet emulated European institutions by expanding its colonial holdings. After the Spanish-American War of 1898, Spain sold its remaining Pacific colonies to Germany. Japan fought wars of acquisition with China (1894-95) and Russia (1904-05) gaining control of the Korean peninsula, Taiwan, and part of Manchuria. Japan entered WWI on the side of the Allies and took possession of all German territory in the Pacific region (Qingdao in China, Bismarck, Caroline, Marinas, Marshall, and Bismarck Islands) and was formally granted a mandate by the League of Nations for the territories. Japan extended its control over much of eastern Asia before its ultimate defeat in 1945.

Japanese hegemony is, in part, responsible for the industrialization of the region. Japan invested heavily in infrastructure, physical plant, and training, principally in Korea and Taiwan. The post World War II period saw marked instability
in the region and the rise of Cold War Ideological lines. The Soviets seized control of
Outer Manchuria, Sakhalin, and Kuril Islands. Civil war developed in China between
the Communist Party under the leadership Mao Zedong and the Nationalist Party of
General Chiang Kai-shek. Mao defeated Kai-shek in 1949 establishing the People’s
Republic of China in 1949. Kai-shek fled to Taiwan and established the Nationalist
Party as the “true” government of the Republic of China.

French Indochina and Dutch East Indies erupted into wars of independence.
The Dutch East Indies declared independence in 1945 and fought a bloody guerrilla
war with the Dutch until 1949. Much of the infrastructure and physical plant built by
the Dutch and Japanese in the lead-up to WWII was now completely destroyed. In
September of 1945 Ho Chi Minh declared independence for the Democratic Republic
of Viet Nam; however, independence was short lived and crushed by British forces
after the Japanese surrender. Ho Chi Minh again fought French control declaring
independence in 1950 and decisively defeating the French in 1954. The country was
partitioned into a communist north and “free” south. Laos and Cambodia were both
granted independence in 1954 with the formal withdrawal of French claims to the
region.

The Korean peninsula was divided in 1945 to be held in trusteeship by the
United States and the Soviet Union. War erupted in 1950 when the communist north
supported by the victorious Chinese invaded the capitalist south. The conflict ended in stalemate in 1953 with the creation of the Democratic People’s Republic of Korea and The Republic of Korea. Similar to Indonesia, most of the Japanese infrastructure and physical capital was destroyed during WWII and the subsequent Korean War.

Following the conclusion of Spanish-American War 1898, Philippine revolutionaries engaged in guerilla warfare until 1913. The US formally granted the Philippines commonwealth status in 1935 with an eye to devolving more autonomy over time. The Japanese invasion of the islands in 1941 lead to massive destruction of infrastructure and degraded the military capabilities of the islands. The Philippines gained independence in 1946 continues to be undermined by ethnic and religious tensions that threaten stability. The Philippines was an important and wealthy colony under the Spanish and retains many of the institutions for control and extraction of wealth. Like much of the region, the country became embroiled in the political machinations of the two emergent superpowers.

The Kingdom of Siam (Thailand) adroitly played the British and French colonial interests against on another preserving its independence, although it lost territory to both France and Britain. Thailand adopted many European institutions during this period and looked at the rise of Japan for inspiration for its own development. Thailand sided with Japan during the war and came under US influence
in the emergent new order. The post-war period was marred by military intervention and paternalistic rule supporting capitalist institutions.

The last area of interest for this paper is the British colonial sphere of Australia, New Zealand, Malaya, British Borneo, and Hong Kong. Unlike the other colonial powers in the region, the British colonies of Australia and New Zealand had been granted commonwealth and dominion status respectively and were developing similarly to other European countries. Britain’s Asian colonies were severely damaged by the Japanese during WWII, for example, reducing Hong Kong’s population by an estimated 1 million. Hong Kong benefited from the relocation of population and assets from Shanghai and Guangzhou in the lead up to the Communist victory in 1949.

British Malaya was granted independence as the Malayan Union in 1946 within the British Commonwealth. Singapore was excluded from this union and became a crown colony. The terms of independence were unacceptable to the ethnic Malays and resulted in violence and the eventual dissolution of the country. In 1948, The Federation of Malaya was formed and included Singapore, Sabah, and Sarawak (the later two are located on the north coast of Borneo.) The Sultanate of Brunei initially intended joining the Federation but later withdrew due to concerns over oil revenue and the political powers of the sultan himself. The Federation was plagued with
violence and ethnic strife well into the 1960s. The Federation adopted the name Malaysia in 1963 and expelled Singapore from the union in 1965.

By the mid-1960s most of the colonial empires were dismantled, granting autonomy and independence to the colonial states. However, the institutions and the power elite in many instances were lacking in legitimacy resulting in weak state capacity, corruption, and the institutionalization of neo-patrimonial rent-seeking behaviors. Many of the resulting states were isolated, resource poor, and lacking in adequate infrastructure and legitimate institutions. Within this framework certain countries developed sound policies and institutions and have successfully managed the transition to modern industrial nations, others have stagnated and even failed.

Legacies of the Cold War

Ideological disputes shaped resource flows for much of the 20th century. In the first half of the century, economic development was geared towards resource extraction and later prestige of owning a colony. However, World War II destroyed much of the world’s capital stock and shattered many of the Jingo institutions imposed by the colonial powers. The second half of the century is shaped by the ideologies of the two great belligerents of the war: The United States and the Soviet Union. Reconstruction
efforts, independence movements, trade, and education were used to sway newly emerging nation-states into one or the other political camp.

After the Communist victory in China, Mao isolated the nation from the world. This ideology spread to neighboring countries as they looked to shake off the yoke of colonial oppression. The United States supported with both economic and military aid dictators that would ensure a suppression of communist ideology. The Soviet Union and China supported regimes that espoused Marxist rhetoric, however opportunistically, granting them technology, grants and subsidies, food, and military aid. The two superpowers divided the world leaving little space for non-aligned states.

Growth in the 60s and early 70s is most robust in the former colonies of Britain, Japan, and the United States. These states are strongly aligned to the US and received vast levels of economic and military assistance during this period. Japan dramatically rebuilt its economy under its new pacifist constitution, establishing new trading arrangements and improving over-all relations with its neighbors during this period. The region prospered under the robust growth of the Japanese economy; adopting many of the Japanese economic models and institutions.
Japan expanded its zaibatsu\(^2\) (horizontal monopoly) system of corporations (e.g. Mitsubishi, Sumitomo, etc.) by establishing joint-ventures and acquiring shares in foreign operations complimentary to existing operations (Beasley 1995). The zaibatsu model has been successfully exported to Korea, in such conglomerates as Samsung and Hyundai, and Taiwan, in such groups as Formosa Plastics and China Trust. These companies are able to internally smooth business cycles and are therefore more robust to external changes. However, the model lacks sufficient transparency and can be used to hide fiscal negligence or wrong doing.

In the British sphere of influence, large holding companies emerged in Hong Kong as it became the sole point of contact with Mainland China. Companies, such as Citic Pacific Ltd and Jardine Fleming,\(^3\) were able to capitalize on the dislocation of financial services from Shanghai and Guangzhou. The use of British law established a strong preference for private property and for transparent legal and judicial process to ensure that right (Shang-Jin 2000). Singapore and Hong Kong further capitalized on their size, location, and transparent legal process to attract investment and develop financial services insulated from political vagaries of neighboring countries.

\(^2\) Zaibatsu literally refers to large family-controlled banking and industrial groups of the Edo- and Meiji periods. The Zaibatsu were broken up after the end of World War II and the term has come to be associated with a large corporation with diversified holdings. They are not a monopoly or trust in the traditional sense, but are able to control most or all of the inputs necessary from start to finish of a product within related corporations. In Korea, the term used is Chaebol, and in Taiwan, Guanxi Qiy.

\(^3\) Subsidiary of Jardine Matheson created when firm moved to Bermuda prior to Hong Kong reverting back to Chinese sovereignty.
Other legacies of the Cold War period include tolerance for local strongmen and rampant corruption so long as the political ideology aligned with Western, principally, US views. Dictatorships or paternal autocratic leaders flourished in most of the region until the end of the 1980s and in some cases (Indonesia) the later 90s. Strong, transparent democratic institutions are relatively new to the region, although various forms and models have been employed throughout much of the 20th century. It was not until the mid-70s that anti-corruption and police reform appeared as useful tools to reduce leakages and rent-seeking activities. However, leaders in Indonesia, the Philippines, and Thailand, were not deterred by the changes occurring in Hong Kong and Singapore, which were viewed as fairly homogenous ethnic Chinese populations that have developed under British law. Strong military and/or single party rule allowed many at the top to prosper, but diminished the overall growth of the country’s economic development.

Leaders such as President Suharto of Indonesia and President Marcos of the Philippines promoted pro-business development by normalizing rent-seeking activities through effective enforcement and publicly acknowledged levels of acceptable bribes (MacIntyre, 2003). As a result, Indonesia and the Philippines both experienced extraordinary rates of economic growth during the late 60s and throughout the 1970s. Investors were attracted to the security of knowing the true cost of business.
opportunities in the respective countries. After Marcos was forced to resign in 1986, the Philippines’ economy declined from its peak in 1982 of USD 1000 per capita and did not again reach this level until 2002.

There are many reasons for the divergent results in the region. This study is principally interested in the role of technology and the rate at which large scale infrastructure is implemented and deployed. The type of corruption experienced in the Philippines under Marcos or Indonesia under Suharto, allowed business development to occur regardless of rent-seeking on the part of government officials. After the removal of these leaders, the cost of corruption hinders the further growth. Political and economic instability seem to inform both the investment decisions of private individuals as well as governments. Establishing credible signals to investors seems to be critical in leveraging the necessary capital to expand necessary infrastructure (McLeod, 2004). Without credible signals or sound fundamentals capital will not be available for use in development.

The use of official development assistance to offer private institutions the sense of credibility is only useful in so much as local governments are able to demonstrate their ability to exercise state capacity. As the fall of Suharto has illustrated, weak state institutions are not able in and of themselves to demonstrate a credible investment environment. The austerity of International Monetary Fund (IMF) programs coupled
with reforms implemented by the central bank have been insufficient to restore Indonesia to pre-Asian Financial Crisis (1997-1998) levels of growth (Drakeley 2005). State capacity and effective enforcement are necessary conditions for the deployment of large-scale energy systems.

GDP per capita growth rates for Japan, Hong Kong, and South Korea over the period 1961 – 1979 are shown in figure 1. The three countries exhibit very strong annual growth over the period. Hong Kong experienced large scale rioting in 1966-67 in part due to pro-communist sentiment in support of China’s Cultural Revolution leading to lower than expected growth. The Organization of Arab Petroleum Exporting Countries’ oil embargo of 1973 resulted in a sharp cut in growth and resulted in prolonged recovery for Japan throughout the rest of the decade. However, average growth over the period was quite robust Hong Kong (HKG), Japan (JPN), and South Korea (KOR) at 6.9%, 6.6%, 6.0% respectively.
Japan’s heavy dependence on imported oil for its energy needs exposed grave weaknesses in its development strategy. The reduced output of the Japanese economy throughout the 70s and early 80s lead to slower growth in the region as a whole than would otherwise have been the case. That being said, growth in East Asia remained robust throughout the period.
Chapter 3. Economic Indicators & Data

The East Asian region has experienced robust growth in both GDP and in electricity demand over the last 40 plus years. I compiled data from Asian Development Bank (ADB), Organization of Economic Cooperation and Development (OECD), International Energy Agency (IEA), and/or World Bank on 12 countries Australia, People’s Republic of China (China), Hong Kong, Japan, Indonesia, Malaysia, New Zealand, the Philippines, Singapore, Thailand, and the USA] for the period 1971 – 2003.\(^4\) Australia, New Zealand, and the United States are included due to their strong presence in terms of aid, military presence, and trade with the region, as well as providing a reference as to level of development of the other countries. The data compare countries at various states of development. There are three main groups: Advanced Industrials, Newly Industrialized, and Developing. Advanced Industrials contain Australia, Japan, New Zealand, and the USA. Newly Industrialized contains Hong Kong, Singapore, and South Korea. Developing Countries contain China, Indonesia, Malaysia, the Philippines, and Thailand. Due to China’s size and unique conditions it was removed from Developing Countries and given its own dummy

\(^4\) Additional data has been used where available for the period 1960 – 2005 to further elucidate trends or explain relationships.
variable. Lastly due to the size and magnitude of the US economy it was also addressed separately in certain models and used as the reference group.

There are four broad groups of variables: Electricity, Capital, GDP, and Population. The electricity variables measure production (actual output), consumption (actual used), annual growth in both production and consumption, percent of production by fuel source, renewable electricity production, tradition electricity production (fossil fuels & nuclear), annual growth of both renewable and traditional production, and transmission and distribution losses measured as a percent of output. The capital variables measure gross capital formation as a percent of GDP, gross capital formation in the local currency unit (constant 2000 LCU), and annual growth of gross capital formation. The GDP variables measure GDP in Current US dollars, Constant 2000 USD, and Constant 2000 local currency unit, annual growth, as well as natural log transformation of GDP. Finally, the last group of variables, Population, measure total population, annual population growth, urban population as a percent of total population, and annual urban population growth. Population has additionally been used to calculate electricity output and use per capita and GDP per capita. All growth variables are either obtained directly from one of the above sources or are constructed from previous year data.
For illustration, the following table shows the growth achieved in the newly industrialized countries of Hong Kong, Singapore, and South Korea compared to Australia, Japan, New Zealand, and the United States from 1961 to 2005. South Korea, Singapore and Hong Kong have achieved extraordinary results over the period with average annual growth of 5.80%, 5.55%, and 5.14% respectively. Cumulative results represent an almost eleven-fold increase in South Korea’s GDP per capita achieved in a mere 44 years. By comparison the United States grew its economy at an annual rate of 2.25% over the same period with an increase of 1.6 times that of the 1961 level.

Table 2.

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<th>GDP per capita (constant 2000 LCU)$^5$</th>
<th>GDP per capita (2005 USD)$^6$</th>
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<tr>
<td></td>
<td>AUD</td>
<td>HKD</td>
</tr>
<tr>
<td>1961</td>
<td>15019</td>
<td>26709</td>
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<tr>
<td>2005</td>
<td>38675</td>
<td>233306</td>
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</tbody>
</table>

Figures 2 - 10 exhibit the elasticities for GDP, electricity consumption per capita, and population growth for each of the three groups of countries over the period 1972 – 2003.

$^5$ Local Currency Units are: AUD = Australian Dollar, HKD = Hong Kong Dollar, JPY = Japanese Yen, KRW = Korean Won, NZD = New Zealand Dollar, SGD = Singaporean Dollar, and USD = United States Dollar.

$^6$ Exchange rate used is the average daily interbank rate for the period 1/1/2005 to 12/31/2005 obtained Oanda Corporation.
Advanced Industrials

Figure 2 – 4 shows the Advanced Industrials, where it is easy to see the limited growth of Japan after the collapse of its financial markets in the early 1990s, where as Australia and the United States have enjoyed fairly strong growth from the mid 80s to the end of the period. New Zealand, on the other hand, has strong growth occurring in the final third of the period. The following charts have been scaled to illustrate relative slope although the unit of measure is not the same.
Figure 3.
Electricity Consumption per capita (kWh)
Figure 5 – 7 illustrate the newly industrialized countries relationships. Again it is easy to see the Asian Financial crisis as well as the robust growth in GDP and electricity consumption. Population growth is more mixed but generally steady for the group although Malaysia is somewhat higher.
Figure 5
GDP LCU 2000 Constant

[Graph showing the GDP LCU 2000 Constant for various currencies over time.]
Figure 6
Electricity Consumption per capita (kWh)
Developing Countries

Figures 8 – 10 exhibit the slopes of the developing countries in the study. The scaling alters some of the intuitiveness of viewing the slopes due to China’s size and magnitude. However, it is easy to see the take off of the Chinese economy in mid-80s and also the relative flatness of the Philippines’ economy. The increase in electricity use per capita shows a shift away from more traditions modes of production.
Figure 8
GDP LCU 2000 Constant
Figure 9
Electricity Consumption per capita (kWh)
Table 3 shows the average annual growth of each country for GDP, Population, and Electricity Consumption.

<table>
<thead>
<tr>
<th>Country</th>
<th>Average Annual Growth Rate (%)</th>
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<tr>
<td></td>
<td>GDP</td>
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<tr>
<td>Australia</td>
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<td>Japan</td>
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<tr>
<td>Philippines</td>
<td>3.54</td>
</tr>
<tr>
<td>Thailand</td>
<td>6.37</td>
</tr>
</tbody>
</table>
Many countries in the region do not have access to or have diminishing natural reserves of fossil fuels. As exhibited by Japan’s exposure to imported oil during the 1973 oil embargo, long term economic growth is predicated on sustainable supplies of feed stock to convert to energy. Continued growth in the region is called into question by the dependence of many of the nations on oil as the primary input for electricity generation. Additional concerns are raised due to unprecedented damage to the local environment and growing awareness of the residents as to the trade offs between development and quality of life. Table 4 shows the average annual growth in renewable and traditional energy supply for each country in the cross section.

Table 4.

<table>
<thead>
<tr>
<th></th>
<th>AUS</th>
<th>CHN</th>
<th>HKG</th>
<th>IDN</th>
<th>JPN</th>
<th>KOR</th>
<th>MYS</th>
<th>NZL</th>
<th>PHL</th>
<th>SGP</th>
<th>THA</th>
<th>USA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Renewable Energy</td>
<td>1.61</td>
<td>1.66</td>
<td>2.35</td>
<td>2.10</td>
<td>0.00</td>
<td>9.32</td>
<td>3.51</td>
<td>7.51</td>
<td>9.01</td>
<td>7.72</td>
<td>9.69</td>
<td>10.64</td>
</tr>
<tr>
<td>Traditional Energy</td>
<td>5.28</td>
<td>3.69</td>
<td>14.12</td>
<td>3.03</td>
<td>6.24</td>
<td>12.07</td>
<td>8.43</td>
<td>8.94</td>
<td>16.32</td>
<td>10.95</td>
<td>5.56</td>
<td>12.33</td>
</tr>
</tbody>
</table>

For the most part, renewable energy seems to be the concern of the wealthier nations with the exception of the Philippines.
Chapter 4. Methodology & Model

As mentioned earlier in this paper, this study used a modified endogenous growth model to examine the role of electricity in GDP growth. In looking at GDP Growth as a function of Electricity Production (EP) and growth of capital stock there are several factors that must be considered. GDP growth and EP growth are not unidirectional in effect. Increasing GDP may increase EP or vice versa. Therefore, calculating simultaneous equations to tease out the partial effects of the independent variables may be useful. This can be accomplished by using a two-stage least squares regression model. Due to the nature of the sample which consists of 12 countries over 32 years, country specific effects must be accounted. A comparison of both a fixed effects and first difference were used to control for this effect by removing time invariant data from the model. Considering an endogenous growth model where increased growth rate is a function of technology, capital stock, and population growth, the basic model is as follows:

\[ \text{GDP} = \beta_0 + \beta_1 \text{EP} + \beta_2 \text{Population} + \beta_3 \text{Gross Capital Formation} + \varepsilon \]
Where EP is used as a measure of technology, there are several problems with the limited model above such as omitted variable bias resulting in the independent variables being correlated with the error term and the presence of simultaneous relationships between the dependant and independent variables. Additional problems arise, in that the true variable of interest is maximum electricity generating capacity, as electricity production does not capture the binding constraint due lack of infrastructure. Data was not available for enough of the cross section to be included. Therefore, the model specified uses electricity production as a partial proxy for predicting growth.

\[
\text{GDP Growth} = \beta_0 + \beta_1 \text{EP Growth} + \beta_3 \text{Population Growth} + \beta_4 \text{Gross Capital Formation Growth} + \varepsilon
\]

\[
\text{EP Growth} = \beta_0 + \beta_1 \text{Electricity Consumption} + \beta_3 \text{Population Growth} + \beta_4 \text{Urbanization Growth} + \varepsilon
\]

To better understand the role of technology and its implementation on GDP growth I suggest looking at the following model:
GDP Growth = β₀ + β₃ Population Growth + β₅ Urbanization Growth + β₂₀ EP Growth_{traditional} + β₂¹ EP Growth_{renewable} + β₄ Gross Capital Formation + e

Regression Results

The cross sectional time series data compiled, when run through a two-stage least square regression to control for bi-directional effects between GDP Growth and Electricity Production, shows that although the model fit is very good (adj-R²=0.61, F=151.05), electricity production is insignificant. Due to the nature of the data compiled, electricity production (actual output) and electricity consumption (actual use) predict one another very well, but do not predict demand. Therefore, to adjust for this problem, the fixed effects model attempted to capture the effects of demand (electricity consumption) on GDP growth as the original hypotheses needed to be rejected. The new model was expressed as follows:

GDP Growth = β₀ + β₁ EP Growth + β₃ Population Growth + β₄ Gross Capital Formation Growth + β₅ Urbanization Growth + e
The Two-way fixed effect model produced stronger results yet the variable of interest remains insignificant. This model produced highly significant results for the following countries compared to the United States: China, Hong Kong, South Korea, Malaysia, Singapore, and Thailand. The years 1973, 1987, and 1998 also produced highly significant results compared with 2003. As to the variables contained in the model, only Gross Capital Formation proved highly significant. As noted above, the primary variable of interest is likely not different than zero. Table 5 shows the parameter estimates for the regression.

<table>
<thead>
<tr>
<th>Table 5.</th>
<th>Fit Statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td>SSE</td>
<td>1406.716</td>
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<tr>
<td>MSE</td>
<td>4.1742</td>
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<tr>
<td>DFE</td>
<td>337</td>
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<tr>
<td>Root MSE</td>
<td>2.0431</td>
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<tr>
<td>R-Square</td>
<td>0.7783</td>
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<table>
<thead>
<tr>
<th>F Test for No Fixed Effects</th>
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<tbody>
<tr>
<td>Num DF</td>
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<tr>
<td>42</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Parameter Estimates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable</td>
</tr>
<tr>
<td>Australia</td>
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<tr>
<td>China</td>
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<tr>
<td>Hong Kong</td>
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<tr>
<td>Indonesia</td>
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<tr>
<td>Japan</td>
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<td>South Korea</td>
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<td>Malaysia</td>
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<td>New Zealand</td>
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<td>Philippines</td>
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<td>Year</td>
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<td>2001</td>
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<tr>
<td>2002</td>
</tr>
<tr>
<td>Intercept</td>
</tr>
</tbody>
</table>

| Electric power consumption (annual % growth) | -0.03 | 0.03 | -1.22 | 0.22 |
### Table 1: Key Economic Indicators

<table>
<thead>
<tr>
<th></th>
<th>Value 1</th>
<th>Value 2</th>
<th>Value 3</th>
<th>Value 4</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gross capital formation (annual % growth)</strong></td>
<td>0.20</td>
<td>0.01</td>
<td>20.18</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td><strong>Population growth (annual %)</strong></td>
<td>-0.14</td>
<td>0.21</td>
<td>-0.65</td>
<td>0.52</td>
</tr>
<tr>
<td><strong>Urban population growth (annual %)</strong></td>
<td>0.28</td>
<td>0.19</td>
<td>1.48</td>
<td>0.14</td>
</tr>
</tbody>
</table>

The model specification utilizing renewable and traditional electricity generation resulted in rejecting the null hypothesis. These tests fail to address the underlying concerns about electricity being a binding constraint and do not take into account the accrual of human knowledge. Further study, with appropriate data, may establish a causal relationship between GDP growth and Electricity Generation capacity.
Chapter 5. Conclusion

This study failed to establish a causal link between electricity production (or consumption) and GDP Growth in the Pacific Rim. However, the multiple regressions did point to the high significance of gross capital formation in the role of GDP growth. Capital formation, capital controls, access to financial markets, rent-seeking and corruption are common themes in the development literature. By isolating specific elements of economic growth, those in the development community or appropriate governments can craft policies that enhance, stimulate, or curtail these specific actions. The Asia-Pacific region offers many lessons in the role of institutions, transparency, and strong state capacity. Much of the development in the region has occurred in spite of intervention and show that there is a separation between political and economic institutions.

The regression models do suggest that urbanization does play some role in GPD growth. The more developed countries in the sample have high degrees of urbanization. This allows them to develop infrastructure that would otherwise prove to be cost-prohibitive. These countries have an opportunity to invest in necessary infrastructure due to the large amount of foreign direct investment, official development aid, and domestic investment provide to the region. The costs of late
development may be off-set by newer technologies resulting in more effective growth. Such innovations as wireless phones, the internet, distributed generation, combined heat and power, renewable energy, among others lessen the amount of initial capital and/or operational expenses.

For island nations such as the Indonesia and the Philippines, where traditional fixed line telephones and electricity distribution grids are costly to establish and maintain, new technologies present vital opportunities to make capital more effective. Future costs associated with climate change, development, environmental degradation, among others, will impact decision by the power elite, while at the same time facilitating greater material well-being. Lesson must be drawn from those countries that were able to transition from traditional to modern economies in the post-colonial world. Electrification allows for the substitution of human labor for mechanical labor, or more specifically the substitution of capital for labor. It would seem that in countries where labor is plenty and cheap the cost to employ capital will be high. Additional barriers to capital utilization also exist in the form of small capital markets, high rents, poorly define property rights, and corruption. However, the region as a whole has high savings rates, high GDP growth and low population growth. Policies need to be established that enhance domestic business opportunities and reduce the barriers to effective capital utilization.
References


http://www.adb.org/Documents/CERs/VIE/

http://www.adb.org/Documents/Books/Key_Indicators/1999/default.asp

http://www.adb.org/Documents/Books/Key_Indicators/2000/default.asp

http://www.adb.org/Documents/Books/Key_Indicators/2001/default.asp


World Bank. 2001. Independent Evaluation Group, Operation Evaluation Department, Coal for Power Generation,