DYNAMIC LINKS BETWEEN INSTITUTIONS, INNOVATION AND ECONOMIC GROWTH

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FACULTY OF ECONOMICS AND ADMINISTRATION
UNIVERSITY OF MALAYA
KUALA LUMPUR

2019

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THESIS SUBMITTED IN FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY/ECONOMICS

FACULTY OF ECONOMICS AND ADMINISTRATION
UNIVERSITY OF MALAYA
KUALA LUMPUR

2019

UNIVERSITY OF MALAYA

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Matric No: EHA130007

Name of Degree: Doctor of Philosophy

Title of Thesis: "DYNAMIC LINKS BETWEEN INSTITUTIONS, INNOVATION AND ECONOMIC GROWTH"

Field of Study: Development Economics

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ABSTRACT

The thesis aims to investigate the dynamic links between institutions, innovation and economic growth. Innovation and institutional indices are constructed using nineteen indicators to test three main objectives at different income levels using definition from the World Bank. First is the causality direction between the variables; second, its short-run and long-run relationship and finally, the moderator role of institutions in enhancing the effectiveness of innovation activity on economic growth. The Toda-Yamamoto (1995) causality test shows that innovation and economic growth have a bidirectional relationship in High-Income Countries (HICs), but the same is not true for the Middle-Income Countries (MICs) and Low-Income Countries (LICs). Similarly, institutions and economic growth are found to have a unidirectional impact in the HICs running from institutions to economic growth. However, in the MICs and LICs, only institutional sub-indices show significant causal relationship. In MICs, the political institution tracks a two-way relationship with economic growth while in LICs, only the social institution influences economic growth. The thesis further investigates the short-run and long-run impacts by using the panel Autoregressive Distributed Lags (ARDL) Pooled Mean Group (PMG) estimator at different income level. For all income levels, in the short run, the impact of innovation and institutions on economic growth are generally insignificant. However, the impact on growth in the long run appears to be mostly significant. This suggests that the impact of institutions and innovation can only be realized in the long run. Innovation input is significant to economic growth for all income level. However, similar to causality, innovation index appears to be more beneficial to the HICs due to "founder effects" in the long run, whereas in MICs and LICs, only innovation input (not innovation output) is positively significant to economic growth. In other words, impact

from innovation output may not be adequate to generate additional economic growth in MICs and LICs. It also suggests that MICs and LICs are still in the learning curve operating below the frontier technologies of the more advanced countries. As for the impact of institutions on economic growth, the relationship depends on the types of institution sub-indices and income level. For example, political institution drives economic growth in MICs but the same reduces economic growth in HICs. This relationship appears to be stronger when the role of institutions is moderated. The strengthening of political freedom enhances the impact of innovation activity on economic growth in MICs, but the reverse happens in the HICs. Given that the thesis finds different directional effect based on the income level, the empirical evidence is consistent with Barro's (1996) argument on a non-linear relationship between political institution and economic growth. As for policy recommendation, this thesis suggests that policy makers consider income level and types of institutions in formulating growth policies.

Keywords: Institutions, Innovation, Economic Growth, Income Level.

ABSTRAK

Tesis ini bertujuan untuk menyiasat hubungan dinamik di antara institusi, inovasi dan pertumbuhan ekonomi. Indeks inovasi dan institusi dihasilkan dengan menggunakan sembilan belas indikator untuk menguji tiga objektif utama di tahap pendapatan yang berbeza. Pertama, arah kausalitas antara pembolehubah; Kedua, hubungan jangka pendek dan jangka panjang dan akhirnya peranan institusi sebagai pengantara dalam meningkatkan keberkesanan aktiviti inovasi terhadap pertumbuhan ekonomi. Ujian kausal Toda-Yamamoto (1995) memperlihatkan bahawa inovasi dan pertumbuhan ekonomi mempunyai hubungan dua hala di Negara Berpendapatan Tinggi (HIC), tetapi hubungan yang sama tidak signifikan untuk Negara Berpendapatan Sederhana (MIC) dan Negara Berpendapatan Rendah (LIC) di mana tiada arah kausaliti yang ketara dapat dilihat di dalam ekonomi ini. Begitu juga dengan hubungan antara institusi dan pertumbuhan ekonomi. Hubungan kausaliti hanya signifikan di HIC dimana institusi mempengaruhi pertumbuhan ekonomi. Walau bagaimanapun, di negara MIC dan LIC, hanya sub-indeks institusi menunjukkan hubungan kausal yang signifikan. Dalam MIC, institusi politik mempengaruhi hubungan dua hala dengan pertumbuhan ekonomi manakala di LIC hanya institusi sosial mempengaruhi pertumbuhan ekonomi. Tesis ini selanjutnya menyiasat kesan jangka pendek dan jangka panjang dengan menggunakan kaedah Autoregressive Distributed Lags (ARDL) Estimated Pooled Mean Group (PMG). Bagi semua tahap pembangunan, di dalam jangka pendek, impak inovasi dan institusi keatas pertumbuhan ekonomi pada umumnya tidak signifikan. Walau bagaimanapun, hubugan jangka panjang antara innovasi dan institusi ke atas pertumbuhan ekonomi adalah sangat penting. Impak dari institusi dan inovasi hanya dapat direalisasikan dalam jangka panjang. Input inovasi signifikan untuk pertumbuhan ekonomi di semua tahap pembangunan. Namun demikian, indeks inovasi lebih benefisiari terhadap negara HIC kerana "kesan pengasas" dalam jangka masa panjang, sedangkan di MIC dan LICs, hanya

input inovasi (bukan output inovasi) yang mempengaruhi untuk pertumbuhan ekonomi. Dengan kata lain, impak daripada output inovasi mungkin tidak mencukupi untuk menjana pertumbuhan ekonomi tambahan di MIC dan LIC. Kajian ini juga mencadangkan bahawa MIC dan LICs masih dalam lekapan pembelajaran yang beroperasi di bawah teknologi sempadan negara-negara yang lebih maju. Bagi impak institusi pertumbuhan ekonomi, ia dipengaruhi oleh jenis institusi dan peringkat pembangunan. Misalnya, institusi ekonomi mendorong pertumbuhan ekonomi di HIC dan LIC, manakala institusi politik mengurangkan pertumbuhan ekonomi dalam HIC. Hubungan ini kelihatan lebih kuat apabila diperiksa peranan institusi dalam analisis pengantara. Peningkatan dalam kebebasan politik meningkatkan kesan aktiviti inovasi kepada pertumbuhan ekonomi di MIC, tetapi sebaliknya berlaku di HIC. Pertemuan ini adalah selaras dengan bukti empirikal yang dihasilkan oleh Barro (1996) di mana hubungan nonliniar antara institusi politik dan pertumbuhan ekonomi di sepanjang peringkat pembangunan. Bagi penggubal polisi, tesis ini mencadangkan agar mereka mempertimbang tahap pendapatan dan jenis institusi dalam merangka dasar pertumbuhan negara.

Keywords: Institutsi, Innovasi, Pertumbuhan ekonomi, Tahap Pembangunan

ACKNOWLEDGEMENTS

I would like to express sincere gratitude to my two supervisors, Professor Dr Rajah Rasiah and Assoc. Professor Dr VGR Chandran for their continuous support and belief in me in completing the thesis. In the course of doing this thesis, they not only inspired me but also guided and shared their immense knowledge and experiences with me. I am both proud and honoured to have them as supervisors, considering that both of them are leading scholars in the areas of institutions and innovation economics. Both these eminent scholars have contributed greatly to the extant literatures in innovation and institutions, and I would like to humbly believe that I have done the same in this thesis.

Sincere thanks to my organization, Valuecap Sdn Bhd for their encouragement and support. Being a full-time employee and a PhD candidate at the same time has not been easy and proven a challenge. Nevertheless, I am grateful for the support and encouragement given by the organization, especially the CEO, Pn. Sharifatu Laila Binti Syed Ali, which has enabled me to rise up to the challenge. I also would like to express my gratitude to the Board of Valuecap for granting me sabbatical leave, which has allowed me to complete my thesis within the given time frame.

I also would like to take the opportunity to thank my friends and colleagues for their moral support and encouragement, especially Azleen Osman Rani who has greatly encouraged me to complete the thesis. And my thanks to Sarpanes, Sharizan, Zulfadhlee, Aaina, Aslam, David and the MFMA team for their motivation and assistance. Finally, I would like to thank my beloved parents, siblings and in-laws for their support and blessings. Most of all, to my loving wife, Kalaivani and children, Yessothraa, Bhavatharni and Taran - thank you so much for your encouragement, support, love and understanding.

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LIST OF SYMBOLS AND ABBREVIATIONS

ADF	:	Augmented Dickey-Fuller
ARDL	:	Autoregressive Distributed Lags
DF	:	Dickey-Fuller
DH	:	Dumistrsu-Hurlin
ECM	:	Error Correction Model
ECO	:	Economic Institution Index
EM	:	Expectation Maximization
GDP	:	Gross Domestic Product
GII	:	Global Innovation Index
GNI	:	Gross National Income
HICs	:	High-Income Countries
HNC	:	Homogenous non-Causality
HQ	:	Hannan-Quinn Information Criterion
INS	:	Institutions Index
INV	:	Innovation Index
INVIN	:	Innovation Input Index
INVOUT	:	Innovation Output Index
IP	:	Imputation-Posterior
IPR	:	Intellectual Property Right
LICs	:	Low-Income Countries
LR	:	Long-run
MAR	:	Missing at Random
MI	:	Multiple Imputation

MICs	:	Medium-Income Countries
MWALD	:	Modified Wald Test
NIS	:	National Innovation System
OECD	:	Organisation for Economic Cooperation and Development
OLS	:	Ordinary Least Square
PMG	:	Pooled Mean Group
POL	:	Political Institution Index
PPP	:	Purchasing Power Parity
R&D	:	Research and Development
SDR	:	Special Drawing Rights
SIC	:	Schwarz Info Criterion
SOC	:	Social Institution Index
SR	:	Short-run
TFP	:	Total Factor Productivity
TM	:	Toda Yamamoto
US	:	United States
VAR	:	Vector Autoregression
WIPO	:	World Intellectual Property Organisation

CHAPTER 1: **INTRODUCTION**

1.1 Background

Growth theory has a long history from the time of Adam Smith to the period of the neoclassical and more recently, the evolutionary scholars. The factors explaining growth too have evolved from focusing merely on physical factors such as labour and capital to other forms of complex factors including institutions and innovation. In this thesis, we will focus on the role of institutions and innovation in promoting economic growth. Although these two factors are not new in the growth literature, the understanding of dynamic link between these complex factors and economic growth in my view remains ambiguous. Therefore, further research is required to address the gaps.

In the past, scholars mostly ignored causal relationship as the empirical research on institutions and innovation was conducted using cross-sectional data. Given the availability of panel data more recently, it is timely to review the dynamic link between institutions, innovation and economic growth at different income level. Without completely understanding the link between these factors, past research on growth theory could have missed necessary information in constructing the growth framework.

Economic scholars have been working over the years on growth theory to identify the factors promoting convergence of per capita income between the under-developed economies and developed economies. Despite all these efforts, the global economy remains divided, and past evidence shows that long-term convergence rate is rather slow and has been discontinued (Barro & Sala-i-Martin, 1990; Mankiw et al., 1995; Martin &

Sunley, 1998). Furthermore, it is clearly articulated in Figure 1.1 that the income gap between the high-income economies and under-developed economies diverges rather than converges over the years. In reality, the actual condition of per capita income growth is opposite to what the scholars envisaged in the past.

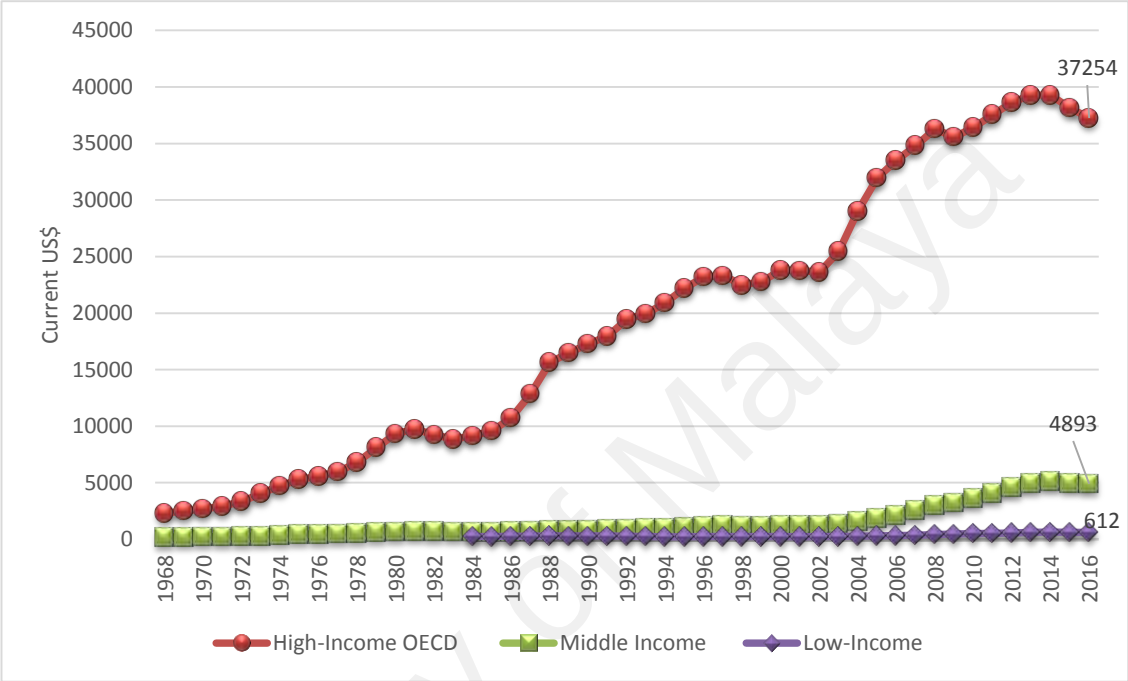


Figure 1.1: Gross National Income Per Capita (in Current USD Atlas Method)

Source: World Bank (2017)

The neoclassical growth theory argues that growth rate is inversely related to per-capita income assuming diminishing returns to capital. Based on this theory, the rate of convergence should be faster if the economy is poorer. However, the reality has proven otherwise. Rich countries remain wealthy while the poor are trapped in a vicious poverty cycle. The neo-Keynesian and neo-classical argue that under-developed economies fail to grow faster due to lower saving rates compared to the high-income countries (HICs). Even that argument has been proven wrong as depicted in Figure 1.2, where the saving rates in the Middle-Income countries (MICs) are higher than in the HICs, but the convergence between HICs and MICs does not seem to happen. Ragnar (1952) has an

interesting argument where he claims that a country is poor just because it is poor. Using the Young (1928) interpretation on market size, Ragnar argues that small market size inhibits capital productivity, hence keeping developing countries poorer.

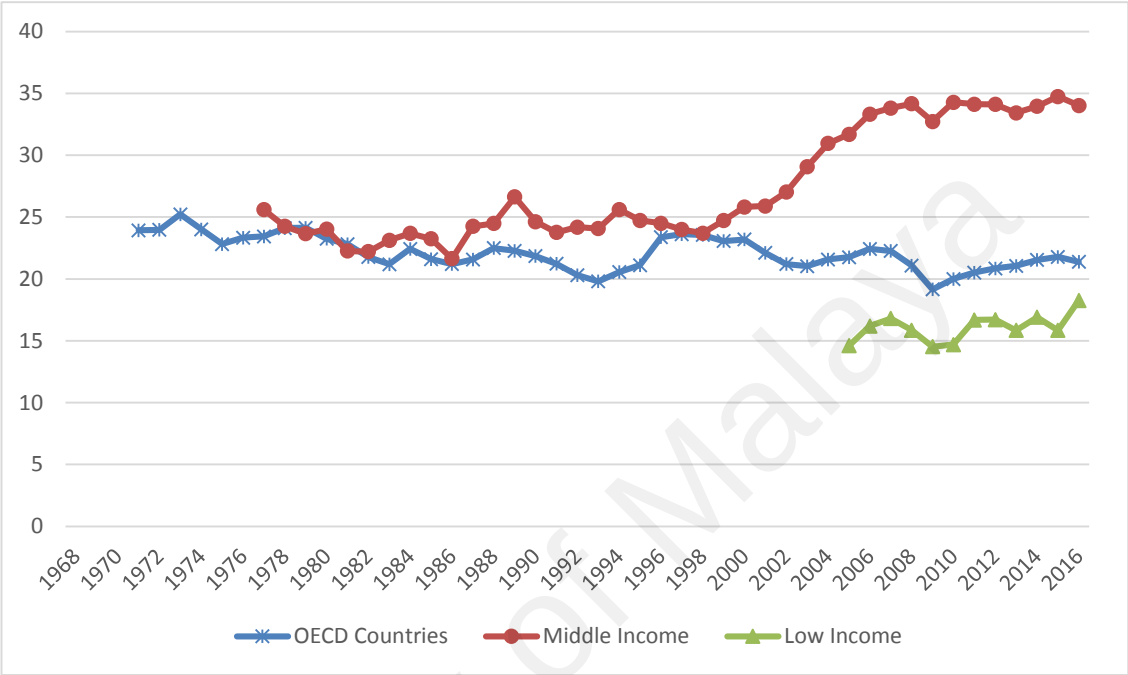


Figure 1.2: Gross Saving Rate (percentage of GNI)

Source: World Bank (2017)

Meanwhile, Barro (1991) finds that the convergence hypothesis is inconsistent with the cross-country evidence, which suggests no correlation between the growth rate and the initial level of per capita income. Instead, higher initial schooling, better institutions, lower population growth, price stability and ability to export are the major factors in enhancing the growth rate.

As the convergence growth theory loses its popularity, the alternative literature contributed by the evolutionary economics has revitalised the interest of economic scholars in revisiting the growth theory. The evolutionary economics emphasise on the role of institutions and innovation in influencing economic growth (Nelson and Winter,

1982; Dosi, 1988; Dosi & Nelson, 1994; Lall & Teubal, 1998; Lundvall et al., 2002). This literature has gained traction and attempted to provide a new perspective to explain the speed of growth convergence at the national level despite it still not being considered as mainstream economics.

Even after scholars have used various methodologies and multiple factors to explain growth differences, the debate over the growth convergence continues, considering that the real economy remains diverged rather than converged between the income level. Specifically, the role of institutions and innovation in promoting economic growth looks promising but it is not without its critics. For example, institutional scholars promote democratization but countries such as Korea and Singapore experienced sturdy growth during a period of authoritarian regime. Likewise, between democratic India and communist China, the economic progress is much stronger in China than in India. Hence, given the abstract concept of institutions and innovation, it is important to identify which sub-indices of institutions and innovation promote economic growth and if the relationship is universally observed in all different income level.

In my view, the inadequate understanding on how the dynamic links between institutions, innovation and economic growth function could explain why scholars may have failed to discover the so-called "policy panacea," which allows growth to converge. This condition suggests that further study is needed to close the gaps of the existing growth theory and it provides a new perspective to the existing literature. Nonetheless, it should be acknowledged that this thesis does not aim to produce policy panacea to address the convergence issues, instead the thesis intends to explore the true relationship between institutions, innovation and economic growth at different income level.

Past literatures mostly focused on unidirectional relationship between innovation and growth and the institutions and growth (Scherer, 1986; Grossman & Helpman,1990; North, 1991; Easterly and Levine, 1997; Cameron, 1996; Rosenberg, 2004; Rodrik et al., 2004; Acemoglu et al., 2005; Uppenberg, 2009). However, the importance of causality is often ignored in these studies (Archibugi & Pianta, 1995; Chang, 2011). Indeed, growth literature seldom takes into consideration the complexity that arises from causality between institutions, innovation and the economic growth. Secondly, past literature also often ignores income level as an important criterion when studying the growth factors.

Therefore, this thesis aims to fill these gaps and contributes to the extant literature. The thesis also attempts to robustly re-examine the relationship between economic growth, institutions and innovation by incorporating the direction of causality and the income levels to assess these linkages. As mentioned earlier, this thesis may not produce a policy panacea, but it seeks to provide a different perspective on the growth theory. The focus is in understanding how institutions and innovation influence economic growth while examining the complexity arising from causality between these factors if there is any. Besides that, the study also aims at examining the causal direction at various levels of income to ascertain how the relationship holds true when levels of income are taken into consideration.

This chapter attempts to provide the background and motivation of the study by examining the progress of the growth theories and setting the stage to investigate the dynamic links between institutions, innovation and economic growth. The chapter further outlines the specific objectives, scope and limitations of the study. The final section in the chapter highlights the significance of the study to the policy makers and economic

scholars as the thesis aims to advance the existing knowledge and contribute to the extant literature in growth theory.

1.2 Revisiting the Growth Theory

Growth theory has evolved from using a simple Cobb-Douglas production function to a more complex model. The evolution is supported by improvements in understanding the factors that drove growth. Smith (2012) emphasises the importance of production to create the "wealth of a nation". Economic growth depends on the ability to increase the scale of production by concentrating on the specialisation of economic activities. However, Young (1928) rebuts Smith's claim on specialisation by using the reverse causality argument and establishing the idea of "increasing returns" whereby economies of scale are needed to enable specialisation in the economy.

During the post-Keynesian period (Harrod, 1939; Domar, 1946), "Harrod-Domar model" and Neoclassical (Solow, 1956; Swan, 1956) "Solow-Swan model" have been the primary models developed to measure the growth convergence rate. Both models apply a mathematical approach derived from the Cobb-Douglas production function to calculate the speed of convergence. The growth of an economy is determined by the ability to accumulate labour and capital, while the speed of convergence is subjected to the initial conditions of the capital-labour ratio. An economy with a smaller capital to labour ratio is expected to converge faster when the economy increases its capital spending.

However, the Abramovitz (1956) landmark study on the historical growth rate of the United States (US) disagrees with this finding. The historical evidence suggests that stronger growth in the US was only partially explained by capital accumulation while

other elements attributed to growth were unknown. This finding justifies the need to develop "The New Growth model" by Solow (1956) that defines the unknown factor as technical change. The Solow model picks up the residual as technical change, which explains the role of technology in the economy. However, the model treats technology as exogenous to the economy. Hence, factors promoting technological capabilities are omitted. The inability to explain the technical change is criticised by Schmookler (1962) as ignorant and an inadequate interest in finding the facts.

Since the neoclassical model has its limitation, scholars continue to search for the unknown using various other variables and methodologies that could explain the growth convergence between nations. Romer (1986) and Lucas (1990) extend the neoclassical growth model by explaining the source of the technological change. Romer (1990) argues that an extensive stock of human capital and direct subsidies undertaking research and development (R&D) in an open economy would speed up the growth rate of the economy. The study also highlights that a low level of human capital attributes to slower growth as observed in the under-developed economy.

Although the endogenous growth theory has revived scholars' interest to study long-term growth, the contribution is mostly concentrated in the expansion of the existing neoclassical framework and still fails to explain growth pattern over the long run (Pack, 1994). Meanwhile, Aghion and Howwit (2007) study the long-run growth using a hybrid model that combines capital accumulation and productivity growth. The results show that neoclassical theory can explain between 30 and 70 percent of output per worker growth in OECD countries. However, in the long run, economic growth is entirely caused by the Schumpeterian's notion of technological progress.

In contrast to the neoclassical growth theory, the evolutionary scholars often isolate themselves from using the production function, citing weaknesses in neoclassical assumptions that contradict the actual condition in the real economy. Instead of focusing on the production function, the evolutionary scholars have adapted a learning-based model to explain economic growth and the convergence rate. The model is influenced by the Schumpeterian business cycle theory, which emphasises on the role of institutions in supporting and facilitating learning and innovation activities in an economy (Nelson, 2008).

1.3 Institutions, Innovation and Economic Growth

The failure of capital accumulation model alone to explain the long-run economic growth has led to a proliferation of new ideas incorporated into the growth theory. Gerschenkron (1962) and Schmookler (1966) stress that technological change and the use of new knowledge are more important contributors to income per capita rather than capital accumulation. Technological accumulation and diffusion of new technology are vital elements to promote innovation activities. Indeed, the role of innovation has become one of the most crucial instruments in determining economic growth.

Innovation is defined as *"an implementation of a new or significantly improved product (good and service), or process, a new marketing method, or a new organizational method in business practices, workplace organization or external relations" (*OECD, 2005, p.146). In this regard, innovation is expressed in three forms, i.e. product innovation, process innovation and organisational innovation.

The ideology of innovation theory is mostly developed based on the Schumpeterian works of "creative destruction" in Mark I and "creative accumulation" in Mark II (Breschi et al., 2000; Malerba, 2002; Rasiah, 2007). In both these volumes, Schumpeter emphasises the importance of innovation, which is embedded in the entrepreneurs (Mark I) and organisations (Mark II) in driving the business cycle.

Meanwhile, the evolutionary scholars emphasise innovation as a process of economic development with technological learning at its heart (Lall, 2000). For them, the role of knowledge accumulation through a learning process is more pertinent than the accumulation of physical capital. Therefore, in the evolutionary perspective, the speed of convergence in an economy depends on the ability of the economy to learn and catch up against the advanced economies, which are at the frontier of the technological trajectory (Bell & Pavitt, 1997).

The challenge for a latecomer is to learn and do things in a new way that breaks from the circular flow of economic activity (Nelson, 2008). The catching up that is needed does not necessarily have to be radical and revolutionary, but even the cumulative impact of an incremental innovation does matter in contributing to long-term economic growth and social changes (Lundvall, 1992).

Moreover, the evolutionary model also believes that invention is not the only source of innovation. Instead, using the latecomers' model, Kim (1997), Hobday (2000) and Rasiah and Lin (2005) have recognised the role of creative imitation as part of the innovation process. At the beginning of the learning stages, firms tend to adopt new technologies through imitation and later apply changes and produce a new product or process to the market. The imitation model apparently works in the East Asian "Newly

Industrialised Economies" mainly in Taiwan and Korea. The imitation model helps these economies to leapfrog from being technological users (imitators) to becoming technological producers (innovators).

Furthermore, the imitation-based growth model has also enabled income per capita to grow faster in Korea and Taiwan allowing them to progress from the status of least developed country to high-income economy in a shorter span of time. Nonetheless, the imitation model has its own limitation. Even though a technological shift via adaptation of imitation enhances growth by promoting neck-to-neck competition, Aghion and Howitt (2000) however, find that too much imitation could also unambiguously lead to a reduction in growth.

Besides innovation, the evolutionary economics also emphasise the role of institutions as a pillar to support growth convergence. The failure of under-developed economies to converge is mostly attributed to the lack of quality institutions (North, 1990; Anon et al., 2018). Institutions have two significant roles in development economics: the first is to drive changes in society and the second is to facilitate the role of the market by increasing efficiency and reducing transaction cost.

1.4 Problem Statement

The growth theory has evolved in the past, from a mere expansion of the neoclassical framework to more complex alternative approaches, using the evolutionary and neo-Schumpeterian frameworks (Fagerberg, 1994; Aghion & Howitt, 2007). With these new developments, the policy recommendation goes beyond the standard prescription of

capital accumulation. The current development policies focus more on accumulations of innovation and institutional capabilities rather than capital accumulation.

Nonetheless, the existing growth literature remains stranded with limitations within each framework. The neoclassical framework provides a strong theoretical and technical background and is still widely used in the mainstream economics. However, the assumptions used in the neoclassical theory are too simplistic and out of touch with reality. It has also failed to explain the historical economic growth (Nelson & Winter, 1982; Lall & Teubal, 1998). In contrast, the alternative approaches such as evolutionary and neo-Schumpeterian frameworks are promising but often suffer from complexity and are criticised as technically, a less rigorous method.

The National Innovation System (NIS) framework provides a theoretical background to explain the nexus between institutions, innovation and growth, but the technical support of this framework is still lacking (Lundvall, 1992). The empirical evidence by the dominant discourse on evolutionary framework is mostly produced using cross-sectional evidence (Fagerberg & Srholec, 2008; Nelson, 2008; Chang, 2011). The lack of panel data that covers a range of quantitative and qualitative variables limits the empirical study in this area. Moreover, the evolutionary scholars also believe that macro-level explanation using ineffectual assumptions to fulfil the requirement of the mathematical model does not add value to policymaking (Lall & Teubal, 1998; Nelson, 2008).

Meanwhile, the discourse on institutions and economic growth endures theoretical problems as it often neglects the causality running from economic development to institutions (Chang, 2011). While the interest to study the impact of innovation and institutions on economic growth is growing, the research on the causality between these

variables is mostly ignored. Without identifying the causation, the likelihood of producing erroneous policy recommendations is higher. For example, development policies in the under-developed economies are mostly driven by experience from the advanced nations without understanding Ragnar's argument whereby a country can be poor simply because it is poor. The path dependence policy strategy may not work if the policymakers fail to incorporate the uniqueness of the individual economy. The unveiling of a causal effect improves policy recommendations especially by targeting factors that produce increasing returns to the economy. When a factor which is recommended relishes increasing return, the convergence from low income to high income is likely to be faster.

The mainstream research has accepted the role of innovation in driving the economic growth. Nonetheless, efforts in conducting empirical testing and finding the causal direction between the factors remain limited albeit scholars from various schools of thought highlighting the importance in recognising this relationship. Archibugi and Michie (1995) stress that although past research tends to ignore causality in their empirical study, many of these scholars did acknowledge the two-way processes, i.e. innovation fosters growth and reciprocally growth induces innovation. Indeed, there is enough evidence to suggest that institutions and innovation are likely to be influenced by higher per capita income. For example, Lipset (1960) shows that institutional quality improves when income rises and not vice versa. Society tends to demand higher quality institutions and social changes, including the need for democratisation as income begins to rise (Barro, 1996). Therefore, simply assuming that institutions drive economic growth may lead to erroneous policy recommendations.

Meanwhile, the levels of income are expected to have a bearing on the effectiveness of institutions and outcome of innovation activity. Peretto (1999) urges the expensive in-

house manufacturing sector R&D to be more viable in the high-income economies and not in under-developed economies because of the availability of incentives for systematic R&D efforts. The under-developed economies suffer from low R&D expenditure due to higher transaction cost and higher probability of market failure. The lack of incentive discourages the firms in under-developed economies to engage on R&D activities.

The demand factors that explain innovation and institutions are often missing in the mainstream economic arguments. Thus, innovation capabilities and institutional changes driven by the size of the market remain unanswered. Policy decisions are primarily concentrated on supply-side dynamic without understanding the importance of the market size and the effective demands of society. Nonetheless, the evolutionary scholars emphasise the need to understand both the demand and supply side of the economy. Lundvall (1992) highlights the balance approach between demand and supply which is essential in building institutions and innovation capability framework.

The institutional strength and innovation capability are expected to increase efficiency and reduce long-term average costs and allow the economy to operate in economies of scale. Even though there is no doubt that the supply-side dynamic is the centre for increasing national output, the question remains whether per capita income matters in influencing the institutional strength and innovation capabilities. This argument goes back to Young (1928) on the role of market size and economic efficiency. Per capita income reflects an effective demand on the economy and the bigger the size of the market, the bigger the increase in the ability of the economy to invest on institutions and innovation drivers. This may explain why the under-developed economies have failed to have the same level of innovation and institutional capabilities as the developed economies.

Past studies have confirmed that institutional strength and innovation capabilities are stronger in high-income economies, but severely lacking in the under-developed economies (Aubert, 2005; Guloglu & Tekin, 2012; Anokhin & Wincent, 2012). The inability to expand the economic growth by merely acquiring capital and the availability of human capital has encouraged the advanced economies to build institutional strength and innovation capabilities. In contrast, budget constraints and weak governance have restricted the Government to incentivise innovation activities and provide effective institutions in the under-developed economies (Mahagaonkar, 2010). Chang (2011) argues that even if the Government in the under-developed countries can enact a law similar to the advanced economies, the implementation of such laws remains challenging without a capable enforcement team.

The need to understand the direction of causality is an important task even before seeking to establish the long-run and short-run relationship. Only after the causality is established (if there is any) using a quantitative framework will the study then determine the long-run and short-run relationships between institutions, innovation and growth. In the presence of causality, the standard Ordinary Least Square (OLS) model is inappropriate, considering the model is likely to underestimate the parameters (Gujarati, 2009). The OLS estimator is inconsistent to estimate the coefficient of the neoclassical growth framework (Vogelvang, 2005). Taking alternative methods in replacement with the OLS strengthen the technical literature in the growth theory framework which is lacking thus far.

Meanwhile, the incorporation of the income level in the policy recommendation does matter if causality direction is significantly distinguished by the level of income. We

believe that the heterogeneity nature within the various income levels must be considered in the empirical examination. Hence, the econometrics testing conducted in this thesis segregated sample based on income levels as defined by the World Bank Atlas method. It reduces the problem associated with heterogeneity in the sample and provide a more practical recommendation for a cross-country study. Indeed, in estimating the long-run effect, the issue of non-linearity can be handled by splitting the sample based on the income levels.

Most empirical studies in the past are conducted using a single variable as a proxy to innovation, i.e. patent, human capital, R&D expenditure (Mansfield, 1986; Khan & Sokoloff 1993; Archibugi & Pianta, 1996; Gallini, 2002; Chandran & Wong, 2011; Moser, 2013). Each variable has its limitation as to why it does not adequately represent the innovation activity and institutional strength. Therefore, in this thesis, we have developed an index using multiple indicators to capture the broader definition of innovation and institutions. Unlike the limitations in the past, various international organisations have begun to compile a range of large panel data which could explain institutions and innovation on a broader definition rather than a single proxy. It allows us to solve the researchable issues, which is the main reason for the lack of causality study in the past.

1.5 Research Questions

The study on dynamic links between institutions, innovation and economic growth remain scarce. The unidirectional relationship between innovation to growth and institutions to growth has been explored extensively in the past. However, the discourse on causality is somewhat still lacking in the growth literature. The reasons for establishing

the causality direction have been discussed briefly as mentioned in this chapter. Further arguments to justify the need for causality study between institutions and innovation with growth are presented in the entire thesis.

The following are some interesting and necessary questions to reveal the fundamental roles of institutions and innovation in economic development, particularly in per capita income growth. Indeed, this is required to deepen our understanding of the link between institutions, innovation and economic growth along the income trajectory.

1. How do institutions, innovation and economic growth progress at different income level?
2. What is the causality direction between innovation and growth as well as institutions and growth at a different income level?
3. Is there any relationship between institutions, innovation and the economic growth in the short and long run at a different income level?
4. Do institutions play a moderating role in enhancing the impact of innovation activity on economic growth across the different income level?

1.6 Research Objectives

The objective of this thesis is to explore the dynamic links between innovation, institutions and the economic growth. Besides that, the thesis also seeks to establish if the dynamics of innovation and institutions on economic growth relationship differs between income levels.

Specifically, the study sets the following objectives:

1. To examine the progress of institutions, innovation and economic growth at a different income level.
2. To examine the presence of causality direction between innovation and growth as well as institutions and growth at a different income level.
3. To assess the short-run and long run relationship between institutions, innovation and economic growth at a different income level.
4. To assess the role of institutions as a moderator in enhancing the impact of innovation activity on economic growth.

1.7 Significance of the Study

This study seeks to contribute to the existing body of knowledge specifically on the theory of growth and broadly to development economics. Limited empirical research is available with regards to examining the systematic relationship between institutions and innovation with economic growth at different income levels. Moreover, the discourse on growth convergence has been mostly conducted separately through the nexus of growth-innovation and growth-institutions. In fact, limited empirical cross-country analysis conducted in the past systematically studies the causal relationship between institutions, innovation and economic growth along the income levels.

Research on institutions and innovation in a growth framework is mostly conducted using cross-sectional data. The lack of cross-country time series makes the feasibility of the research in the area to be limited and increasingly difficult and costly (Rasiah, 2005).

However, with the cross-sectional data, scholars in the past have failed to establish the causal relationship, which is fundamental in establishing the real dynamic of growth convergence.

The major challenges when conducting an empirical study on institutions and innovation is to fulfil the definition and present it in an empirical framework. Most common observations from past empirical studies have shown that a very narrowly defined or a single proxy has been used to represent institutions and innovation in the growth framework. The incomplete representation is a reflection of using an individual proxy and not representing the overall concept of institutions and innovation. The construct of institutions and innovation index will allow the capturing of a more broader definition of both factors, hence allowing it to be more represented. The new index developed for this thesis should address the weaknesses of the past research in using a single proxy. In addition, the index also captures the different types of institutions i.e. economic, political and social. It is important to distinguish the type of institutions to provide a targeted policy recommendation across different income levels. The index is also comparable across countries.

The empirical finding is presented by segregating the cross-country sample based on the income levels to produce a robust policy recommendation. The development scholars suggest that cross-country data should be subjected to heterogeneous behaviour and therefore, the analysis should control the heterogeneity by clustering the sample according to the income level. The elimination of heterogeneity is crucial to capture the dynamics between countries in the different levels of income, which will influence the policy outcome. Furthermore, policy failure in the under-developed economies often attributes to “one-size-fits-all” policy recommendation which has failed to appreciate the

local dynamics, including the socio-politics and cultural ignorance (Stiglitz, 1998) (Tucker, 1996). Therefore, by differentiating the samples, this thesis aims to control the heterogeneity problem and produce a robust policy outcome.

The core contribution of this thesis is to produce empirical evidence that captures the systematic relationship between institutions, innovation and economic growth between the income levels. There are three empirical findings that the thesis has produced, i.e. testing for causality direction, examining the short-run and long-run relationship and finally, assessing the role of institutions as a moderator in enhancing the effectiveness of innovation activity on the economic growth.

First, the thesis has identified the direction of panel causality between innovation-growth and institutions-growth at different income levels. The assumption of unidirectional relationship in the past, especially tilted to supply-side factors may not necessarily reflect the actual relationship between institutions, innovation and growth whilst both demand and supply dynamics are equally important in determining the success of development policy. For example, ignoring demand dynamics such as the size of the market in influencing institutions and innovation impact on growth is something too costly to forego. Hence, the findings of this thesis provide a clear guidance for policy recommendations and at the same time, further strengthen the existing literature on growth theory by fixing the research gap. Besides that, the thesis also can help to revive the interest of economic scholars to refine the existing growth model to capture the growth convergence using an improved methodology, although the thesis.

Besides identifying the direction of causality, the thesis also captures the short-run and long-run relationship between institutions, innovation and growth across the income

levels. More interestingly, due to the presence of causality, we have employed more sophisticated econometrics techniques using the panel Autoregressive Distributed Lag (ARDL) model to establish the relationship between the factors. The empirical results are expected to be more robust compared to past research that uses OLS model to support its policy recommendation.

The thesis also presents the role of institutions as a moderator in enhancing the effects of innovation on the economic growth. The understanding of the role of institutions and the types of institutions that are effective will further enhance the literature in the development economics. Indeed, the variation in the results along the income levels facilitates quality recommendation for policymaking which is tailored-made based on the income levels.

1.8 Research Boundaries

This thesis attempts to capture multiple proxies that represent institutions and innovation to match the broader definition of these factors. The multiple indicators capture the role of institutions and innovation more systematically and improve the strength of the factors to explain economic growth. Nonetheless, the scope of the thesis is limited by availability of panel data and the nature of the two factors, which is derived from an abstract concept. Despite of the limitation, the thesis has captured the critical ingredients explaining innovation and institution index based on the past literatures. The choice of institution measures is only limited to economic, political and social, whereas for innovation, only the common inputs and outputs are used as the indicators. For instance, process innovation is not captured in this study.

Likewise, the time series used in the thesis is optimal to meet our research objectives, whereas the extension of a longer time series in the future would be more desirable to improve the results, especially in the direction of causality. The choice of time is limited with data availability and the study only uses a time period of 34 years (from 1980 to 2013). Nevertheless, the study does not suffer from any observational adequacy given that a panel approach is used.

It is important to note that the research scope of this thesis does not include the convergence hypothesis. The thesis only focused on explaining the role of innovation and institutions in driving economic growth. Nonetheless, the outcome from this thesis is useful for future research on converge hypothesis. The clarity on how institutions and innovation interact and contribute to growth at a different income level provide insightful information on building convergence hypothesis based on income level.

1.9 Organisation of Study

The thesis starts with introduction chapter. It followed by literature review, where it critically examines the past research related to institutions, innovation, and economic growth. In chapter two, the evolution of growth theory is presented from the period of classical economics to the recent argument including neoclassical, neoShumpterian, evolutionary economics and neoinstitutionlism. The empirical evidence on the role of institutions and innovation in driving economic growth is also discussed in this chapter.

Chapter three describes the conceptual framework. The framework covers research objectives aimed for this thesis. The data and variable measurements also deliberated in this chapter. The thesis has developed innovation index and institutional index to facilitate

for empirical examination of these two abstract factors. The methodology of construction of the indices is explained in this chapter.

The next chapter examine the progress of innovation and institutions at different income level. This chapter shows the level of innovation and institutions based on country's income group. In chapter five, the dynamic of causality between innovation and economic growth and institutions and economic growth is examined. This chapter also discuss the role of income level in influencing causality direction.

In chapter six, the thesis further tests the relationship between institutions, innovation and growth in the short-run and long-run. While chapter six focused on direct relationship between institutions, innovation and growth, in chapter seven, the role of moderation effect is tested. Institutions expected to have direct and indirect effect on the economic growth. To empirically examine this effect, the thesis employs moderator analysis, where the role of institutions as a moderator between innovation and economic growth is presented in this chapter. Finally, chapter eight presented summary, implication, and limitations of the thesis.

CHAPTER 2: **LITERATURE REVIEW**

2.1 Background

In this chapter, we review past literature to understand the progress of the growth theory. The scholars of the growth theory are mostly divided into two groups. The first group is driven by neoclassical and neo-Keynesian scholars, which concentrate on mathematical modelling using production function to explain economic growth. The inputs used in the production function model expand beyond physical labour and capital. The model includes technological change and human capital to demonstrate the impact on economic growth. Despite all the efforts using the updated methodology, Rosenberg (2004) claims that Abromovitz's unexplained residual in the growth model remains the same at 85 per cent.

While this group has failed to capture the reality of growth convergence, the evolutionary economic literature has become a viable alternative source to pursue the growth theory. The evolutionary scholars pose that the Schumpeterian concept of the non-equilibrium market provides a better explanation to the black box in Abromovitz's study. Rather than focusing on capital accumulation policy, the evolutionary scholars emphasise on the importance of learning and knowledge stocks in promoting public policy (Arrow, 1962; Lall, 1987; Johnson, 1992; Lundvall & Johnson, 1994; Rasiah, 2002; Dosi & Nelson, 2016). The accumulation of learning capabilities explains the growth convergence better compared to the focus on accumulating physical capital.

Two factors that are mainly emphasised in evolutionary works are given to explain growth, i.e. institutional strength and innovation capabilities. In this thesis, we focus on these two factors and understand how these factors influence the economic growth. The roles of innovation and institutions are traced to the early works of Schumpeter, Veblen, Schmookler, which continue on to present evolutionary scholars that include Nelson, Lundvall, Aghion, Fagerberg, Verspegan, Dosi, Lall and Rasiah.

While innovation and institutions as a function of economic growth are well studied, there is less research on the role of causality between these factors, especially in which direction causality moves between the income level. The motivation to understand the causation is missing whereas policy decision concentrates on the supply side factors. Lundvall (1992) highlights the importance of demand factors including the size of the market in building innovation and institutional capabilities. In our view, the argument on growth theory can be strengthened if the understanding of causality direction between these variables is thoroughly explored.

Nonetheless, so far, both arguments have their own merits. In this chapter, we explore the critics of both arguments and found the research gap that is relevant to this thesis. We have also included the evidence from development scholars to support the need to study the relationship between institutions, innovation and growth across the income levels.

The literature review is divided into four sections. The review begins by exploring the evolution of literature growth from Smith to the recent development in the growth theory. It will be followed by empirical evidence to support the relationship between innovation-growth and institution-growth. The third section emphasises the debate and gaps in the current literature. Finally, the fifth section concludes the literature review.

2.2 Evolution of Growth Theory and the Role of Institutions and Innovation

2.2.1 Theory of Economic Growth: From Feudalism to Market Economy

The literature on economic growth has evolved along with motivation that drives the growth which is constantly shifting. During the period of feudalism, economic activities were mostly focused on agricultural production. Surpluses from the agricultural output were used for trading purposes. The decline in feudalism and the beginning of the industrial revolution had created a new environment where it had further strengthened the dynamics of the market, especially via international trade. The merchants were mushrooming, and the era is famously known as "Mercantilism." Power and wealth were concentrated in the accumulation of precious metals, i.e. gold and silver. The mercantilists promoted international trade, especially exports, which brought gold and silver as positive trade balance returns (Waddell, 1958).

Unlike the Mercantilists, Adam Smith values gold as a kind of money and not wealth. Instead, he views production as the real wealth of a nation. This period is the beginning of the "classical economics." Emphasis would be on the roles of economic specialisation and efficiency building based on a laissez-faire model. Smith argues that "division of labour" enhances skills and increases the productivity of a firm.

In addition to labour, Adam Smith also stresses the importance of capital accumulation. The manufacturer could utilise its savings to invest in capital goods or hire more workers to increase output that leads to higher economic growth. The excess output can be exported but the focus should be based on specialisation of the country. The idea of absolute advantage is also an extension from the era of Mercantilism where an

economy should leverage on its potential based on the availability of resources, i.e. land, labour and capital.

However, due to the scarcity of resources, growth based on the absolute advantage model is subject to diminishing returns in the long run. Thomas R.Malthus studies the relationships between population and agricultural growth. He discovers a mismatch where population growth expands exponentially while food production experiences arithmetic output growth (as cited in Barber, 2009). He concludes that potential imbalances could lead to social catastrophe. Similarly, David Ricardo expounds the idea of the "Law of Diminishing Returns" where he finds that productivity of fixed input, i.e. land in the long run would reduce despite the increase in variable inputs, i.e. labour and machine (as cited in Samuelson, 2002).

In contrast to the idea of diminishing return, the new growth theory is developed based on the constant return over the long run. The usage of labour and capital is substitutable to produce constant economic returns. This relationship is captured in the well-established neoclassical growth model.

Besides the constant return, Young (1928) posits the idea of increasing return as a result of his study on causation effect between income growth and the division of labour. He expands Smiths' dictum of "division of labour" that emphasises the role of specialisation of labour leading to income growth. In contrast, Young concludes the reverse of what Smith had expounded earlier, which is the scale of operation reflecting the size of the market.

2.2.2 The Neoclassical Growth Theory

The traditional production function limits itself to the accumulation of physical capital and labour. The Harrod (1939) – Domar (1946) model is the earliest post-Keynesian growth model which pioneers the understanding of potential dysfunctional aspects of economic growth using the production function. The model exhibits constant return to scale using a mathematical equation to explain national output as a function of saving rates and productivity of capital. The model concludes that countries with a higher saving rate tend to benefit from higher investment activity. The model helps to explain why the low-income countries (LIC) experience slower growth while having a surplus of labour. The insufficient rate of savings in LIC limits its ability to accumulate capital stocks and therefore experiencing a slower growth rate. It is a vicious cycle of income, saving, investment and capital stocks that is causing the LIC to remain poor.

While the Harrod-Domar model provides useful information for policymakers, the actual drivers influencing economic growth are not adequately captured in the capital accumulation policy. A landmark study conducted by Abramovitz (1956) on the US historical data between 1870 and 1950 found that a large growth in net product per capita could not be explained by an increase in factor productivity alone and indicated the importance of understanding the unknown element too. His study shows that the growth of inputs only accounts for 15 per cent of the US economy, and no less than 85 per cent is put on the unexplained residual.

Solow (1956) introduces the growth model with a technical change to account for the unexplained residual or black box which Abramovitz mentions in his paper. The model introduced by Solow which earns him the noble prize is also known as the neo-classical

growth model or the AK model. His works begin with a criticism of the assumptions of the Harrod-Domar model. Solow (1956) argues that the Harrod-Domar production function is conditioned by fixed proportions with no substitution between labour and capital. Instead, the Solow (1956) and Swan (1956) neo-classical growth model improved it by allowing a substitution between labour and capital. The capital-labour ratio is the primary determinant of the speed of convergence.

Besides that, the other significant contribution of the model is the inclusion of technical change in the new growth analysis. He adds technology as the shifter of the production function. The New Growth theory explains the role of technology as an exogenous factor to economic growth. Technology is deemed as a public good, and therefore, the flow of technology is non-excludable. Solow argues that with technological progress being exogenous to growth, economies with less capital per worker tend to have a higher rate of returns and a higher economic growth.

The neoclassical growth model is often criticised for using too simplistic assumptions. In fact, while criticising the Harrod-Domar model for its assumptions, Solow in the original paper did admit that "*the art of successful theorizing is to make the inevitable simplifying assumptions in such a way that the final results are not very sensitive*" (Solow, 1956, p. 65). Nonetheless, the simplified assumptions used in Solow's AK model suffered a similar criticism which he raised against the Harrod-Domar model. Even though the neoclassical model has its weaknesses, Acemoglu (2009) finds that the contribution of the model to growth or macroeconomic equilibrium is remarkable despite its simplicity and abstract representation of a complex economy.

2.2.3 The Endogenous Growth Theory

By the early 1970s, the neoclassical growth model had become out-dated. It happens despite some attempts being made to explain factors driving technological changes. Kaldor and Mirrlees (1962) and Arrow (1962) present the endogenised technological change function using "learning by doing" model. Unlike the neoclassical assumption that assumes technology as a public good and therefore has no externality, they interpret technological change as an externality derived from capital accumulation process.

After almost two decades, the endogenous growth theory was developed based on two primary ideas. First is the extension of learning as an outcome of positive externalities to the economy and another focuses on technological progress as an output from separate technological sectors (Fagerberg 1994). The factors that represent the endogenous growth theory include the human capital accumulations and Research and Development (R&D) activities besides maintaining the factor inputs, namely labour and capital. The endogenous new growth theory model explains the factors that drive the rate of technological changes that eventually result in growth convergence between the high-income countries and low-income countries.

The role of knowledge and human capital in the endogenous growth theory expounded by Romer (1986), Lucas (1988) and Scott (1992) is based on work done by Kaldor-Arrow "learning by doing". Romer (1986) produces the increasing return model by combining the idea of specialisation and externalities and focusing on spill overs from knowledge to growth. In a separate article, Romer (1990) also rejects the notion that countries with a larger population will generate higher growth. Instead, he promotes the idea of developing the stocks of human capital to achieve more significant growth prospects. Likewise,

Lucas (1988) develops human capital as an endogenous factor of growth whereby mobility of labour will increase the wages based on the worker's skill level. Thus, high skill translates into higher wages and increases the wealth of a country.

Uzawa (1965) and Romer (1990) bring in the idea of the R&D theory and imperfect competition in the growth framework. Technological advancement from purposive R&D activity is rewarded in some forms of ex-post monopoly power. The rate of growth is not Pareto optimal given the distortions related to the creation of new goods and methods of production that allow the firm to make abnormal profits over the long run without facing competition.

Grossman and Helpman (1990) study the relationship between trade and growth in the long run based on the entrepreneur's profit maximisation behaviour. The analysis is an extension from Romer (1986), but the focus is on cross-country differences and efficiency of R&D activity. They conclude that a country with improvement in R&D tend to enjoy the benefit of higher growth when those changes happen in the economy with comparative advantages.

The endogenous growth theory is further developed by the neo-Schumpeterian, where the assumption of growth is driven by Schumpeter’s creative destruction model and not the neoclassical assumptions. The neo-Schumpeterian modifies the neoclassical production function to include Schumpeterian concepts which will be discussed in the next section.

2.2.4 The Schumpeterian Approach

The neoclassical framework provides useful information to understand the growth pattern. However, accepting the macroeconomic and microeconomic phenomena within the same intellectual border certainly stands as an obstacle (Nelson & Winter, 1982). Hence, the alternative approach based on the evolutionary concept, which is derived from Schumpeter's work in Mark I and Mark II, becomes a viable option to understand growth especially the black box identified in the neoclassical growth model.

We begin by exploring the origin of Schumpeter's argument and the logic that supports his ideas. Schumpeter criticises the Walrasian equilibrium economics, which he deems as static in explaining the economic growth (Andersen, 2012). In his view, the process of development is not gradual as argued by Marshall and Smith. Instead, he explains the process of development as evolutionary and is continuously changing by using the business cycle approach (Schumpeter, 1947).

Schumpeter's business cycle model lucidly captures the evolution of firms coming into existence, growing, declining and disappearing. Schumpeter interprets innovation as industrial mutation, which continuously revolutionises from within, destroying the old and creating a new one (McCraw, 2009). Andersen (2011) draws on Schumpeter's wave indicator which explains innovation as a basis of economic prosperity and 'erroneous' investment during the boom cycle causing recession subsequently.

The critical element of a Schumpeterian growth model lies in the role of entrepreneurship. The "creative destruction" concept posited by Schumpeter (1934) explains the role of innovation and innovators in an economy where firms with a tendency

to innovate continue to progress and benefit the society while firms that are reluctant to change will be phased out from the market over a period due to competition. The creative destruction is the basis of capitalism's survival and the capitalists in his view have no choice but to evolve and change to remain relevant. Nonetheless, unlike the neoclassical view on the rate of changes, Schumpeter did not anticipate a smooth growth path. Instead, the disruptions of entrepreneurial innovation have led to "irregular regular" intervals (McCraw, 2009).

Schumpeter's ideology is mostly driven by a logical approach based more on the economic agent's behaviour and less of the mathematically inclined. His works are mainly divided into Mark I and Mark II. Mark I focus on "creative destruction" while Mark II discusses on "creative accumulation." Both views are contradicting given that Mark I deal with the innovation contribution by individual and entrepreneurs, while Mark II focuses on innovation by the large oligopolistic firms (Winter, 1984).

Schumpeter believes that firms will not make economic profits unless they choose to innovate. Innovation and invention of new products and process allow the firms to enjoy economic profit better known as "Schumpeterian rent." The output of new product and process from the innovation activities will be cost competitive and will create its own demand. Hence, the innovative firms are price makers and not price takers.

2.2.5 The Evolutionary Economics and Neo-Schumpeterian Approach

The concept of evolutionary biology expounded by English naturalist Charles Darwin has a considerable influence not only in the study of biology but also on many other academic fields including economics (as cited in Hodgson, 1992). In economics, the

concept of evolutionary theory is mooted by Nelson and Winter (1982) as an alternative to the neoclassical approach, which is explored later by many others including Dosi et al. (1988); Witt (1992); Metcalfe (1992); Andersen, (2013).

However, the evolutionary argument is not all new to economics, but its influence has been traced to works done by Marshall, Malthus and Marx followed by Veblen, Hayek and Schumpeter (Dosi & Nelson, 1994). The evolutionary arguments go a long way back to Malthus and Marx with their contrarian thoughts on equilibrium theory. In a similar vein, scholars of Institutionalism like Veblen and Hayek further expand the idea of evolutionary thinking, especially on the role of institutional changes.

The evolutionary and neo-Schumpeterian approaches are often used interchangeably. The neo-Schumpeterian works build upon the study of technology, innovation and growth using a dynamic perspective provided by Schumpeter (Magnusson, 1994). The neo-Schumpeterian approach is centred on accumulating knowledge, enhancing firm-level capabilities and building institutional support for innovations. It is hard to discuss the role of innovation and institutions separately when it comes to evolutionary concept.

Using the mathematical approach, the neo-Schumpeterian revisits the endogenous growth theory by applying the Schumpeterian "creative destruction" into the neoclassical growth model. The pioneers in this field are Aghion and Howitt (1990) and Fagerberg (1994). The Aghion and Howitt (1989) model captures the technology obsolescence by imputing technological shock into the model. His model assumes that technology is ultimately bounded and therefore a higher innovation will result in a lower amount of research as innovation is subjected to creative destruction.

While there are neo-Schumpeterian scholars still working on the equilibrium model, there are others who strictly follow the non-equilibrium argument posited by Schumpeter and Veblen. Nelson (2008) defines the evolutionary theory *"as always in the process of change, with economic activity almost always proceeding in a context that is not completely familiar to the actors, or perfectly understood by them"* (Nelson, 2008, p.10). From the definition, we can conclude that the evolutionary theory propagates a non-equilibrium model given that economic agents are not always rational. The rationality of the actors is bounded (Simon, 1955) as the information flows between agents are asymmetric due to the process of constant changes. Therefore, a full understanding of the operating environment is impossible.

The non-equilibrium model posited by evolutionary scholars also suggests the non-existence of the theoretical optimum expounded by the neoclassical (Nelson, 2008). This model is in line with the earlier argument that economic activity is continuously changing; hence, the current economic capacity and the theoretical optimum point should also constantly change.

Hence, in the evolutionary perspective, economic progress is defined by a country's ability to progress in a learning process (Lall, 2000). The ability to learn largely depends on the availability of resources, experience, culture and more importantly, the willingness to learn. The higher the capacity of learning, the higher will be the economic progress in the long run.

Learning is an integral part of innovation and growth. Indeed, learning itself often is to be learned (Lall, 2000). Notably, in the evolutionary theory, the process of catching up in growth trajectories often is not limited to the Schumpeterian innovation, but the process

also requires learning and adopting new knowledge and technology from others, especially from the technological frontiers. The process of learning is categorised as follows - learning by doing (Arrow, 1962), learning by using (Rosenrberg, 1982) and learning by interacting (Lundvall, 1992), learning by exporting (Loecker, 2013).

While the neo-classical economist omits the role of government in economic growth, the evolutionary scholar emphasises the need for the government to support the economy as an intermediary and to facilitate innovation activities. One significant difference between Schumpeter and the evolutionary scholar is the role of institutions in driving the economic growth. Schumpeter's work mostly focuses on criticism of the equilibrium theory, but little attention is paid on the focus of a broader role of institutions in the economic ecosystem. It is only later, through the introduction of National Innovation System (NIS) based on work done by Nelson (1990) and Lundvall (1992) that the broader role of institutions is recognised. The NIS approach is a combination of the Schumpeterian work with the institutional approach developed by Veblen, Wesley and Hayek.

Lundvall (1992) defines the NIS as a social system with a central activity that focuses on learning by interacting and a reproduction of knowledge based on feedback. The NIS primarily focuses on the role of economic agents and their interaction within a conducive environment that allows them to compete and complement each other for the accumulation of higher efficiency and an increase in the economic well-being. A similar interaction between economic agents is also expounded by the geographical economic scholars, i.e. Porter (1990) and Krugman (1991) in their work on economic clusters.

2.2.6 Institutionalism and Economic Growth

The study on the economics of institutions has become the important determinants of economic analysis, especially in addressing growth and developmental issues. Institutionalism is currently addressed as the main integral part of policy making in most economies. There is no specific definition on Institutionalism as the concept of institutionalism remains evolving. During the earlier period of the economics of institutionalism, it is expressed as a formal social organisation, which is influenced by political behaviour that embeds morality in the society by using the law or bureaucracy and address conflict of interest (March & Olsen, 1983). However, the earlier account of Institutionalism is often ignored in the mainstream economics now due to two factors – first, the history of economic thought is currently neglected, and secondly, it is criticised for failing to provide a systematic approach to economic theory (Hodgson, 1998) although the evolutionary scholars often challenge this view. The institutionalism emphasizes on the non-equilibrium or the condition of partial equilibrium considering the economy is constantly evolving unlike the main stream scholars who believe on the market equilibrium.

Of late, the main stream scholars have more widely accepted the term New Institutionalism due to two propositions - firstly, on the acceptance that institutions do matter and secondly, institutions are a subject of analysis using the existing economic theory (Matthews, 1986). Besides that, New Institutions are also accepted widely now for their focus on the role of market as a superior institution. Indeed, the renewal of interest in institutional economics is driven by its leanings towards the discipline of economics and is not limited to political science (March & Olsen, 2006).

The New Institutionalism is a complicated concept in nature with the blend of political, social and economic interrelationships that enable the market to perform efficiently. North (1991) defines institutions as a constraint that influences the interaction between politics, economics and social structure of an economy. The constraints asserted by North consist of both informal constraints as well as formal rules to reduce uncertainties and allow exchanges of function efficiently. North notices that these constraints are needed to avoid high transaction costs that result from uncertainties which could inhibit the role of the market as an efficient resource allocator. Therefore, by having quality institutions, the market is expected to perform more efficiently and as a result, transaction cost drops substantially (Coase, 1937).

The role of institutions in influencing the direction of the economy is becoming increasingly important, especially in the field of development and growth (Easterly and Levine 1997; Rodrik et al. 2004; Acemoglu et al. 2005). The lack of institutional capabilities explains why nations failed (Acemoglu et al. 2005). Myrdal's (1968) thesis on South Asia concludes that irrational attitudes and outmoded institutions are the cause of low-income growth in South Asia and not because of a lack of capital as argued by the neoclassical.

The initial study of Institutionalism is mostly conducted by political scientists and sociologists but later it has become a more cross-disciplinary field. The institutional scholars believe that the impact of good institutions or the absence of quality institutions would have a bearing on the economic growth and social order in the society. Veblen (1899) is one of the earliest scholars of economics of institutionalism who has criticised the classical theory of laissez-faire and division of labour for causing division and classes in the society. In his argument, Veblen condemns the leisure class (who are exempted

from industrial labour) for exploiting the working class who is productive to the economy. By exploiting the working class, the leisure class could preserve their social status from being challenged. Hence, Veblen proposes the need for social and cultural changes to the economy for it to continue to grow more equitably.

The idea of laissez-faire is the basis for capitalism's survival to fulfil individual self-interest. Capitalism fails to recognise the role of government in correcting market failure. Rebutting capitalism ideology, Hamilton (1919) argues that the beneficence of a free market system has failed to organise in response to the pecuniary self-interest of an individual as they see that the real organisation of society is immutable. In contrast, Hamilton recognises the role of institutional changes in correcting market failure and distributing resources efficiently.

The rise of New Institutionalism in the 1980s has influenced policy-making including international institutions such as the International Monetary Fund (IMF) and the World Bank (Chang, 2011). Even though New Institutionalism has not progressed in an advancing overarching theory, Williamson (2000) finds that by uncovering and explicating the micro-analytic features, the New Institutionalism has contributed to economic thinking substantially by asking perplexing questions on how growth work and subsequently addressing it by backing with micro-level corroborative evidence. Besides new institutionalism, the advanced of evolutionary economics theory has further enhanced the importance of institutions in the economic growth (Nelson, 2012). The evolutionary theory focuses equally on the role of institutional changes and innovation, unlike the neoclassical and endogenous growth theory that focus predominantly on technical change while ignoring the role of institutions, especially the role of the government.

2.3 The Empirical Evidence to Support the Role of Institutions and Innovation in Influencing Economic Growth

The role of innovation and institutions to explain economic growth has been presented in many studies in the past. Rosenberg (2004) considers technological innovation as a major force of economic growth in OECD countries. The historical analysis on Britain in the 18th century, the US in second half of the 19th century and latecomers in the 20th century suggest that the variations in economic growth rate are attributed to the innovation system (Freeman & Hew, 2002).

The process of innovation in the development policy is differ between the experience of western economies and East Asian latecomers. Unlike the industrial revolution in western economies which focused on invention and innovation, East Asian latecomers strategised its developmental policy on the basis of learning (Amsden, 1992). The East Asian economies have adopted the process of catching up in contrast to forging ahead, the model of development in a post-industrial revolution in Britain and post-World War II in the US. Gerschenkorn (1962) argues that being latecomers are not necessarily a disadvantage as they can learn and imitate from the more technologically advanced nation at a lower cost. Kim (1997) confirms the argument posited by Gerschenkron who supports the Korean experience of technological accumulation strategy, that is, by just copying from the frontier nation. The paradigm shifts from an agrarian society to modernise industrial nations among the successful latecomers such as Japan, Taiwan and Korea attributed to the strategy of adaptation and accumulation of learning capabilities. Similar observation expounded by Rasiah (2010) using a firm-level study on technological catch-up in Taiwan's integrated circuits after learning it from foreign Multi-National Corporations.

The process of learning in East Asia although started with imitation policy, but they have eventually progressed to innovation-driven economies considering the imitation policy alone is unsustainable over long-run. Lundvall (1992) criticises the idea of naive copying in developing economies. Instead, he argues that the policymakers in the developing economies should focus on policy recommendation to encourage cross-border institutional learning rather than simply engaging in imitation strategy

Learning from the successful experience of technological frontier is essential but following exactly their path is not necessarily the best way. Imposing westernised thinking and identifying developing countries as homogenous are the biggest mistakes of the development theory in the past (Schuurman, 2000). Stiglitz (1998) argues that despite the financial crisis in 1997, the Asian economies have successfully transformed and significantly elevated themselves from a vicious poverty cycle. It was done using their development recipes and not following the western experience. A similar argument also posited by Hausmann et al. (2005) where they find that Asian countries have experienced fast growth without fully confined to the Washington Consensus.

The success of the East Asian economies, i.e. Japan, Korea and Taiwan in transforming the nation from an underdeveloped economy into becoming a developed nation within a short span of time has inspired many other developing economies to follow a similar path. While the experience of latecomers has inspired other developing economies to follow the same path, it does not guarantee the same outcome. Shin (1996) highlights that the catching up process may not necessarily follow the same pattern with all the latecomers. Each country has gone through different experiences even though in general, all of them have focused on accumulating capabilities via learning by doing. Shin criticises

Gerschenkron's idea of uniformity of industrial development, which is the presumption that the latecomer should be right by merely following the route of forerunners. Instead, the latecomers' ability to overtake the leaders is only possible when the institutions and innovation facilitate the process of catching up. Lee and Lim (2001) found that technological evolution in Korea differentiated based on industries, where the process of catching-up is not limited to path-following catching-up, but also include path-creating catching-up and path skipping catching-up in the industries such as CDMA mobile phone and D-RAM and automobile, respectively. The different path of catching-up enable the industries in Korea to compete with frontiers within short-span of time by focusing on "leapfrogging" strategy.

Recent development policy has given greater emphasis on improving innovation and institutional capabilities. Innovation is become increasingly important now, where empirical evidence from Fagerberg and Verspagen (2002) finds that the probability of growth divergence in the world economy is increasing with radical innovation happening through the Information and Communication Technology. Brynjolfsson *et al*. (2014) propose a "New World Order" where automation is increasingly squeezed cheap labour and ordinary capital, and wealth creation is in favour of innovators who can produce new products, services and business model.

Besides innovation, the role of institutions in economic development is also increasingly accepted by the mainstream scholars. To promote innovation activity, the role of institutions is pertinent. While the neoclassical scholars criticise the limits of institutional existence in the free market theory, they begin to acknowledge the role of institutions in facilitating market efficiency. The recent researches on institutions focus on the quality of institutions and their influence on economic growth. Knack and Keefer

(1995) highlight the quality of institutions especially the security of property and contractual rights and the efficiency of government managing the public goods which are the critical determinants of economic growth. The inability to enforce contracts efficiently at a lower cost has resulted in underdevelopment in the Third World economies (North, 1990).

Looking at the latecomers' experience, the strategy of rapid technological assimilation in East Asian economies also supported by institutional strengthening during this period. While many countries have a similar industrial policy as to Japan or Korea, only a few are successful. The critical element that determines the success of the industrial policy is the availability of quality and functioning institutions (Wade, 1990). Institutions are prerequisite for innovation efficiency. Johnson (1982) identify the role of Ministry of International Trade and Industry (MITI) in Japan, which transformed industrial policy approach in Japan that enable Japan to become the first Asian Economies to achieve modernised industrial capabilities and be the leader of technological development in the world.

Besides directly benefiting to economic growth, the institutional strengthening also benefits the economy by enhancing the outcome of innovation activity. Wang (2013) provides empirical evidence that shows a significant relationship between quality of institutions and R&D intensity. The study suggests that countries that offer a better quality of institutions tend to attract a higher number of scientists and engineers in the research fields and spend more on R&D as well.

More recently, the study on how the European integration project has attracted the transition economies in Europe to adapt to institutional changes has revealed interesting

outcome. Chousa et al. (2005) argue that attraction to European integration has enticed most Central and Eastern European countries to embark on institutional reforms. These reforms include having democratic governments and effective rules of law have stimulated the economic growth of the transition economy by attracting more investment, especially in the export-oriented sectors.

Besides emphasizing the role of innovation and institutions in economic growth, this thesis is also seeking to establish the role of country's income level as a critical factor to accumulation of innovation and institutional capabilities. The income level and market size have a key role in fostering innovation activities and institutional strength. It is not only institutions and innovation that contribute to economic growth, but it is also necessary to understand the causality relationship between these factors. The causation reflects the actual complexity of the interaction between these variables in the real world. Innovation and invention of new goods and services would make no sense if the output fails to create any demand. Market size and effective demand are essential to enjoy the benefits of the first mover in experiencing new technology.

Guloglu and Tekin (2012) argue that both the 'technology-push" and "demand-pull" model of innovation equally make sense. Schmookler (1962) finds that "Necessity is the mother of innovation", hence the reverse of the "Say Law" is applied. Robinson (1971) blames neoclassical economists for treating technology as if God and engineers provide it without understanding the actual reasons driving the technological changes. Instead, the two-way process of growth where innovation activity and economic development often change each other reciprocally (Pianta,1995; Gittleman & Wolff, 1995).

Theoretically, a firm's investment decision is subjected to future growth expectation. Firms tend to invest lesser when they have negative growth expectation. Indeed, growth expectation could be even more sensitive to innovation-led investment considering the nature of these investments is subjected to a higher risk of failure. Financial institutions and capital market will become risk-averse during the period of recession to preserve their capital. Geroski and Walters (1995) study the causal relationship between the business cycle and variation in innovation activities. The result suggests that variation in economic growth does affect innovation progress significantly.

Nonetheless, there are not many past studies that analyse the demand dynamics of institutions and innovation by looking at economic growth. It is important to acknowledge the heterogeneity across the income levels to minimise policy failure. The demand dynamics and learning capabilities differ across the income levels. The demand side variables including economic growth and market size are critical catalysts to the technological progression of a nation. The role of entrepreneurship is one of the primary foci of the Schumpeterian growth theory. Anokhin and Wincent (2012) find that the relationship between entrepreneurship and innovation is not uniformly positive but depends on the developmental stages. Developed economies exhibit a positive relationship between start-up rates and innovation, compared to the negative relationship in the country in the early developmental stages. Therefore, it is misguiding to simply promote entrepreneurship to the economy during the early development stage without understanding the limitation of the policy.

Mincer (1984) produces an aggregated production function framework to show that accumulation of human capital is a condition and a consequence of economic growth. Akcay (2011) finds that real GDP and total R&D investment indicate two-way causality

in the US economy. Increase in the real GDP has incentivised the investment in innovation activities and vice versa. Peretto (1998) argues that expensive in-house manufacturing sector R&D supports the economic growth in the advanced economies, but similar facilities may not necessarily support economic growth in the early stage of industrialisation. Instead, incentives for systemic R&D efforts only nurture in the developed economy.

The study on causal direction is essential as economic theory in the past has been challenged based on new evidence emerging from the causality test. The concept of feedback mechanism has been recognised in economics since the period of Alfred Marshall, where he was concerned that the feedback mechanism could undermine a condition forming an equilibrium (Berger, 2009). Myrdall (1957) formulates a model called "cumulative causation" that criticises the notion of stable equilibrium which assumes social reality move in a single direction. In contrast, he views that constant changes in the society do not only change the economic environment, but each change happens faster than before due to the nature of cumulative causation.

The idea of causation influenced by Myrdal contributes to further development in the new economic theory and challenges the existing conventional thinking in the economics. The outcome from causal relationship leads to the establishment of increasing return argument in economics. For example, Verdoorn (1949) dispels the conventional thinking in economic theory on productivity driving growth by establishing the Verdoorn's Law. The law poses that the reverse occurs when productivity grows proportionate to economic output. A faster growth rate increases productivity due to increasing returns. Using the same argument, Kaldor (1966) explains that higher economic growth leads to an increase

in productivity of the manufacturing sector compared to the customary view that higher productivity drives a higher output growth.

Similarly, the causation between institutions and economic growth also has been addressed since the period of Veblen. He is highly critical of the equilibrium approach and is a strong proponent of the non-equilibrium approach. Veblen posits the famous notion of cumulative causation in his work published in The Quarterly Journal of Economics 1898 titled "*Why is economic not an evolutionary science?"* later expanded by Myrdal.

In more recent studies, Dawson (2003) conducts the Granger causality test and finds that institutions and growth appear to have mutual causation. The economic freedom emphasises the role of property rights and the free market. It has a vital role in promoting economic prosperity in the long run. Meanwhile, Kim et al. (2018) study the impact of government size and governance on economic growth and find that better governance helps large size governments to increase productivity, but those that are impacted are only applicable to a certain threshold. Any further increase in the size of government could lead to a harmful impact on growth.

The cross-country Granger causality study by Law et al. (2013) reveals a non-uniform causal relationship between growth and institutions at different level of income. Institutional change drives economic progress in the higher income economies, whereas growth contributes to improvement in institutional quality in lower income countries. The results are also echoed by earlier studies conducted by Barro (1996) that claim income follows democratisation. He produces empirical evidence to confirm that mean income grows in tandem with a demand for democracy.

2.4 The Debate on Growth Theory

2.4.1 The critics of the Neoclassical Growth theory

The neoclassical growth theory provides insightful information in developing the growth strategy. However, the overly simplistic approach and aggregation problem have resulted in an ambiguous outcome. The central assumptions of the neoclassical growth theory that the market possesses perfect information, no externalities and the economy only produce a single commodity are too simplistic and may poorly represent the reality on the ground. These assumptions do provide an assurance in explaining the theory mathematically, but undoubtedly, it is very different from the reality (Lall & Morris, 1998).

The most important contribution of neoclassical growth theory is the attempt to include technology as an additional factor besides capital accumulation and labour. Nonetheless, the way technology is conceived by neoclassical scholars is inconsistent with reality. The neoclassical model assumes that technological change is exogenous to the economy. There is no effort taken to explain the differences in the rate of technical change between countries. Schmookler (1962) highlights that failure to explain technological change reflects ignorance and low interest in finding the facts.

Meanwhile, Fagerberg (1994) criticises the assumptions used in Solow (1956) that define technology as a public good, which means it is non-excludable and available to all nations at no cost. In reality, not all economies share the same pool of technology. Legal restriction often limits the discovery of new technology, i.e. trade secret, patent,

copyrights and there is a time lag before the technology is available for others to use freely. Therefore, technology as a public good is only applicable in the long run, while the short-run technology should be expressed as non-rival but partially excludable as defined by Romer (1990).

Besides that, it is challenging for the growth scholars to segregate the contribution of technological change independently from capital stocks. The accumulation of capital and technological changes is interdependent as new technology is mostly embedded in capital goods. Nelson (1964) argues that it is misleading to assume total factor productivity is independent of capital growth rate. Countries with higher capital spending tend to enjoy higher total factor productivity as opposed to the neoclassical conclusion which believes otherwise that the marginal product of capital is subject to diminishing returns as the ratio of capital to labour increases.

In the real world, the role of a functioning market is more complicated than just a single commodity as described in neoclassical theory. The existence of many markets within economic borders involves more than the role of households and firms to work well. Institutions play a pivotal role as the third agent of the economy that interacts and plays intermediary on the relationship between households and firms via the elements of cooperation and trust.

2.4.2 Critics of the Endogenous Growth theory

The endogenous growth theory provides a better alternative to offset the weaknesses in neoclassical growth theory. The effort to explain the growth more holistically has drawn the interest of many economic scholars to revive the growth theory framework.

Nonetheless, the attempt to explain growth endogenously remains challenging, especially in dealing with logic satisfactorily and empirical plausibility.

McCallum (1997) finds two logical difficulties in the work of the endogenous growth theory, first is that the never-ending growth model requires a never-ending increase in human capital and secondly, the assumption of precisely constant returns to scale. In his first critic, McCallum argues that the accumulation of knowledge is essential for a never-ending growth since knowledge carries infinite property and not human capital as explained in the Lucas - Rebelo model. Secondly, on the assumption of a precise constant return to scale, he argues that the empirical evidence of having an exponent value of endogenous factor close to 1.00 seems to produce similar results in the neoclassical growth theory that has slowed the speed of convergence in per capita income.

Aghion and Howitt (1989) criticise the endogenous growth model on two aspects. Firstly, the endogenous growth model assumes technological progress has only positive spillovers and fails to understand the obsolescence of old skills, goods, markets and manufacturing processes. Besides that, the endogenous growth does not produce a random trend. King and Rebelo (1989) add that exogenous technology shocks to capture the random trend. However, Aghion and Howitt view that technological shock should not be regarded as an exogenous shock. Instead, the Schumpeterian concept of "creative destruction" explains the need to endogenise the distribution of technological shocks in the model.

The empirical result from Martin and Sunley (1998) discovers that regional convergence in the industrialised world is much slower than the rate proposed by neoclassical models. It confirms the need for an alternative framework that empirically

can capture broader factors that include the importance of the social-institutional role and regional economic development.

Endogenous growth theory also fails to capture other relevant variables, including the role of entrepreneurship. Emmanuel et al. (1982) query the policy implication from growth theory that encourages the economy to have a higher saving rate. The surplus could finance capital investment; yet, the capital investment may not happen if the economy lacks entrepreneurs.

2.4.3 Critics of the Neo-Schumpeterian and Evolutionary theory

The obsession with neoclassical theory does not last long, mainly due to weaknesses in the assumptions used in the framework, i.e. perfect rationality among the economic agents and technology is treated as public goods. During this period, the work done by Nelson and Winter (1982) help to revive the scholars' interest in exploring the evolutionary theory in economics.

The evolutionary theory has given a new perspective in devising policies for growth and development. However, in the mainstream economics, the evolutionary theory is still perceived only as an alternative approach to the neoclassical framework. Even among the neo-Schumpeterian scholars, the approach is divided into two different paths. The first group focuses on extending the neoclassical framework by including the Schumpeterian variables in the production function. The Aghion and Howitt (1990) model become the pioneer reference for this group, where the idea of growth remains centred on the convergence rate. In contrast, the second group led by Nelson and Winter (1982) totally rejects the neoclassical growth theory. They believe that the process of learning results in

economic progress. Nelson (2008) stresses that the empirical model is a challenge when it is used to explain economic progress given the large variance during the innovation process. In addition, the complexity of changing ecology during the post-innovation period also limits the predictability of the model (Andersen, 2012).

While the second group does not have much faith in explaining growth and learning mathematically, the attempt made by the first group has yet to prove any significant breakthrough. Alcouffe and Kuhn (2004) admit that the Schumpeterian endogenous growth theory is far from reflecting the actual Schumpeter's idea of the evolutionary approach. Hence, a lack of a formal structure theorising the Schumpeterian model in a scientifically-accepted method remains a challenge in maintaining the neo-Schumpeterian theory in the mainstream economics, which is in line with the neoclassical approach.

Besides that, the evolutionary approach also allows for a continued and infinite economic progress as long as the economy persists in the learning path. With this assumption, even the Schumpeterian business cycle argument may not exist, considering there is no cyclical movement along the growth trajectory. This assumption is echoed in the evolutionary approach which in our view is too ambitious.

While Schumpeter's "creative destruction" lucidly articulates the movement in the business cycle, the argument is severely lacking in clarity when explaining the condition for a recession or a down cycle. According to Schumpeter, erroneous investment is the major cause of the recession. However, erroneous investment alone may not be enough to explain recession. Instead, we believe that factors triggering erroneous investment including the fluctuation in money supply fail to be highlighted. Hence, we find the

Schumpeter's model to be insufficient to explain the cycle of innovation and growth. In our view, the evolutionary and neo-Schumpeterian scholars should also consider the role of money supply when proposing development policies.

2.4.4 Critics of Institutionalism Approach

The most significant challenge in analysing institutions is to define the scope of institutions. What comprises an institution depends on the discipline of the study, i.e. politics, law, sociology or economics. Even among the institutional economists, the orientation of institutions is determined by their scholarly belief on either neoclassical approach or alternative schools. North (1991) defines institutions as constraints that are constructed by humans based on political, economic and social interaction. In his seminal work, North discusses the role of exchanges by using three cases, namely the local exchange (within a village), regional exchange and world trade. By having the formal institutions that safeguard the traders (e.g. legal contract), the producer can increase productivity and minimise the risks of fraudulence and forgery. It also reduces the transaction cost and benefits the economic growth, especially in the long run. Indeed, the term New Institutional Economics came from the introduction of transaction cost by Coase (1937).

However, the role of institutions should not be limited to improvement in production efficiency and profit maximisation as expounded by the utilitarian and neoclassical scholars. Beyond that, institutions have a more direct role in shaping up society and influencing economic growth directly as posited by the earlier scholars of institutionalism (Veblen, 2009; Commons, 1931; Selznick, 1996). The role of non-market institutions like university and public research institutions, scientific and technical society and

government programmes are equally crucial in influencing economic growth (Nelson, 2008). For example, Chandran et al., (2014) observe that the failure of research institutions to link properly with industries obstructs the development of high value-added manufacturing activities in Malaysia.

Nonetheless, the critics of Institutionalism often regard the research on the institutional role in economics as technically less rigorous and complex, lacking theoretical support (Hodgson, 1998; Chang, 2010). Supporting the institutional role in economic development also produces mixed results. Glaeser et al. (2004) argue that poor countries come out of poverty due to a good policy which is often pursued by dictators. This evident corroborates with the success of industrialisation in Singapore under Lee Kuan Yew and Korea under Park-Jung-Hee (Kim,1995; Rasiah et al., 2017).

Nonetheless, economic development cannot be understood by merely limiting the growth analysis on households, firms and market. Indeed, Nelson (2008) argues that the development process is a vibrant mix of institutions within economic activities, which includes the pivotal role of government. He adds that the government should play a more significant role in the development process, unlike the neoclassical understanding that limits the government's role only in reaction to market failure events, if any.

2.6 Conclusion

The growth theory has evolved significantly from a simple neoclassical production function to the evolutionary perspective which tries to assimilate a more complicated interaction between the systemically connected economic agents. Nonetheless, the

existing theories are still a far cry from being able to adequately explain the actual progress of development economy. The income gap between the high-income countries and developing countries continues to widen.

This thesis attempts to address the weaknesses in the existing growth model, although we admit that the objective of the thesis is not to solve all the mismatches between economic theory and the actual evidence. Instead, the thesis only focuses on understanding the link between innovation, institutions and economic growth across the income levels. In our view, the thesis will further improve the understanding of the role of institutions and innovation in influencing economic growth.

However, in an attempt to reduce the gaps, we are also aware of Mankiw's caution on haphazard policies, which inevitably are worse than no policy at all (Mankiw et al. 1995). For example, measuring the speed of convergence is not included in this thesis, as we believe that the variance of the output from innovation and institutional changes is hard to measure as each innovation and institutional change leads to new path dependency.

CHAPTER 3: **METHODOLOGY**

3.1 Introduction

This chapter explores the conceptual framework that explains the dynamic link between institutions, innovation and economic growth at different income levels. The conceptual framework of the thesis is developed based on the synthesis of a large body of past literatures from the neoclassical to the neo-Schumpeterian growth theory. Besides these, the literatures on institutionalism are instrumental in order to understand the systemic relationship among the three factors.

With regards to the contribution towards the body of knowledge, the integration of various literatures allows the thesis to form a unique framework that would contribute to the body of literatures on the growth nexus. In addition, the thesis compiles a fairly comprehensive dataset, which has the necessary ingredients to explain the dynamic link between institutions, innovation and economic growth. This approach helps to overcome the downside of using only one indicator as a proxy to reflect institutions and innovation. For instance, a broad range of nineteen indicators has been selected to construct the Innovation and Institution Index. These indices enable the thesis to capture the core construct of innovation and institutions without compromising on the broader definition of innovation and institutions. In other words, this will also be more representative of the abstract factors of institutions and innovation compared to a single proxy or a narrow definition as used in the past.

The following sections introduce the conceptual framework of the thesis. This is followed by a discussion on the data properties and variable measurements. Subsequently, the section discusses the details of the innovation and institution index construction. The last section elaborates on the analysis of descriptive statistic and charts to illustrate the relationship between institutions, innovation and economic growth.

3.2 The Conceptual Framework

Figure 3.1 presents the conceptual framework to address the research objectives of the thesis. The literature discussion in Chapter 2 provides details for the relationship established in the framework. The framework seeks to establish the dynamic relationship between institutions, innovation and economic growth. The thesis is focused on four different empirical objectives - i. study the progress of innovation and institution at different income level, ii. determining the direction of causality, ii. the short-run and long-run relationship between institutions, innovation and growth, iii. the role of institutions as a moderating factor between innovation and growth. All empirical examinations are tested separately across different income levels to account for the counterfactual arguments that income levels matter in examining the relationships between innovation, institutions and growth.

Previously, the growth theory focuses mainly on production factors to explain the economic growth. Capital accumulation is deemed as a crucial element in promoting economic growth. Initial income and saving rate are two key factors that are emphasised by the neoclassical that have links to capital accumulation which are then used to determine the speed of growth convergence. In this argument, a country with lower

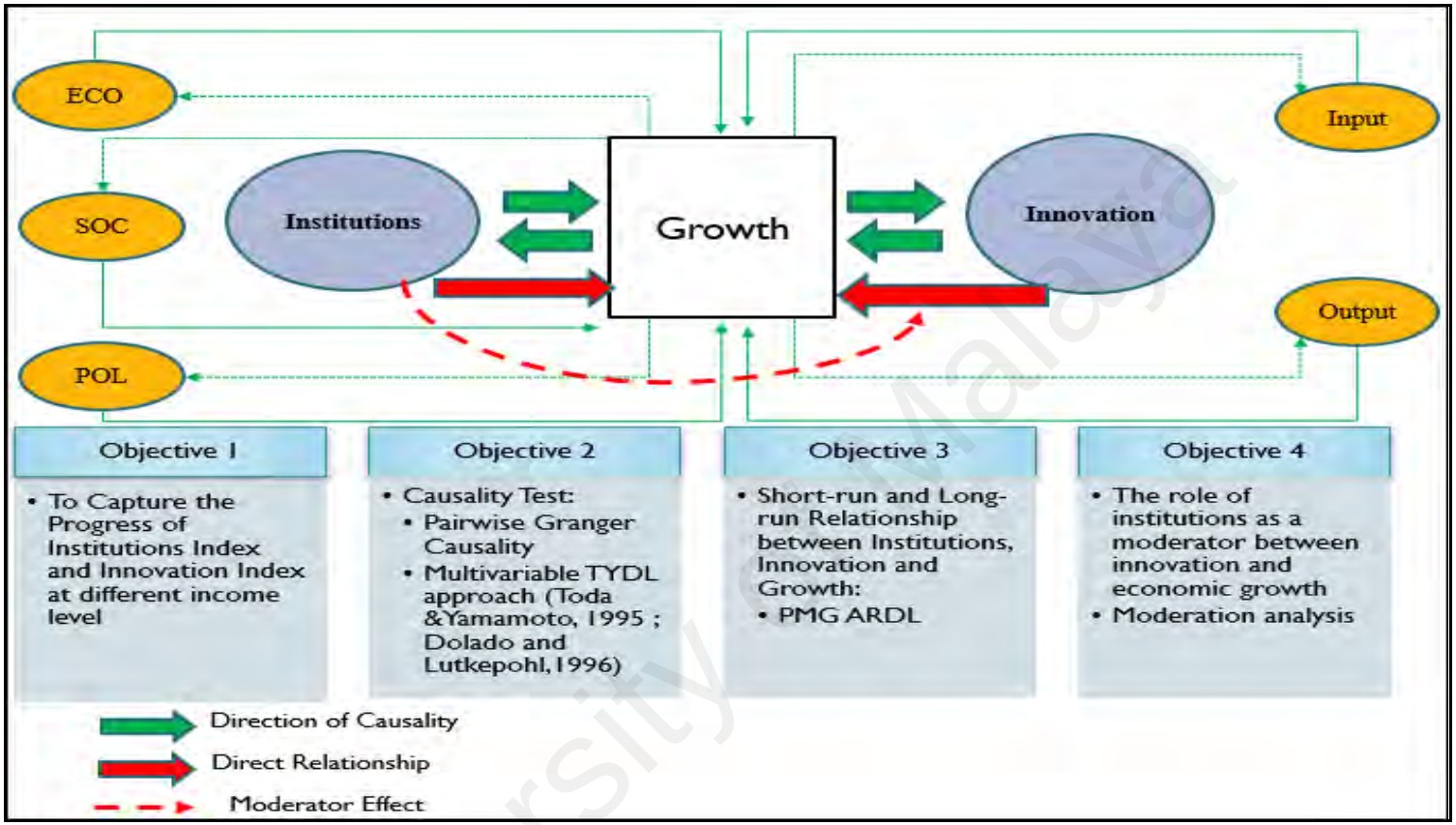


Figure 3.1: Conceptual Framework[1]

Source: Author

[1] ECO, POL and SOC refers to Economic Institution, Political Institution and Social Institution

initial income should be able to progress faster than the process of capital accumulation that takes place. Nonetheless, the process of capital accumulation in the under-developed economies remains disappointing as it is at a slower pace. Despite having high domestic interest rates, the saving rate in under-developed economies have failed to grow at a faster rate considering there are other complementary factors to boost the domestic saving rate such as demand for innovation and institutional change (Amable, 2000).

Unlike the neoclassical approach which is focused on capital accumulation, the Schumpeterian and Evolutionary scholars argue that the role of knowledge accumulation should be considered more important than the process of capital accumulation in driving a healthy and sustainable economic growth. Knowledge accumulation is reflected in the innovation capabilities and institutional strength of an economy. Countries with a high knowledge accumulation tend to grow stronger and converge faster with the frontiers like the latecomers in the East Asian economies.

Meanwhile, in the recent growth argument, the role of institutions and innovation gains more attraction in growth framework discussion. These additional factors have become increasingly important drives of the economic growth. Unlike the neoclassical growth theory that treats technological change as a black box and considers it as a residual that consist of everything and anything, this thesis unveils two important elements of the black box, namely institutions and innovation. To explain precisely, using multiple indicators, innovation and institutions promote economic growth on the basis of the endogenous growth theory, evolutionary economics theory and institutionalism theory.

The impact of innovation and institutional measures varies depending on the developmental stages. It is not easy for the under-developed economies to invest in

innovation and institutions considering numerous limitations including budget constraint, inadequate human capital and weaker institutions. For example, a sophisticated level of human capital is required to drive technological capabilities in an economy (Romer, 1990; Lucas, 1988). Given the low level of human capital development in low-income economies, research activity may not be vibrant enough to benefit the local economy. Hence, Parreto (1990) suggests that the transformation of economy from capital accumulation to technological change happens only when the economy has reached a certain level in its income levels.

The empirical evidence on the impact of innovation activity and institutional strength on economic growth remains divided and mixed. Most important, the relationship between these factors depends on the measures that represent innovation and institutions in past studies. For example, Madsen et al. (2010) find no robust relationship between Total Factor Productivity (TFP) and research activity in India using the endogenous growth model, but when the Schumpeterian growth theory is applied, the thesis finds a significant relationship between research activity and product varieties.

Given the complexity of the relationship between economic progress, innovation and institutions, there might be a need for an alternative approach to econometrics modelling that could account for the complexity of the economy. The ex-ante expectation of this thesis assumes that there will be a causality effect between the parameters in a non-uniform pattern along the income levels. Hence, ignoring such a relationship could lead to the problem of endogeneity where the explanatory variable correlates with the error term (Gujarati, 2009).

To avoid problems associated with endogeneity, this thesis has performed an empirical test on causality by running the relationship between Growth-Innovation and Growth-Institutions separately as expressed in the framework. The framework employs the modified neoclassical production function model with additional parameters of innovation and institutions included besides the labour and capital variables. The Innovation index is represented by the innovation input and innovation output while the Institutional index captures the structural interaction among economic institutions, political institutions and social institutions as defined by North (1990).

After establishing the causality direction, the thesis continues with the examination of the short-run and long-run relationship between the factors. The short-run and long-run tests allow to study the contribution of innovation and institutions to economic growth. Given the potential problem of endogeneity, a proper econometric technique is required. If a causality test confirms the presence of a complex relationship, the Ordinary Least Square (OLS) may be insufficient to handle the regression and will be subject to bias. Hence, econometric methods that have the power to handle endogeneity are required, for instance the Auto Regressive Distributed Lag (ARDL) approach.

Finally, the thesis also seeks to determine the role of institutional strength in enhancing the outcome of innovation in increasing the speed of growth convergence. The role of formal and informal institutions is becoming increasingly important in driving development policies. For example, the effectiveness of public goods provision improves when the government strengthens institutional capability. The practice of good governance minimises unproductive rent-seeking and improves public goods delivery. Institutions that protect property rights enable improvement in economic growth as transaction cost will be lowered due to market efficiency (Knack & Keefer, 1995).

Abramovitz (1986) points out that a country with different productivity levels will potentially lead to a stronger convergence only when it has an adequate "social capability" to absorb technological advancement. Besides that, institutional capabilities via quality and effective government policies are significant to promote economic growth mainly by investing in infrastructure development (Esfahani & Ramirez, 2003).

3.3 Data

3.3.1 Data Source

Data for this thesis is compiled from various sources produced at the national level and surveys conducted by International Organisations, i.e. the World Bank, International Monetary Fund (IMF), United Nations Educational, Scientific and Cultural Organisation (UNESCO), Transparency International and Freedom House from 1980 to 2013. We also use data provided by the Norwegian Institute of International Affair (NUPI) from its cross-country analyses of national systems, growth and development (CANA) database project websites.

The sample size is divided based on income levels in year 2013 using the World Bank Gross National Income (Atlas Method). The income level classification is determined by operational lending guidelines of the World Bank. From a total of 189 countries, we chose only 80 countries based on the availability of data. Countries with less than 90 per cent data availability are excluded from the study for HICs and MICs and 85 per cent for the LICs. Non-OECD high-income countries are also excluded to avoid the results being skewed by the small and resource-based economies. The list of countries included in this study is presented in Table 3.1.

The major challenge for a cross-country panel analysis is to handle the presence of missing values. Lack of quality data has limited the ability of scholars to conduct quantitative research in the past. However, with recent development in the missing data imputation techniques, this study has managed to overcome the problem of missing values by producing useful and reliable dataset to conduct quantitative analysis. This is discussed in more details in section 3.5.

Table 3.1: List of Countries

Development Stages	OECD High Income		Middle Income		Low Income
Criteria ($US Atlas Methodology)	> $12,745		$1,046-$12,745		<= $1,045
Sample	25		37		18
Countries	Australia	Spain	Bangladesh	Lesotho	Benin
	Austria	Sweden	Bolivia	Malaysia	Burkina Faso
	Belgium	Switzerland	Botswana	Mauritius	Burundi
	Canada	United Kingdom	Brazil	Mexico	Ethiopia
	Chile	United States	Bulgaria	Namibia	Gambia
	Denmark		China	Nigeria	Guinea
	Finland		Colombia	Pakistan	Madagascar
	France		Costa Rica	Panama	Malawi
	Germany		Dominican Republic	Peru	Mali
	Greece		Ecuador	Philippines	Mozambique
	Iceland		Egypt, Arab Rep.	South Africa	Nepal
	Ireland		El Salvador	Sri Lanka	Niger
	Israel		Ghana	Swaziland	Rwanda
	Italy		Guatemala	Thailand	Senegal
	Japan		Honduras	Tunisia	Sierra Leone
	Korea, Rep.		India	Turkey	Togo
	Netherlands		Indonesia	Zambia	Uganda
	New Zealand		Iran, Islamic Rep.		Zimbabwe
	Norway		Jordan		
	Portugal		Kenya		

Source: World Bank (2013)

3.3.2 Variable Definitions

A total of twenty-two variables were collected to run the analysis. Nineteen of these variables were then transformed to the innovation and institutions index, guided by the existing literature. The definitions of the variables are presented in Table 3.2.

The index is developed by combining multiple factors that represent the observable variables. The observable variables are not limited to the innovation and institution index but also include the sub-indices that represent both main indexes. Given that the latent variables are captured in various formats including level, ratios and scales, we use the normalisation technique to make the variables comparable, enabling an indexation exercise.

Normalisation score formula:

$$S_{i,t} = \frac{(X_{i,t} - X_{min,t})}{(X_{max,t} - X_{min,t})} \times 100$$

Where S_{it} refers to the normalisation score of a variable for the *i*th country at time *t*. The X_{it}, $X_{min,t}$ and $X_{max,t}$ refers to the country *i*th in period t, minimum and maximum value of variable X respectively in period *t*. A score of 100 denote highest score while 0 is the lowest score. This score is only a representative value and not an absolute.

Table 3.2: List of Variables

	Variables	Code	Inputs	Definition	Source
Production Function	Output	Y_t^a	GNI per capita	GNI per capita (formerly GNP per capita) is the gross national income, converted to U.S. dollars using the World Bank Atlas method,	World Bank
	Capital	KI	Capital Intensity	Capital Stock (in percentage of nominal GDP)	IMF
	Labour	LAB	Labour Productivity	Total output produced per unit of labour force	World Bank
Innovation (INV)	Innovation Input (INVIN)	HC	Tertiary Enrolment (Human Capital)	Gross enrolment ratio, tertiary, both sexes (%)	UNESCO, World Bank
		KA	IP payment (Knowledge Accumulation)	Payment for the use of intellectual property between residents and non-residents for the authorised use of proprietary rights per GDP.	World Bank
		RDI	R and D Expenditure	Expenditures for research and development (R&D) (in percentage of nominal GDP)	World Bank
	Innovation Output (INVOUT)	PAT	Patent	Total Patent Application per population	USPTO, WIPO
		THE	High Tech Exports	Exports of products with high RD intensity as a percentage of merchandise exports	World Bank
		TM	Trade Mark	Trademark applications filed with a national or regional Intellectual Property (IP) office per population	World Bank
		SCJ	Scientific and Technical Journals	Number of scientific and engineering articles published per million people.	World Bank
Institutions (INS)	Economic Institution (ECO)	CONT	Enforcing contract time	Number of days needed to enforce a contract.	World Bank, Castellaci and Natera (2011)
		CONC	Enforcing contract costs	Enforcing Contracts: Cost. Percentage of the claim needed to proceed with it. Low (high) values of the variable indicate high (low) competitiveness.	World Bank, Castellaci and Natera (2011)
		CREDIT	Domestic bank credit	Domestic credit to private sector as a percentage of GDP	World Bank
		TRADE	Economic Openness	Total Trade as a percentage of GDP	World Bank
	Political Institution (POL)	CPI	Corruption Perception Index	Corruption Perception Index. Transparency International Index, ranging from 0 (High Corruption) to 10 (Low Corruption)	Transparency International, Castellaci and Natera (2011)
		PRESS	Freedom of press	Country scoring for freedom of press using common criteria. Score from 0(best) and 100 (worst)	Freedom House, Castellaci and Natera (2011)
		RIGHT	Political right	Country scoring for ability of its citizen to participate in political processes. 1=most free and 7=least free	Freedom House, Castellaci and Natera (2011)
		LIBERTY	Civil liberty	Country scoring for ability of its citizen to have basic freedom without interference of state. 1=most free and 7=least free	Freedom House, Castellaci and Natera (2011)
	Social Institution (SOC)	PRIMARY	Primary school enrolment	Net enrolment of primary school (percentage of net)	UNESCO, World Bank
		SECOND	Secondary school enrolment	Net enrolment of secondary school (percentage of net)	UNESCO, World Bank
		INTERNET	Internet connection	Internet user (per 100 people)	World Bank
		TELECO	Telecommunication connection	Mobile and Fixed telephone subscriptions (per 100 people)	World Bank

Source: World Bank (2017)

3.4 Variable Measurements

3.4.1 Innovation Index

The European Commission (EC) and Organisation for Economic Co-operation and Development (OECD) have developed the Oslo Manual – a guideline for collecting and interpreting innovation data. It defines innovation as a new or significantly improved product, process or organisational change (OECD, 2005). Based on this definition, innovation activity should not be restricted only to technological creation but to include the incremental process of learning and adaptation. The evolutionary scholars focus on this element too. However, quantitative research using the evolutionary approach is mostly conducted on cross-sectional data collected from firm-level surveys. It is often challenging to test this theory on a macro-level cross-country analysis, given the limited availability of quality panel data.

Therefore, aggregated macro-level research on innovation in the past is mostly tested using innovation proxies, e.g. R&D data and patent data. These proxies have a limited representation of the true character of innovation as defined in the Oslo manual. Dutta et al. (2015) criticise R&D and patent as only concentrating on product creation specifically covering the manufacturing sector while foregoing the incremental innovation in process, service and organisational change. Besides that, the patent alone has a limited role in explaining increases in innovation rate (Mansfield, 1986).

As an alternative to using a single proxy, the Johnson Cornell University, INSEAD Business School and World Intellectual Property Organisation (WIPO) jointly published the Global Innovation Index (GII) that aims to capture the broader dimension of

innovation and ranks countries based on innovation capabilities. The index is divided into two sub-indices, i.e. innovation input and innovation output. Innovation input captures the elements of the national economy that promote innovation activities while innovation output is the result of innovation activities. The innovation index is calculated by taking a simple average of the Input and Output sub-indices and no weightage is assigned (Dutta, 2007).

A similar methodology is used in this thesis to develop the Innovation Index. The index is divided into two subcategories – innovation input and innovation output. Although the GII dataset is more comprehensive than the Innovation Index constructed in this thesis, we have decided not to use the GII data due to two factors. Firstly, the major difference between the GII and Innovation Index is the separation between innovation and institutional factors. Also, the GII index includes Institutions as one of its five pillars to explain innovation input. Institution factors which are stable political environment, quality regulatory framework and ease of doing business are expected to contribute positively to innovation input. However, the debate on the role of institutions in economic development is still ongoing. It is part of the objective of this thesis to establish the relationship between institution-growth separately from innovation-growth.

Another limitation of using the GII is its relatively short time series data. The annual series only started in 2007 onwards. As mentioned earlier, a longer time series is required to conduct causality test and the result is sensitive based on the lag selections. Therefore, we have decided to use a longer time series (in this case from 1980) despite the limited variables. Although our data is not as comprehensive as the GII data, the ability of the data collected for this thesis to fulfil the research objectives remains uncompromised.

Innovation Index:

$$INV = \frac{1}{2}(INVIN + INVOUT)$$

Where Innovation Index (INV) is calculated based on a simple average between Innovation Input (INVIN) and Innovation Output (INVOUT).

The thesis identifies three pillars to represent innovation input – i. Human Capital, ii. Research Intensity and iii. Knowledge Accumulation. Human capital plays an important role in building innovation capacity. Both scholars of the neoclassical and neo-Schumpeterian have accepted the role of human capital in the economic development. The term human capital is used to differentiate between skilled and unskilled labour force. Investment in skilled labour is expected to provide a positive return on the economy and increase the speed of convergence (Lucas, 1990). Becker (1994) highlights the idea that education and training are the most important investments to increase human capital development in the economy. Higher tertiary education greatly raises income level. This evidence is produced in various past studies (Petrakis & Stamatakis, 2002; Artadi & Sala-i-Martin, 2003; Gyimah et al., 2006).

Research intensity is the second pillar of innovation input. The R&D expenditure as a part of GDP is used as a proxy to research intensity. Neoclassical economists establish the role of technological change in economic growth. Technological change is mostly explained as an outcome of R&D activities. Higher investment in R&D has an important effect on productivity, especially in the industrial sector (Mansfield, 1972). Frenken et al. (2007) who study regional knowledge spillovers known as "Jacobs Externalities" find that productivity growth is determined by investments in R&D expenditure. In the case

of developing countries, Chandran et al.'s (2014) study on university-industry collaboration discover that R&D collaboration between public universities and industry is important for the sustainable development of innovation system. The study also acknowledges that insufficient understanding among the policymakers to identify the mismatch in R&D activities between university and industry has hindered the developing countries from fully exploring the potentials in advancing the national innovation system.

Finally, innovation input is also represented by knowledge accumulation. The core factor promoting innovation from an evolutionary perspective is the role of knowledge accumulation and its spillover. Knowledge partly carries public goods characteristics - non-rival but not completely non-excludable. Some knowledge has to be acquired for a cost. For example, knowledge embedded in goods and services with intellectual property rights is not freely transferable. Hence, copying without prior approval is illegal. Therefore, to acquire the knowledge, the user must pay a fee and get permission from the owner. The thesis uses intellectual property payment as a proxy to capture cross-border knowledge flows. These are the charges for the use of intellectual property, which is captured in the balance of payment data.

Innovation Input:

$$INVIN = \frac{1}{3}(HC + RDI + KA)$$

Where Innovation Input (INVIN) is calculated based on a simple average between human capital (HC), research and development intensity (RDI) and knowledge accumulation (KA).

Innovation output is represented by the outcome of investing in innovation activities. Four outcomes of innovation are measured in this thesis, namely i. Patent, ii. Trademark iii. High-Tech exports and iv. Scientific and Technical Journal articles. The first three emphasise on the production of new inventions and improvement in goods and services while the final element captures the knowledge spillovers.

The patent is widely used in innovation literature as a proxy for the technological progress of a firm or a country (Trajtenberg, 1990). It is a document issued by the authority to grant rights of ownership to exclude others from producing or using a product or process for a stated period. The patent is granted to a firm or individual that invents a new product or process that focuses on novelty and its potential utility (Griliches, 1990). Due to a monopolistic nature as a price setter, the patent holders can enjoy the benefit of abnormal profits by creating rent. The monetary incentives from the patents encourage innovators to invest in R&D spending. A country that has patents with a higher degree of commercialisation tends to gain higher economic growth (Mansfield, 1986).

Besides patents, the trademark is the other component of Intellectual Property Right (IPR). Trademark is a symbol or words that are legally established to represent a company. Unlike patent, trademark does not provide monopoly power to the trademark holders. Nonetheless, trademark holders could use branding to differentiate themselves from their competitors. Trademark registration can explain new products or processes or organisations entering the market. Therefore, it is considered a proxy for the entrepreneurial element which is emphasised by Schumpeter in his creative destruction argument. A country with a higher registered trademark can also represent a higher formation of new companies thus suggesting a lesser barrier for entry.

The contribution of high-tech exports explains the level of technological intensity in the economy. Technological specialisation is an important driver of the economic development. Developing economies build comparative advantages on technological specialisation by liberalising the economy. Mani (2000) conducts an empirical study on the role of high-tech exports in developing countries and finds that a country with higher concentration in technological exports tends to catch up faster than the rest. Nonetheless, Lall (2000) argues that trade liberalisation alone is insufficient to develop technology-intensive export industries. In contrast, the role of domestic technological input is most pivotal in acquiring comparative advantages. To develop and deepen technological structures beyond simple assembling activities, the role of government through effective intervention is needed. Even though high-tech exports as a gauge of technological advancement in the developing economies is often debated by scholars, it is still useful to explain innovation as a compliment to other local capabilities factors that are included in innovation output.

Finally, the innovation output is represented by a number of publications in the scientific and technical journal per million population. The number of publications is a good measurement of output produced by scientific and technological communities in an economy. Knowledge creation often begins in universities, technological parks and research centres. These institutions have a critical role in the advancement of innovation and provide a platform for the scientific and technological network (Murrary, 2002). The active role of the scientific communities is essential in expanding the “learning system" and technological deepening which is essential for economic development, especially in the developing economies (Lall, 2000). Meanwhile, geographical economic scholars, David and Rosenblom (1990), Krugman (1991) and Glaeser et al. (1992) emphasise on the Marshallian spatial externalities that explain the spillover between knowledge

creation in research institutions and a firm's production. Hence, the number of publications explains the level of innovation output of an economy.

Innovation Output:

$$INVOUT = \frac{1}{4}(PAT, TM, HTE, SJ)$$

Where Innovation Output (INVOUT) is calculated on a simple average between Patent per population (PAT), Trade Mark per population (TM), High-tech Exports (percentage of merchandise exports) and Scientific and Technical Journal per population (SJ).

3.4.2 Institutional Index

The major challenge in developing an institutional index is to fulfil the definition of institutions, which varies from one discipline to another. This thesis employs North's (1991) definition of institutions - formal rules and informal constraints devised by humans to reduce uncertainty in the market. These constraints are essential to mould the structure of political, economic and social interaction.

The scholars of Institutionalism believe that institutions have a pivotal role in the market to distribute scarce resources efficiently. The economic efficiency is enhanced by minimising the transaction cost (Coase, 1937; Williamson, 1985). Nevertheless, having necessary rules and laws alone may not be sufficient without effective enforcement. In many countries, the capacity of enforcement often requires political intervention and

social maturity. The interaction between economics, politics and social factors are important to gain economic efficiency.

In this thesis, institutions are expressed in three forms: economic institutions, political institutions and social institutions. The Institutional index is calculated by taking a simple average of the three factors. An economy with a higher degree of interaction will have a greater score of institutional indices compared to an economy with less interaction.

Institutional Index:

$$INS = \frac{1}{3}(ECO + POL + SOC)$$

Where Institution Index (INS) is calculated based on a simple average between economic institutions (ECO), political institutions (POL) and social institutions (SOC).

Economic institutions play a pivotal role in development economics. Acemogelu et al. (2005) present empirical evidence on the role of economic institutions as a fundamental factor causing differences in economic development. There are two forms of incentives derived from economic institutions: i. lower transaction cost and ii. property rights to asset owners. Transaction cost and property rights are captured from efficiency in the implementation of contracts. Different countries have different efficiency levels in enforcing a contract. We use time and cost of contracts to gauge economic efficiency. Countries with the lowest costs and fastest implementations tend to incentivise economic agents more than countries with higher costs and slower implementations. It is an important factor in influencing a firm's decision in investing in innovation and human capital.

Besides contracts and the rules of law, another part of formal constraint includes financial intermediation and trade liberalisation. The effective enforcement of contracts is pivotal in facilitating financial intermediation. Without resilient financial institutions, it is difficult to develop domestic investment capabilities. Effective enforcement reduces the risk to capital and then lowers the cost of capital. Hence, risk premium in the advanced economy tends to be lower compared to the developing countries. The lower cost of borrowing and the easy access to credit encourage entrepreneurial activities.

Meanwhile, trade liberalisation is also important in enhancing economic efficiency. A country that has opened up its economy tends to benefit from capital inflows and accumulation of foreign reserves (Bevan et al., 2004). Trade has a vital role in economic development, especially in the developing economy. Lack of effective domestic demand and limited domestic capital inhibit economic growth. Therefore, opening up an economy could integrate domestic economy into the global value chain using domestic capabilities and foreign direct investment. The East Asian economies, i.e. Japan, Korea, China, Taiwan, and Singapore have benefited from opening up their economy and have moved up in the growth paradigm in a relatively shorter span of time (Rasiah 2002, 2003; Wong & Chan, 2003).

Economic Institutions:

$$ECO = \frac{1}{4}(CONT + CONC + CREDIT + TRADE)$$

Where Economic institution (ECO) is calculated based on a simple average of time taken to implement contracts (CONT), cost of implementing contracts (CONC), Domestic credit as a percentage of GDP (CREDIT) and Trade openness (TRADE).

The role of institutions is limited not only as providing an incentive to the market to work efficiently. There is also the non-market role that has equal importance in contributing to the quality of economic growth. Political institutions are informal constraints that drive societal behaviour and play an important role in determining market efficiency. It allocates *de jure* political power to individuals and groups to determine the distribution of resources. Economic efficiency is achievable when political institutions allow the market to allocate property rights and relatively few rents left for political holders to capture (Acemolugu et al., 2005).

Participatory democracy is a major part of political institutions. A society that engages in a participatory democratic political system provides greater predictability, economic stability, a resilience to shock and superior distribution (Rodrik, 2000). Democracy allows for check and balance between self-interest capitalism and societal benefits. Historical evidence shows that democratisation has an important role in the underdeveloped countries. Barro (1996) finds that economies with a low level of political rights tend to stimulate economic growth and improve standards of living only when democracy is introduced. In the case of post-communist transition economies in Europe, a study by Fidrmuc (2003) suggests that democracy reinforces economic growth during the period of transition via facilitating economic liberalisation.

In this thesis, political institutions emphasise two major factors discussed earlier, i.e. democratisation and good governance. The process of democratisation is measured by political rights, freedom of press and civil liberty while good governance is represented by the level of corruption perception index.

Political Institution:

$$POL = \frac{1}{4}(CPI + PRESS + RIGHTS + LIBERTY)$$

Where Political institution (POL) is calculated based on a simple average of Corruption Perception Index (CPI), Press Freedom (PRESS), Political Rights (RIGHTS) and Civil Liberty (LIBERTY).

Social institutions are informal constraints that shape societal behaviour. Many past studies specify basic education, network cohesion, culture and religion as factors influencing institutional change coming from society (Veblen, 2009; Casson, 1994; Selznick, 1996). In this thesis, we emphasise two major factors influencing social behaviour: basic education and network strength. Basic education is the root of human capital development. No country has ever achieved sustainable economic development without investing in human capital (Ramcharan, 2004). The theoretical argument on human capital supports the role of education in economic development (Barro & Sala-I Martin, 1992; Barro, 1996; Ramcharan, 2004). While tertiary and technical education will assist innovation activity to flourish, basic education has its role in providing a simple understanding of production system in a firm. Besides education being a system of economic allocation, it also affects society by socialising individuals (Meyer, 1977). Schools are organised networks that allow individuals to interact and experience socialising. They prepare individuals to progress as a society.

Meanwhile, social interaction is more vibrant now with the availability of telecommunication and internet technology. Cross-border knowledge flows minimise the

problems associated with information asymmetry. Social connectivity and network cohesion allow productions to become more integrated, efficient and marketable beyond the geographical borders. Unlike the traditional market, internet platforms are replacing physical market to determine the clearing price. With minimum barriers to entry and many choices for consumers, the economic agents are better informed to make a rational decision (Rezabaksh et al., 2008). Network cohesion allows faster long-run convergence between different income levels (Cavalacanti et al., 2017).

Social Institutions:

$$SOC = \frac{1}{4}(PRIMARY + SECONDARY + INTERNET + TELCO)$$

Where Social institution (SOC) is calculated based on a simple average of Net Primary Education Enrolment (PRIMARY), Net Secondary Education Enrolment (SECOND), Internet Connection (INTERNET) and Fixed and Mobile phone connection per 100 people (TELCO).

3.4.3 Income per Capita

In the neoclassical growth model, economic output is expressed in the form of per capita rather than level data. The size of the countries tends to skew GDP data and does not represent the actual level of development. Therefore, by dividing the total real output with its population size, the average income of the population truly represents the level of development in an economy.

Given that the thesis deals with cross-country analysis, economic growth is better represented by the Gross Nation Income (GNI) per capita using the World Bank Atlas method. This method is developed by the World Bank to determine its operational lending policy and analytical purpose. The method is used to do a comparison between countries, considering that the exchange rate conversion and adjustments for inflation are accounted for.

The Atlas conversion factor is calculated by the World Bank (1989) using the following methodology:

Inflation rate (I) of an economy between period t and period t-n is measured by changes in GDP deflator (Pt).

$$I_{t-n} = \frac{p_t}{p_{t-n}}$$

International inflation rate (I^s) is measured by using the deflator of the International Monetary Fund's (IMF) unit of account, known as special drawing right (SDR). The SDR deflator (P^s) is a weighted average of GDP deflators (in SDR terms) of Japan, United States, United Kingdom and the Euro area.

$$I^s{}_{t-n} = \frac{P^s{}_t}{P^s{}_{t-n}}$$

The Atlas conversion factor (e^a) for each country for year t is given by:

$$e^a{}_t = \frac{1}{3}\left[e_t + e_{t-1}\left(\frac{I_{t-1}}{I^s{}_{t-1}}\right) + e_{t-2}\left(\frac{I_{t-2}}{I^s{}_{t-2}}\right)\right.$$

Where $e^a{}_t$ is the average annual exchange rate for the year t.

GNI per capita of a country in U.S. dollars (Atlas method) for year t ($Y_t{}^a$) is calculated as follows:

$$Y_t{}^a = \frac{Y_t}{e^a{}_t}/N$$

Where Y_t is GNI in current price (local currency), $e^a{}_t$ is atlas conversion factor and N is midyear population.

GNI per capita is a broad criterion used by the World Bank to distinguish the level of development whether a country is rich or poor. The thesis employs this criterion to group the samples by income levels, i.e. high-income, middle-income and low-income countries as prescribed by the World Bank.

However, there are some limitations in using this measure, which is commonly associated with the measurement of national income. While the method emphasizes reducing the fluctuation in exchange rates and global inflation, it does not account for domestic price changes. As an alternative, the Purchasing Power Parity (PPP) can be used to capture the domestic price changes. However, we have decided not to use the PPP method due to the limitation of having relatively shorter time series, inadequate geographical coverage, and a concern on the methodology and extrapolation techniques measured by PPP conversion factors.

3.4.4 Productivity of Labour and Capital Intensity

To run the econometrics procedure using the modified neoclassical production function, this thesis has included labour and physical capital measurements in the model. Labour is represented by labour productivity while capital is represented by capital

intensity. The labour productivity (lab) is defined as output provided by total labour force. The calculation is as follows:

$$LAB = \frac{Real\ GDP}{Total\ Labour\ Force}$$

In measuring the rate of capital accumulation, the thesis uses capital stock (published by International Monetary Fund) instead of gross fixed capital formation in the GDP calculation. The measurement of capital stock includes general government capital stock and private capital stock. It provides a better representation of investment of physical assets over time compared to the measurement of flows. We use capital intensity rather than capital stock to understand the orientation of the economy in its specialisation of production factors. Capital intensity (KI) is measured as a percentage share of GDP.

$$KI = \frac{Capital\ Stock}{GDP} \times 100$$

3.5 Missing Data and Multiple Imputation

Most study on the link between innovation, institutions and economic growth in the past were conducted in the HICs. The unavailability of quality data is the major reason the studies were restricted to HICs. Nonetheless, with the recent development in institutions and innovation-based surveys and data collection by the International Organisation, the thesis has managed to compile a fairly comprehensive dataset that covers geographical boundaries across income levels. Furthermore, with recent improvement in the techniques of analysing missing data, the empirical research including the sample of MICs and LICs are feasible now.

It is important to note that the analysis of causality requires a long time series data as the output from the empirical test is sensitive to the lag selection process. For lack of better procedures, scholars in the past tended to simply aggregate covariates into five or ten-year averages. As a result, the study tends to lose out on potential information as explained by Honaker and King (2010) using various past research examples.

Ideally, scholars want to test parameters using observed data. In reality, however, missing values in cross-country time series data are often unavoidable. Data availability in a cross-country panel study is mostly scattered and discontinued, especially in the LIC and MIC economies. Even in the HICs, not all data are collected on a fixed frequency, e.g. income distributions and Gini coefficients are collected based on different intervals. To address the missing data problem, the common techniques such as listwise deletion is the most convenient method for fixing the missing value problem. However, such techniques come at the expense of preceding useful information that is relevant to make a policy recommendation. Hence, rather than simply deleting the data, quantitative analysis with missing values are becoming more acceptable lately due to the development of sophisticated multiple imputation techniques.

Multiple Imputation (MI) was introduced by Rubin (1987) and has been widely used in various disciplines including healthcare (Harel & Zhou, 2006), behavioural ecology (Nakagawa and Freckleton, 2010) and most importantly, in economics (Spence, 2007; Honaker & King, 2010; Castellaci & Natera, 2011). The MI method estimates missing values based on the information gathered from the observed data. The MI method is unlike listwise deletion and other ad hoc procedures which fill in missing data by simply imputing the mean or just base on intuition. For example, Spence (2007) criticises the

seminal work of Rodrik (1998) on economic openness and the size of the government. The findings from Spence show that Rodrik's results are sensitive to the treatment of missing values and after using updated data, Rodrik's original findings are found insignificant. Similarly, Honaker and King (2010) re-estimate the work of Baum and Lake (2003) on democracy and growth as the study which uses the listwise deletion method appears to produce conflicting results against the norm. With the MI method, Honaker and King (2010) find that the effect of democracy is consistent with earlier works done in the field.

The imputation method follows three steps: impute data series, analyse the completed data sets and integrate (pooling) data for the final result. The computational algorithm is employed to generate imputed data. The estimation is repeated (m) number of times to produce m complete datasets. Each complete dataset will have the same observed values, but imputed data varies depending on an estimated uncertainty in predicting the missing values (Castellaci & Natera, 2011). Finally, the regression analysis is estimated from each completed dataset before pooling them together for the final result.

The most common method for running statistical analysis is the rectangular dataset. However, when a study is found with missing values, the researcher has two options: discard the missing values or fill in the data using statistically accepted techniques. In the case of MI techniques, two assumptions are usually observed. Firstly, the data is assumed as "Missing at Random" (MAR) where the missing data (Dmis) can be predicted by the observed data (Dobs), or p (M/D) = p (M/Dobs). Therefore, the key to improve MI output is to include more information that is relevant to the model so that stringency of ignorance is minimised (Schafer and Olsen, 1998; Honaker and King, 2010). Secondly, the data (D) is assumed to have a multivariate normal distribution: D ~ N (μ, σ^2) where $\mu \; and \; \sigma^2$

represent mean and variance. This assumption is useful in describing each function as linear to the others (Castellaci and Natera, 2011).

There are two statistical algorithms commonly used to take a random draw on $\mu \, and \, \sigma^2$. They are the Monte Carlo-based method called Imputation-Posterior (IP) approach and Expectation Maximization importance sampling (EMis) approach. However, both approaches have limitations in running a large panel dataset. They may take hours and days to run and they cannot be fully automated given that the models rely on stochastic convergence rather than deterministic convergence (King et al, 2001). Moreover, it is also reported that the methods created are unacceptable for long-run time series imputed data (Honaker and King, 2010).

In this study, we use Honaker and King (2010) multiple imputation using Expected Maximization Bootstrap (EMB) algorithm, which is developed especially for handling large panel dataset. Unlike EMis and IP methods with the algorithm requiring hundreds of computer-coded lines, the bootstrapping method can be implemented with a few lines. The bootstrapped estimates of $\mu \, and \, \sigma^2$ have similar properties to draw from the posterior in large samples (Efron, 1994). In addition, bootstrapping has lower order asymptotic than parametric approaches of IP and EM (Honaker & King, 2010).

The major contribution from Honaker and King (2010) is the novelty of running MI on the panel data. Commonly used MIs are not organised in a hierarchical structure and often consider missing values as a linear function. However, those assumptions are invalid for a panel data. Honaker and King (2010) address this issue by providing solutions to smooth the process of the time series and reduce cross-country heterogeneity in a panel data. The researchers could choose the basic smoothening functions using

software developed by Honaker, King and Blackwell (2011) called Amelia II: A Statistical Computing using R-Statistic interface.

3.6 Conclusion

In this chapter, we have presented the conceptual framework to address research questions raised in Chapter One. The framework aims to capture the link between institutions, innovation and economic growth across the income levels. The link is established by performing empirical analysis to identify three objectives. The first is to identify the direction of causality, second, the short-run and long-run relationship between innovation, institutions and economic growth and finally, the role of institutions as a moderator to enhance the effectiveness of innovation activity to economic growth.

The empirical framework in this thesis is developed using neoclassical production function as the basis. Besides capital and labour factors, the production function in this thesis also includes the innovation and institution variables to explain the economic growth. These are abstract factors and therefore, a broader definition is required to represent these factors. Unlike past researches which often used a single proxy to represent these factors, this thesis has employed nineteen indicators to construct five sub-indices (two for innovation and three for institutions) that represent the innovation and institution indices. In our view, the broad-based indicators supported by past growth literature has a stronger representation to reflect the abstract factors.

CHAPTER 4: **INSTITUTIONS, INNOVATION AND ECONOMIC GROWTH AT DIFFERENT INCOME LEVELS**

4.1 Introduction

This chapter seeks to examine the progress of institutions, innovation and economic growth at different income level. It is common understanding that innovation and institutions are better in the developed economies compared to the developing countries. However, in this chapter we attempt to analyse whether innovation and institutions are indeed influenced by the income level or otherwise. The thesis uses a simple analysis such as descriptive statistic, scatter plot and correlation analysis to understand the level of innovation and institutions indices across different income levels.

4.2 Analysis of Institution and Innovation Index and the Economic Growth

The descriptive statistic from Table 4.1 shows the level of income per capita, innovation index and institution index based on the income levels. Between the year 2003 to 2013, the per capita income expanded most in the MICs at annualised growth rate of 10.1 per cent compared to 7.67 per cent in LICs and 6.0 per cent in HICs. Despite of the higher growth rate in the MICs and LICs, the median per capita income in HICs is still higher almost by ten times more than the MICs and 75 times larger than LICs in 2013. Hence, the effective demand is larger in the HICs compared to MICs and LICs. This signifies that the divergence of economic growth between the rich and poor countries

remain despite the economic scholars have continuously seeking to find for solution on how the reduce this gap in the global economy.

Interestingly, the divergence between the income levels do not only appear in per capita income level, but a similar trend is also observed in the innovation and institutional indices. The innovation and institutional index in HICs are mostly ranked in the top 30 percent while LICs rank at the bottom 30 percent. This is an important beginning in our search to study the dynamic links between institutions, innovation and economic growth where we found that the level of innovation and institutions appears to be different across income levels.

Scatterplots in Figure 4.1 and Figure 4.2 illustrate the linear relationship between innovation-growth and institution-growth for the year 2013 respectively. All these factors have been converted to log function to show the linear relationship. The institution and innovation index have exhibited a positive relationship with economic growth with the R-squared of both indexes at 0.85 and 0.80 respectively. The strong positive relationship would suggest that institutions and innovation exhibit positive relationship with the per capita income. Nonetheless the positive relationship alone is not enough to understand the dynamic of how these factors interact. The causality is also important to confirm if innovation and institutions drive per capita income or the reverse or these factors mutually reinforce each other.

Table 4.1 - Descriptive Statistic

		2013								2003							
High Income		Yt	INV	INVIN	INVOUT	INST	ECO	POL	SOC	Yt	INV	INVIN	INVOUT	INST	ECO	POL	SOC
	Mean	47200	80	82	79	75	70	76	80	26477	81	81	81	76	69	76	83
	Median	46350	82	84	80	75	69	78	81	27120	83	83	84	76	70	77	83
	Std. Dev.	19616	8	8	10	7	12	7	8	9904	8	9	8	7	11	7	9
	Observations	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
Middle Income		Yt	INV	INVIN	INVOUT	INST	ECO	POL	SOC	Yt	INV	INVIN	INVOUT	INST	ECO	POL	SOC
	Mean	5356	45	44	46	42	44	36	47	2046	44	44	44	43	47	36	46
	Median	4940	44	43	45	42	45	34	50	2090	44	44	43	45	46	33	49
	Std. Dev.	3249	14	14	15	12	15	18	16	1436	13	14	15	12	15	17	15
	Observations	37	37	37	37	37	37	37	37	37	37	37	37	37	37	37	37
		Yt	INV	INVIN	INVOUT	INST	ECO	POL	SOC	Yt	INV	INVIN	INVOUT	INST	ECO	POL	SOC
Low Income	Mean	611	20	18	19	26	35	24	17	292	19	21	20	24	32	24	15
	Median	615	21	18	20	26	36	23	16	280	19	21	20	24	29	22	15
	Std. Dev.	201	13	10	7	6	9	14	10	112	9	7	5	6	12	14	9
	Observations	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18

Source:Author

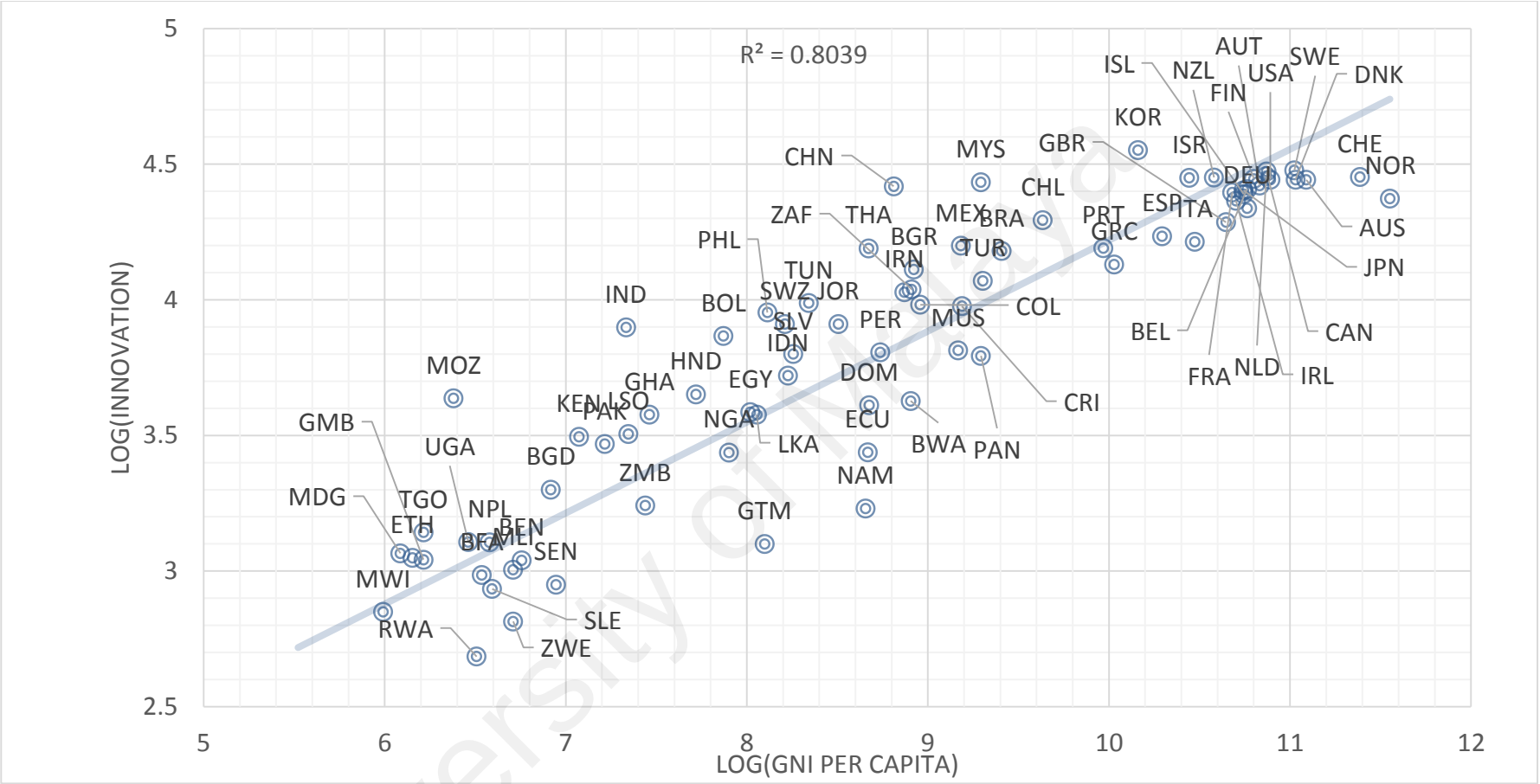


Figure 4.1: Innovation and Economic Growth

Source: Author

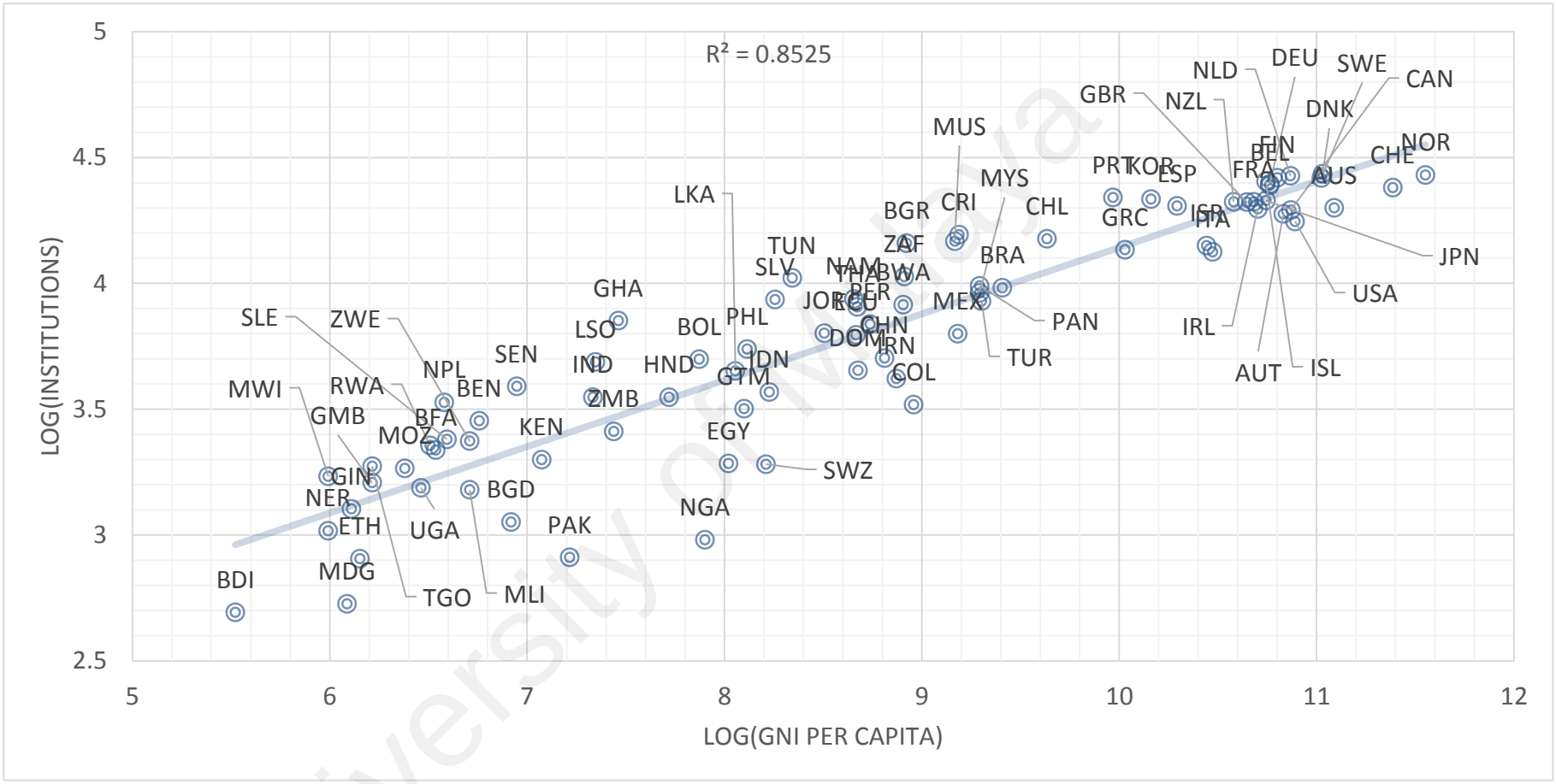


Figure 4.2: Institutions and Economic Growth

Source:Author

Besides linear relationship, Figure 4.3 demonstrates a nonlinear relationship between institutions, innovation and economic growth. In these charts, the institution and innovation index is plotted against the value of GNI per capita and not the log function. We use the nonparametric Locally Weighted Scatterplot Smoothing (LOWESS) techniques pioneered by Cleveland and Mallows (1993) to identify the nearest neighbouring fitted regression line. This regression line displays locally-weighted polynomial regression fit. The fitted line of institution and innovation index suggests a similar positive trend between institutions, innovation index and economic growth.

However, the major difference between the linear and the nonlinear is the relationship of the regression line across the income levels. The nonlinear figure (Figure 4.3) show that the underdeveloped economies require a leapfrog in institutions and innovation to realise higher per capita income as exhibited by the sharply inelastic nature of the regression line. In contrast, the regression line turns flattering in the HICs, where small changes in the institution and innovation index result in a higher expansion of economic growth. Moreover, the economies in the frontier of the institution and innovation curve see a continued expansion in the economic growth which indicates the benefit of being a frontier economy.

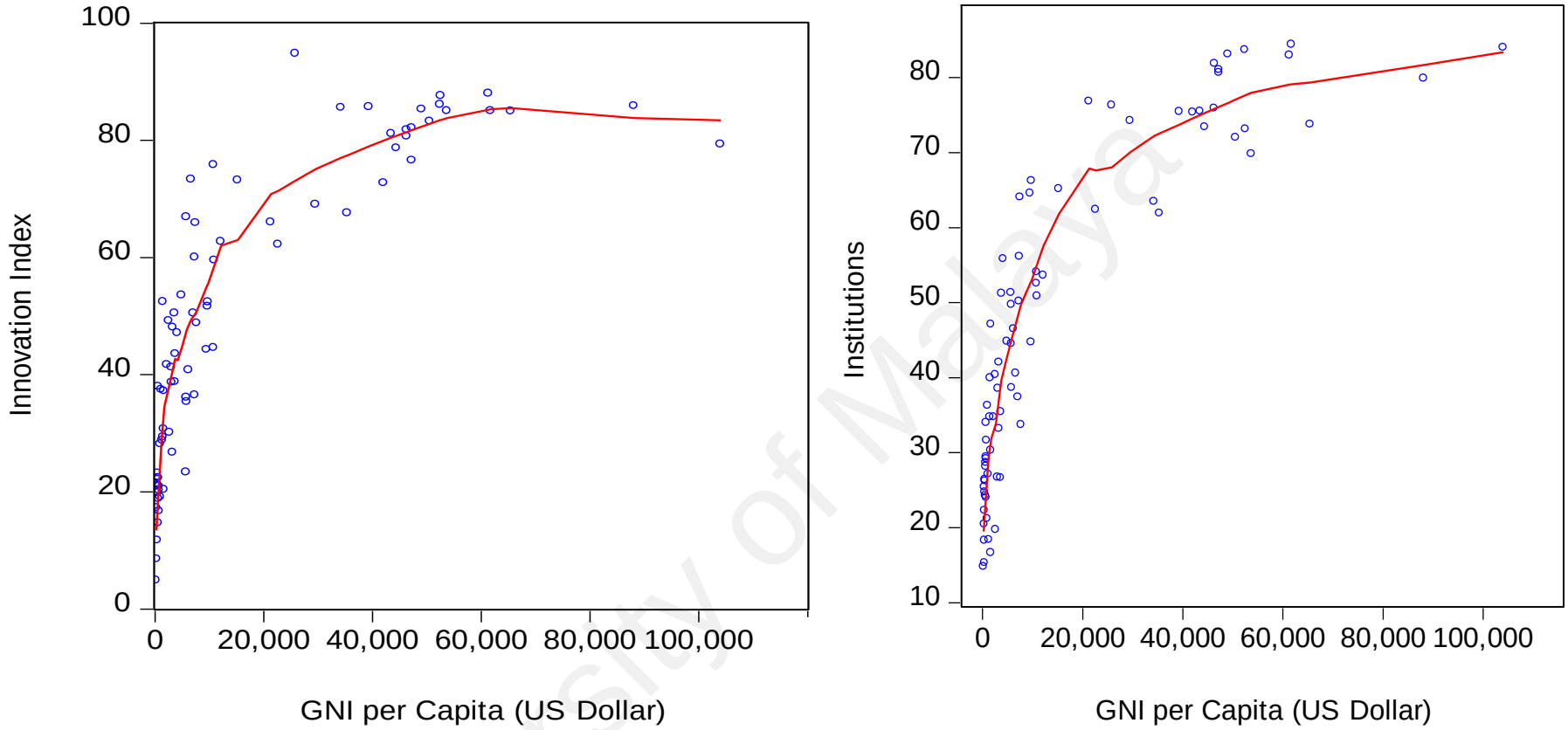


Figure 4.3: Non-linear Relationship Between Institutions, Innovation and Economic Growth

Source: Author

Likewise, the descriptive statistic in Table 4.1 also suggests that the ranking of innovation and institutions appears to be moving parallel with the direction of income per capita. It is not surprising that the median ranking of innovation and the institution index is dependent on the income levels. Past studies confirm that innovation happens more aggressively in HICs due to the readiness of incentives in these economies. In contrast, the weakness in acquiring innovation capabilities and ineffectual institutions has contributed to a slower growth in LICs and MICs (Peretto, 1998; Akcay, 2011; Anokhin & Wincent, 2012). This has hindered convergence between the developed and underdeveloped economies.

During the period of our study between 1980 and 2013, it is found that South Korea is one of the economies that have been remarkably successful in graduating from a developing economy to a high-income OECD country in a short span of time. It gives hope to other developing countries as they too can progress to become frontier economies despite having the limitations of underdeveloped economies. In 1980, South Korea was an underdeveloped economy with a per capita income of only USD$1900. However, in the year 1996, it successfully transformed itself to become a member of the OECD countries and by 2013, the per capita income had increased by more than twelve folds to USD$25 870. As a latecomer, South Korea has embraced economic and institutional reforms by opening its market and increase exports capabilities by focusing on imitation and innovation process, especially in exporting industries (Kim, 1995; Lee & Lim, 2001; Fagerberg & Godinho, 2003). Some scholars argue that South Korea rapid development prompted by high investment in physical and human capital (Young, 1994; Krugman, 1994). Nonetheless, Pack and Nelson (1999) call these argument as “accumulation theories” where in contrast, they believe the true factors driving rapid growth in Korea is

not the accumulation of physical and human capital, but the risk-taking entrepreneurial culture, effective learning and innovation which they call "assimilation theories" (Kim and Nelson, 2000). The assimilation theories explain the strong economic growth in Korea as exhibited in Figure 4.4. Even though the positive relationship is clearly illustrated by the scatterplot, the direction of causality is something that requires further analysis. Only then, the thesis can confirm if institutions and innovation do influence the economic growth or otherwise.

To further understand the relationship between institutions, innovation and economic growth across the income levels, Table 4.2 reports a correlation analysis between these factors and the t-test of the correlations. The results show a high correlation between innovation-growth and institutions-growth in the overall sample. A similar relationship is also found in the innovation and institutional sub-indices in the overall sample. However, when the correlation test is conducted by differentiating the income levels, the result undergoes some changes. The HICs and MICs exhibit a higher correlation between innovation and economic growth, but in LIC, the correlation stays low at 0.1. The institutional index, however, shows a high positive correlation with economic growth across the income levels.

While the correlation analysis provides some indication of the relationship between the factors, the correlation analysis does not necessarily imply causality and the results could be simply spurious. Hence, it requires further investigation on the causal relationship to understand the "cause and effect" between these factors. The causality test is performed using the Dumistrsu-Hurlin bivariate causality analysis and Toda-Yamamoto long-run multivariate analysis.

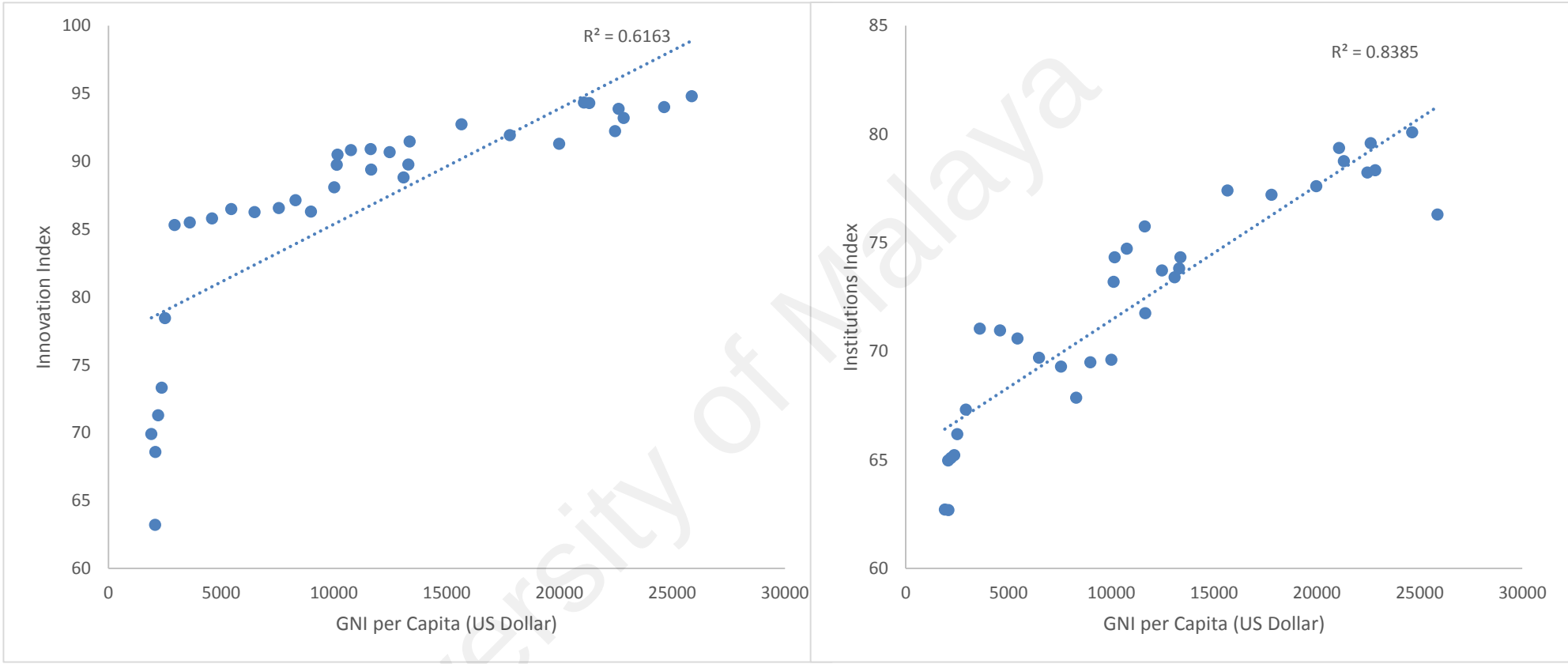


Figure 4.4: Relationship Between Institutions, Innovation and Economic Growth in South Korea (1980-2013)

Source: Author

Meanwhile, Figure 4.5 shows the median changes in the ranking of institutions and innovation index between the year 1980 and 2013. The changes in the ranking of institution and innovation index happen at a slower pace compared to changes in the per capita income. It seems like the median of institution and innovation ranking only change marginally in the long run. Many of the individual countries that we take upon to study in this thesis hardly show any significant movement in their rankings on innovation and institutional index (refer to Figure 4.6). The HICs are in firm footing at the innovation frontier while the catching up pace in the MICs and LICs remain moderate, except for countries like Korea and the transitional economies in Europe.

Nevertheless, there are some marginal improvements in the MICs and LICs ranking, mainly improvement in the social institutions and economic institutions. In the MICs, median ranking of the social institutions has advanced by four rankings compared to the average period of 1990-1995. Social institutions are represented by basic education and connectivity. The MICs have provided better access in primary and secondary education during this period. Likewise, mobile connectivity and internet access also have increased across the income levels, especially in the MICs. These have improved the MICs scoring in their institution rankings over the years.

Table 4.2 Correlations Between Institutions, Innovation and Economic Growth

Variables		All		High-Income OECD		Middle-Income		Low-Income	
		Correlation	t-Stats	Correlation	t-Stats	Correlation	t-Stats	Correlation	t-Stats
LNINV	**LNY**	**0.845**	**82.335**	**0.450**	**14.679**	**0.451**	**17.925**	**0.143**	**3.572**
LNINVIN	**LNY**	**0.763**	**61.509**	**0.365**	**11.418**	**0.316**	**11.803**	**0.130**	**3.249**
LNINVIN	LNINV	0.920	122.103	0.920	68.130	0.855	58.541	0.627	19.902
LNINVOUT	**LNY**	**0.761**	**61.224**	**0.459**	**15.038**	**0.467**	**18.708**	**-0.037**	**-0.909**
LNINVOUT	LNINV	0.914	117.500	0.897	59.240	0.872	63.261	0.643	20.723
LNINVOUT	LNINVIN	0.707	52.078	0.653	25.092	0.508	20.920	-0.095	-2.359
LNINS	**LNY**	**0.870**	**92.179**	**0.484**	**16.106**	**0.579**	**25.167**	**0.465**	**12.957**
LNINS	LNINV	0.846	82.758	0.596	21.589	0.466	18.676	0.208	5.259
LNINS	LNINVIN	0.763	61.467	0.504	16.975	0.344	12.971	0.090	2.240
LNINS	LNINVOUT	0.767	62.377	0.576	20.502	0.460	18.378	0.100	2.485
LNECO	**LNY**	**0.676**	**47.865**	**0.218**	**6.490**	**0.337**	**12.696**	**0.264**	**6.763**
LNECO	LNINV	0.623	41.471	0.443	14.395	0.277	10.223	-0.135	-3.377
LNECO	LNINVIN	0.552	34.505	0.383	12.083	0.188	6.774	-0.099	-2.455
LNECO	LNINVOUT	0.560	35.271	0.414	13.255	0.280	10.326	-0.119	-2.965
LNECO	LNINS	0.814	73.040	0.764	34.471	0.701	34.835	0.599	18.462
LNPOL	**LNY**	**0.704**	**51.670**	**0.517**	**17.611**	**0.336**	**12.649**	**0.227**	**5.760**
LNPOL	LNINV	0.652	44.796	0.444	14.440	0.117	4.171	0.326	8.526
LNPOL	LNINVIN	0.590	38.089	0.308	9.425	0.073	2.584	0.194	4.894
LNPOL	LNINVOUT	0.600	39.100	0.514	17.450	0.132	4.728	0.219	5.543
LNPOL	LNINS	0.808	71.604	0.727	30.861	0.605	26.898	0.641	20.606
LNPOL	LNECO	0.459	26.934	0.321	9.854	0.061	2.183	-0.061	-1.506
LNSOC	**LNY**	**0.804**	**70.550**	**0.350**	**10.883**	**0.607**	**27.039**	**0.411**	**11.139**
LNSOC	LNINV	0.848	83.295	0.372	11.672	0.576	24.969	0.303	7.863
LNSOC	LNINVIN	0.769	62.765	0.364	11.377	0.437	17.229	0.129	3.202
LNSOC	LNINVOUT	0.764	61.804	0.303	9.260	0.569	24.513	0.124	3.092
LNSOC	LNINS	0.899	106.753	0.653	25.126	0.818	50.355	0.628	19.935
LNSOC	LNECO	0.655	45.181	0.185	5.470	0.458	18.235	0.273	7.020
LNSOC	LNPOL	0.623	41.529	0.335	10.355	0.320	11.964	0.168	4.203

Source: Author

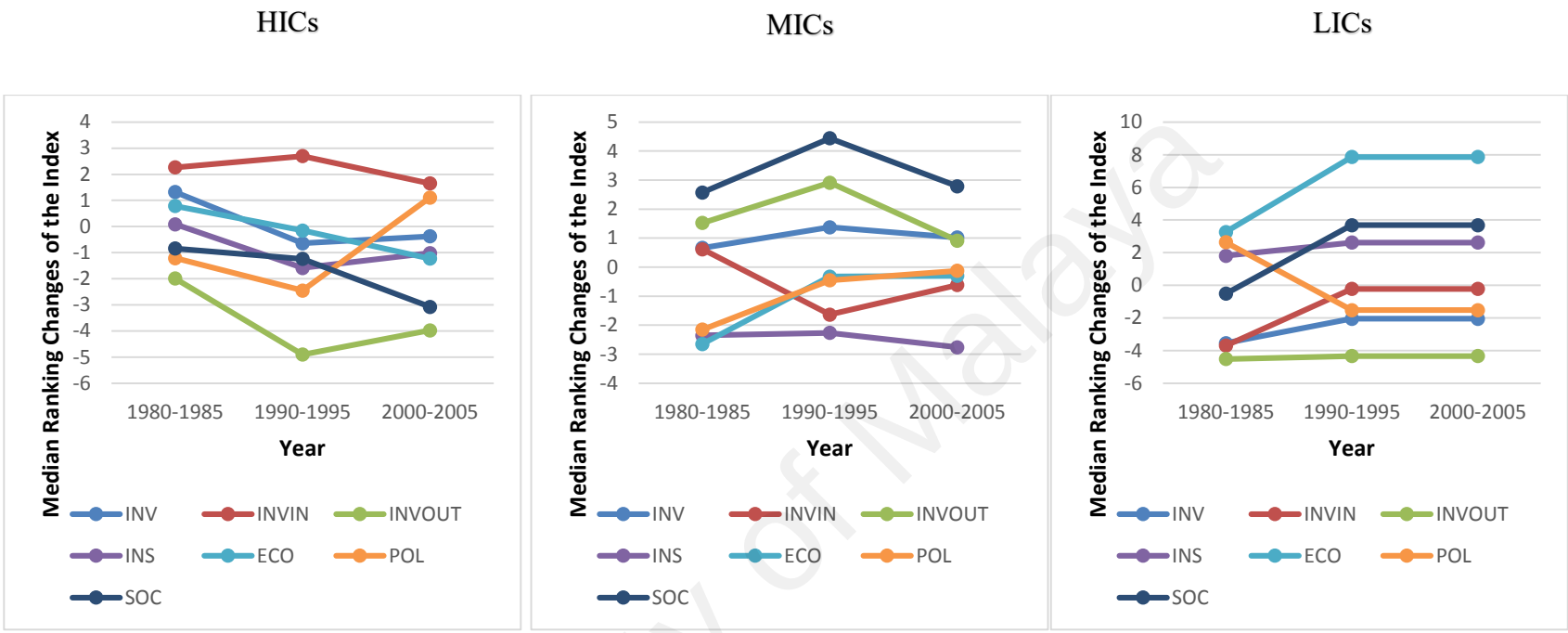
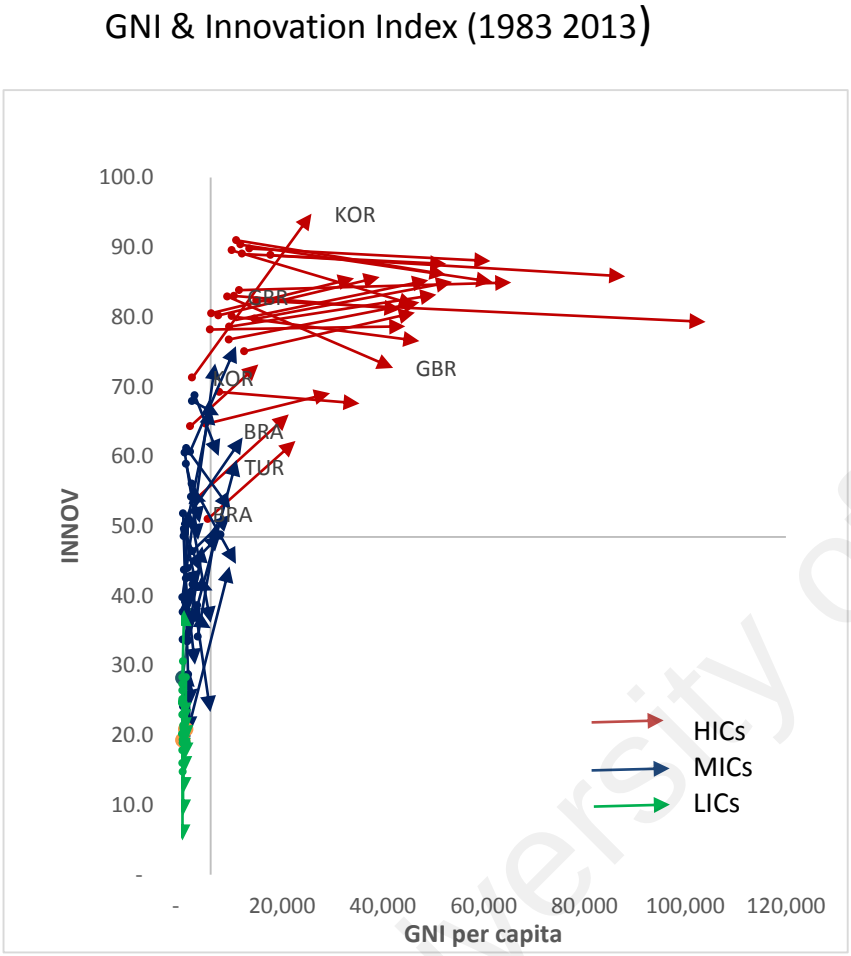


Figure 4.5: Median Ranking Changes (compared to year 2013)

Source: Author



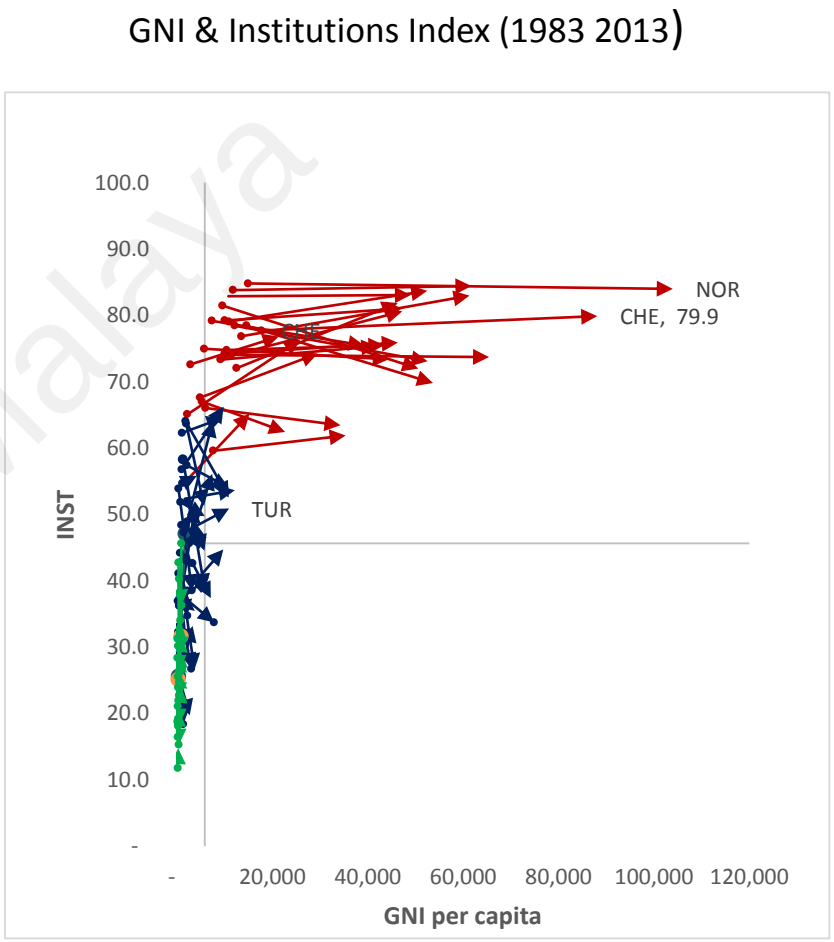


Figure 4.6: Changes in Institutions and Innovation Ranking Between 1980 and 2013

Source: Author

Similarly, some improvements in economic institutions are traced in the LICs after the 1990s. The improvement in economic institutions refers to a reduction in transaction cost, increase in trade openness and improvement in credit access. In the early 1990s, the Washington consensus came into effect. The LICs could have adopted the prescriptions listed in the Washington consensus including globalisation and liberalisation of the economy as many of these economies were depending heavily on funding from the World Bank. In addition to that, the World Trade Organisation (WTO) established in 1995 further promotes the opening up of the global trade, which has benefitted developing countries like China in reducing its poverty rate.

Besides the economic institutions, the median rank of social institutions in the LICs also has improved. The LICs begin investing in basic education and connectivity, especially in countries that have recovered from internal conflicts and civil war. The median social institutions in LICs have gained four positions since the period starting from 2000-2005.

4.3 Conclusion

The descriptive statistics and scatterplots presented in the analysis section illustrate a positive relationship between institutions-growth and innovation-growth. The HICs enjoy the benefits of being in the institutions and innovation frontier. The non-parametric regression fitted line is flatter in the HICs, indicating that growth continues to expand as these economies hold on to their positions in the frontier. In contrast, MICs and LICs register a lower ranking of both the institution and innovation index. Moreover, the movement in the median ranking of institution and innovation index is also very marginal

and changing at a slower pace. Hence, to catch up, the underdeveloped economies are required to leapfrog and advance in institution and innovation index ranking as reflected in the successful accession economies like Korea.

While the institution and innovation index move together in a positive direction with growth, it is still unclear if institutions and innovation drive growth or otherwise influence each other mutually. Therefore, a causality test is required to avoid any misconception and spurious result.

CHAPTER 5: **THE DYNAMICS OF CAUSALITY**

5.1 Introduction

Scholarly evidence on the relationship between the "cause and effect" of innovation, institutions and economic growth remains scarce. While the neoclassical and endogenous growth theory simply assumes that innovation explains growth, the debate on the causal relationship is still ongoing. Similarly, new-Institutionalism scholars too assume that institutions drive economic growth. In this sense, there are enough theoretical underpinnings to explain the role of institutions and innovation in driving economic growth.

From the previous chapter, the charts illustrate a positive relationship between institution-growth and innovation-growth. However, the strength of the relationship may differ depending on level of income. For instance, in the underdeveloped countries, unproductive physical capital, insufficient human capital and a lack of good governance are some important factors that explain why innovation and institutions do not contribute to economic growth significantly. Budget constraint limits the government's ability to invest in human capital and R&D. This condition prevails in underdeveloped economies that could result in a vicious cycle which explains why poor countries remain poor as articulated by Ragnar (1952).

Nonetheless, two main questions remain unexplored and require further investigation. First is the question of causality direction between these factors and second is whether

the causality moves in the same direction regardless of their income levels. To answer these questions, the thesis requires the construction of reasonable empirical measures that could represent the broader definition of innovation and institutions. The quantification of the index allows the thesis to rank countries based on their innovation capability and institutional strength. The construction of the innovation and institution index has been presented in chapter three.

This chapter, we present the analysis of causality direction between innovation-growth and institution-growth. More importantly, the key focus is on establishing the causal direction of these factors among the various income levels. The evidence from this empirical exercise would lead to a better understanding of the dynamic link between institutions, innovation and economic growth across the income levels. The results could enhance policy recommendation and contribute to the existing literature on the growth theory.

5.2 Causality Testing: Methods

This section explains the methodology uses for drawing the empirical inferences on the dynamics of causality.

5.2.1 Unit Root Test

Testing for stationarity is a common practice in handling time series and panel data. Unit root tests are applied to establish whether a time series is non-stationary and

possesses a unit root (stochastic) process. Having tested for unit root, the thesis could avoid potential spurious regression problem and improve the quality of policy recommendation.

The unit root problem is written as follows:

$$Y_t = \rho Y_{t-1} + u_t \qquad -1 \leq \rho \leq 1 \tag{5.1}$$

Where u_t is white noise.

When ρ=1, the equation 5.1 exhibits a random walk without drift, which is known as a nonstationary stochastic process. Alternatively, in practice, the unit root test is estimated based on the first difference of Model 5.1.

$$\Delta Y_t = \delta Y_{t-1} + u_t \text{ where } \delta = (\rho - 1) \tag{5.2}$$

The null hypothesis is to test if δ=0 or ρ =1, which means the time series is nonstationary. However, the null hypothesis cannot be tested using t-value, given that the estimated coefficient of Y_{t-1} does not have asymptotic normal distribution. As an alternative, the τ- statistic estimated by Dickey and Fuller (1979) using tau (τ) critical value is used to test the null hypothesis.

The Dickey-Fuller (DF) test assumes that u_t (error term) is uncorrelated. However, commonly-tested models with large and complicated time series data show that u_t are correlated. Therefore, the Augmented Dickey-Fuller (ADF) test is developed by adding the lagged values of the dependent variable. The estimation is written as below:

$$\Delta Y_t = \alpha + \beta_t + \delta Y_{t-1} + \sum_{j=1}^{p-1} \emptyset_i \, \Delta Y_{t-j} + \varepsilon_t \tag{5.3}$$

Where α and β represent constant and time trend. The null hypothesis of ADF still follows the same asymptotic distribution as DF statistic, where the data is nonstationary when δ=0. However, by including the lags (p) in the model, ADF formulation allows for the higher order of autoregressive process.

Even though the ADF test is commonly used in a time series analysis to test the unit root, its usage in a panel data is somewhat limited. The ADF test is less powerful to reject the null hypothesis of a non-stationary unit root in a panel data. The panel-based unit root tests have a higher power to reject the null hypothesis compared to a separate unit root test for individual time series (Maddala and Wu, 1999; Levin et al., 2002; Hadri, 2000; Pesaran, 2007). The condition is especially true when the time series is relatively shorter (Campbell & Perron, 1991).

Nonstationary test in a heterogeneous panel data deserves serious attention. This thesis tests macro panel data that has a large number of countries (N) and lengthy time series (T). Various alternative methods are used by researchers to test the unit root for heterogeneous panel data. The test is divided into two major categories: i. common unit root process and ii. individual unit root process. In a common unit root process, the parameters ($\boldsymbol{\rho}$) are identical across cross-sections. The test assumes a common auto regressive (AR) structure for all series. There are three commonly used methods in testing common unit root process namely, Levin et al. (2002) (henceforth LLC), Breitung (2001) and Hadri (2000).

The LLC test assumes that both time series and cross-section dimensions grow arbitrarily large to fulfil asymptotic assumption. LLC considers joint limit asymptotic in which both N and T approach infinity, subject to conditions such as $\sqrt{N/T} \to 0$ in some

models and $N/T \rightarrow 0$ in others. It argues that individual unit root tests have limited power to reject the null hypothesis due to a highly persistent deviation from equilibrium (Baltagi, 2014). It has a homogenous autoregressive root under the alternative compared to heterogeneity autoregressive root tested by Im et al. (2003) (henceforth IPS). The LLC model is written as below:

$$\Delta Y_{i,t} = \delta Y_{i,t-1} + \sum_{j=1}^{Pi} \theta_{ij} \Delta Y_{it-j} + \alpha_{mi} d_{mt} + \varepsilon_{it} \qquad (m = 1,2,3) \qquad (5.4)$$

Where d_{mt} indicates the vector of deterministic trend and α_{mi} represents the corresponding vector of ccoefficients for the model (m=1, 2, 3). The mode is as follows: $d_{1t} = \emptyset\ (empty\ set),\ d_{2t} = \{1\}$ and $d_{3t} = \{1, t\}$. The null hypothesis is still similar to ADF where (H0: δ=0) is against the alternative that each time series is stationary (H0: δ≠0). Since the lag order (Pi) is unknown, we choose Pi based on optimum lag from Akaike Information Criterion (AIC).

Unlike the LLC that observes the common unit root process, the IPS observes an individual unit root process that is similar to the Fisher type test proposed by Maddala and Wu (1999) and Choi (2001). When a large enough lag order is selected for underlying ADF regression, IPS performs better than the LLC test. Moreover, the LLC test requires δ to be homogenous across countries (i). However, the IPS allows for heterogeneous coefficient of Y_{it-1} where the nonstationary test is conducted by averaging individual unit root statistics. The average ADF test is reported when u_{it} is serially correlated with different serial correlations across *i* using Model 3.4. The null hypothesis of the unit root is written as:

$H_0: \delta_i=0, for\ all\ i$ (5.5)

Against the alternatives

$H_1: \delta_i<0,\ for\ i=1,2,...,N_1,\quad \delta_i = 0,\ for\ i=N_1+1, N_1+2,...,N.$ (5.6)

The alternative hypothesis requires some of the individual time series that are stationary to be nonzero, i.e. $\lim N\to\infty\ (N1/N) = \gamma$ where $0<\gamma\leq 1$ and the conditions are necessary for the consistency of the test (Baltagi, 2014).

Meanwhile, Breitung (2001) provides an alternative method for Levin and Lin (1993) and Im et al. (1997) which suggests bias adjusted t-statistic when individual specific trends are included. The local power of panel unit root statistic is affected by two factors: i. asymptotic effect is biased due to the de-trending method and ii. local parameters of the limiting distribution are under the sequence of local alternatives. Hence, in the Breitung test, the only autoregressive portion is excluded, and proxies are transformed and de-trended. It includes the power to reject the null hypothesis.

Hadri (2000) offers a null hypothesis test on stationarity against null hypothesis on unit root as per suggested by other methods mentioned above. The test is a complement to the existing methods on deciding hypothesis on stationarity. It is similar to Kwiatkowski et al. (1992) KPSS test that is based on residuals from individual Ordinary Least Square (OLS) regression on a constant trend.

5.2.2 The Bivariate Granger Causality Test

A correlation study can be meaningless, as the direction does not necessarily imply causality and the results could be simply spurious. Hence, it is useful to test causality, which is essential to understand the fundamental relationship between different factors or variables. Granger (1969) provides a useful methodology to establish the "cause and effect" using the forecasting model. For example, supposing there are two stationary time series variables X_t and Y_t with zero means and forecast of X_{t+1} using past information of X_t and Y_t. If adding the lag of Y_t can improve the prediction of $X_{t+1,}$ then X is Granger-caused by Y. The bivariate form of regression is written as below:

$$X_t = \propto_0 + \propto_1 X_{t-1} + \ldots + \propto_n X_{t-n} + \beta_1 Y_{t-1} + \ldots + \beta_n Y_{t-n} + \boldsymbol{\varepsilon}_t$$

$$Y_t = \propto_0 + \propto_1 Y_{t-1} + \ldots + \propto_n Y_{t-n} + \beta_1 X_{t-1} + \ldots + \beta_n X_{t-n} + u_t \qquad (5.7)$$

where $\boldsymbol{\varepsilon}_t$ and u_t are uncorrelated white noise series.

The null hypothesis for the first regression is that Y_t does not Granger Cause X_t as the joint hypothesis of the Wald Statistics is written as:

$$\beta_1 = \beta_2 = \cdots \beta_n = 0 \qquad (5.8)$$

Meanwhile, in a panel data, there are various approaches to test for Granger non-causality. In the case of bivariate analysis, there are two standard approaches – first, by letting the panel data be treated as one large stacked data and the second approach is by assuming individual coefficients across cross-sections.

The second approach is the most relevant for this thesis given the nature of the data, which has to deal with the heterogeneity problem. The method is adapted from Dumitrescu-Hurlin (2012), on testing for Granger non-causality on a heterogeneous panel data with fixed coefficients. In a panel data, cross-country causality observed in one country can also exist in some other countries. The use of cross-country information involves heterogeneity across the individual country in establishing causal relationship. Therefore, imposing homogeneity on the coefficient can lead to fallacious inference.

Panel causality linear model adopted from Granger (1969) is observed for each country i=1,2,3,,,,,N and T periods at time t=1,2, 3,,,T written as follows:

$$Y_{i,t} = \alpha_i + \sum_{l=1}^{L} \gamma^{(l)} Y_{i,t-l} + \sum_{l=1}^{L} \beta^{(l)} X_{i,t-l} + \sigma_{i,t} \quad (5.9)$$

The model assumes a balanced panel data where lag (L) orders are identical for all cross-section units. For simplicity, α_i(individual effects) is to be fixed in the time dimension. It allows the autoregressive parameters $\gamma^{(l)}$ and regression coefficients slope $\beta^{(l)}$ to be varied across cross sections. However, both parameters are constant in time.

The model requires three assumptions to be fulfilled:

1. Individual residuals $\sigma_{i,t}$, $\forall t = 1 \ldots, T$ are independently and normally distributed with E($\sigma_{i,t}$) = 0 and finite heterogeneous variance E($\sigma^2{}_{i,t}$) = $\mu^2{}_{\sigma,t}$.
2. Individual residuals are independently distributed across groups.
3. Both variables are covariance stationary E ($Y^2{}_{,,t}$) < ∞ and E ($X^2{}_{,,t}$) < ∞ .

The Dumitrescu-Hurlin model proposes to test the Homogenous non-causality (HNC) hypothesis by allowing both heterogeneities of regression and causality to exist. The null hypothesis of HNC is written as follows:

$$H_0 : \beta_i = 0 \quad \forall_i = 1,2,\ldots N \tag{5.10}$$

With $\beta_I = (\beta_i^{(1)}, \ldots, \beta_i^{(L)})'$

Under the alternative hypothesis, the coefficient β_i is allowed to differ across countries with some but not all equal to 0 (non-causality).

$$H_1 : \beta_i = 0 \quad \forall_i = 1,2,\ldots N_1 \tag{5.11}$$

$$\beta_i \neq 0 \quad \forall_i = N_1+1, N_1+2,\ldots,N$$

Where N_1 satisfies the condition $0 \leq N_1/N < 1$. When $N_1 = N$ (No causality for any individual); $N_1=0$ (Causality on all individuals) and $N_1>0$ (causality relationship is heterogeneous).

The test is conducted by running the regression on each cross-section and taking the average test statistic which is termed as Wbar statistic.

5.2.3 The Toda-Yamamoto Approach of Augmented VAR

The Vector Autoregression (VAR) is the most commonly used method to perform a hypothesis testing for Granger non-causality study. In a case where the variables are co-integrated, the VAR model is subjected to nonstandard distributions and produces nuisance parameters where the test cannot be conveniently tabulated. Therefore, it is

replaced with Error Correction Model (ECM), whereby most hypothesis testing can be conducted using a standard asymptotic theory. Nonetheless, both methods still require pre-testing on the variables, and they have to be stationary to conduct the test for Granger non-causality (Engel & Granger, 1987; Dolado and Lutkepohl, 1996).

The pre-testing exercise will confirm if the data are stationary at level *I(0)* or at first difference *I(1)* or at second order difference *I(II).* In fact, sometimes the data can be stationary at an arbitrary order. For example, some variables in the unit root test are stationary at levels while others at first difference. If the unit roots of the variables are integrated of an arbitrary order, both VAR and ECM models cannot run on Granger non-causality test as it could lead to false inferences.

The solution to this problem is found in Toda Yamamoto's (TY) approach (Toda & Yamamoto, 1995). According to Clarke and Mirza (2006), the TY approach fulfils the standard VAR model requirement using the augmented VAR model to handle mixed integrated data. The TY produces long-run causality using the level form that minimises the risks of identifying the correct order of integration and limits the problem of testing Granger Causality without paying too much attention to power and size properties of unit root and co-integration test (Zapata & Rambaldi, 1997). This procedure runs hypothesis testing on a modified Wald test statistic (MWALD) and the Chi-square ($\chi 2$) distributions produced are valid regardless of the cointegration order of the variables. Zapata and Rambaldi (1997) present evidence using the Monte Carlo experiment where MWALD has comparable performance in size and power in the likelihood and WALD test (Wolde-Rufael, 2009).

The basic idea of running TY is to establish long-run causality by artificially augmenting the true order of the VAR lag length (p), and then estimating (p+dmax) th where dmax refers to the expected maximum order of integration. The optimal lag length (p) is identified by using the common selection criterions, i.e. Schwarz Info Criterion (SIC) and Hannan-Quinn Information Criterion (HQ), which cater for a large sample size. Given the sensitivity of the lag selection process, we decide to use the optimal lag of both criterions in our TY regression.

5.2.4 Model Specification and Granger Causality

In this thesis, we adopt the neoclassical aggregate production function to investigate the causal relationship between economic growth, innovation and institutions. Innovation and institutions are treated separately in the model:

$$Y_t = f(KI_t, LAB_t, INV_t) \quad (5.12)$$

$$Y_t = f(KI_t, LAB_t, INS_t) \quad (5.13)$$

The extended model included sub-indices representing innovation and institutions using the same neoclassical aggregate production function model mentioned above. The models are written as:

$$Y_t = f(KI_t, LAB_t, INVIN_t, INVOUT_t) \quad (5.14)$$

$$Y_t = f(KI_t, LAB_t, ECO_t, POL_t, SOC_t) \quad (5.15)$$

Where Y_t is Gross National Income (GNI) per capita using the World Bank Atlas Method, KI is capital intensity, LAB is labour productivity, INV is Innovation Index, INS is Institutional Index, INVIN is Innovation Input index, INVOUT is Innovation Output Index, ECO is Economic Institution, POL is Political Institution and SOC is Social Institution.

The models are transformed to log linear function where the coefficient is expressed as an elasticity. The log linear models are as follow:

$$lnY_{i,t} = \alpha_0 + \beta 1 lnKI_{i,t} + \beta_2 lnLAB_{i,t} + \beta_3 lnINV_{i,t} + \varepsilon_{i,t} \quad (5.16)$$

$$lnY_{i,t} = \alpha_0 + \beta 1 lnKI_{i,t} + \beta_2 lnLAB_{i,t} + \beta_3 lnINS_{i,t} + \varepsilon_{i,t} \quad (5.17)$$

The extended log linear models:

$$lnY_{i,t} = \alpha_0 + \beta 1 lnKI_{i,t} + \beta_2 lnLAB_{i,t} + \beta_3 lnININ_{i,t} + \beta_4 lnINOUT_{i,t} + \varepsilon_{i,t} \quad (5.18)$$

$$lnY_{i,t} = \alpha_0 + \beta 1 lnKI_{i,t} + \beta_2 lnLAB_{i,t} + \beta_3 lnECO_{i,t} + \beta_4 lnPOL_{i,t} + \beta_4 lnSOC_{i,t} + \varepsilon_{i,t} \quad (5.19)$$

Where i=1, 2,…..N; t=1, 2,…..T. All variables are transformed to natural logarithm (ln).

To perform the Toda-Yamamoto Granger causality test, the model has to be presented in a VAR system model. The model specification and hypothesis are as follows:

Model 1: Granger Causality between Economic growth and Innovation Index

$$lnY_{i,t} = \propto_0 + \sum_{i=1}^{p} \beta_{1,i}\, lnY_{t-i} + \sum_{j=p+1}^{dmax} \beta_{2,j} lnY_{t-j} + \sum_{i=1}^{p} \theta_{1,i}\, lnKI_{t-i} + \sum_{j=p+1}^{dmax} \theta_{2,j} lnKI_{t-j} + \sum_{i=1}^{p} \vartheta_{1,i}\, lnLAB_{t-i} + \sum_{j=p+1}^{dmax} \vartheta_{2,j} lnLAB_{t-j} + \sum_{i=1}^{p} \varphi_{1,i}\, lnINV_{t-i} + \sum_{j=p+1}^{dmax} \varphi_{2,j} lnINV_{t-j} + \varepsilon_{1t} \quad (5.20)$$

$$lnINV_{i,t} = \propto_0 + \sum_{i=1}^{p} \beta_{1,i}\, lnY_{t-i} + \sum_{j=p+1}^{dmax} \beta_{2,j} lnY_{t-j} + \sum_{i=1}^{p} \theta_{1,i}\, lnKI_{t-i} + \sum_{j=p+1}^{dmax} \theta_{2,j} lnKI_{t-j} + \sum_{i=1}^{p} \vartheta_{1,i}\, lnLAB_{t-i} + \sum_{j=p+1}^{dmax} \vartheta_{2,j} lnLAB_{t-j} + \sum_{i=1}^{p} \varphi_{1,i}\, lnINV_{t-i} + \sum_{j=p+1}^{dmax} \varphi_{2,j} lnINV_{t-j} + \varepsilon_{2t} \quad (5.21)$$

In testing the hypothesis, Granger causality from $lnINV_{i,t} \Longrightarrow lnY_{i,t}$ implies that $\varphi_{1,i} \neq 0 \forall_i$ while Granger causality from $lnY_{i,t} \Longrightarrow lnINV_{i,t}$ implies that $\beta_{1,i} \neq 0 \forall_i$

Model 2: Granger Causality between Economic growth and Institutional Index

$$lnY_{i,t} = \propto_0 + \sum_{i=1}^{p} \beta_{1,i}\, lnY_{t-i} + \sum_{j=p+1}^{dmax} \beta_{2,j} lnY_{t-j} + \sum_{i=1}^{p} \theta_{1,i}\, lnKI_{t-i} + \sum_{j=p+1}^{dmax} \theta_{2,j} lnKI_{t-j} + \sum_{i=1}^{p} \vartheta_{1,i}\, lnLAB_{t-i} + \sum_{j=p+1}^{dmax} \vartheta_{2,j} lnLAB_{t-j} + \sum_{i=1}^{p} \Upsilon_{1,i}\, lnINS_{t-i} + \sum_{j=p+1}^{dmax} \Upsilon_{2,j} lnINS_{t-j} + \varepsilon_{1t} \quad (5.22)$$

$$lnINS_{i,t} = \propto_0 + \sum_{i=1}^{p} \beta_{1,i}\, lnY_{t-i} + \sum_{j=p+1}^{dmax} \beta_{2,j} lnY_{t-j} + \sum_{i=1}^{p} \theta_{1,i}\, lnKI_{t-i} + \sum_{j=p+1}^{dmax} \theta_{2,j} lnKI_{t-j} + \sum_{i=1}^{p} \vartheta_{1,i}\, lnLAB_{t-i} + \sum_{j=p+1}^{dmax} \vartheta_{2,j} lnLAB_{t-j} + \sum_{i=1}^{p} \Upsilon_{1,i}\, lnINS_{t-i} + \sum_{j=p+1}^{dmax} \Upsilon_{2,j} lnINS_{t-j} + \varepsilon_{2t} \quad (5.23)$$

In testing the hypothesis, Granger causality from $lnINS_{i,t} \Longrightarrow lnY_{i,t}$ implies that $\Upsilon_{1,i} \neq 0 \forall_i$ while Granger causality from $lnY_t \Longrightarrow lnINS_t$ implies that $\beta_{1,i} \neq 0 \forall_i$

Model 3: Granger Causality between Economic growth, Innovation Input Index and Innovation Output Index

$$lnY_{i,t}$$

$$= \propto_0 + \sum_{i=1}^{p} \beta_{1,i}\, lnY_{t-i} + \sum_{j=p+1}^{dmax} \beta_{2,j} lnY_{t-j} + \sum_{i=1}^{p} \theta_{1,i}\, lnKI_{t-i} + \sum_{j=p+1}^{dmax} \theta_{2,j} lnKI_{t-j}$$

$$+ \sum_{i=1}^{p} \vartheta_{1,i}\, lnLAB_{t-i} + \sum_{j=p+1}^{dmax} \vartheta_{2,j} lnLAB_{t-j} + \sum_{i=1}^{p} \lambda_{1,i}\, lnINVIN_{t-i}$$

$$+ \sum_{j=p+1}^{dmax} \lambda_{2,j} lnINVIN_{t-j} + \sum_{i=1}^{p} \omega_{1,i}\, lnINVOUT_{t-i} + \sum_{j=p+1}^{dmax} \omega_{2,j} lnINVOUT_{t-j}$$

$$+ \varepsilon_{1t} \qquad (5.24)$$

$$lnINVIN_{i,t}$$

$$= \propto_0 + \sum_{i=1}^{p} \beta_{1,i}\, lnY_{t-i} + \sum_{j=p+1}^{dmax} \beta_{2,j} lnY_{t-j} + \sum_{i=1}^{p} \theta_{1,i}\, lnKI_{t-i} + \sum_{j=p+1}^{dmax} \theta_{2,j} lnKI_{t-j}$$

$$+ \sum_{i=1}^{p} \vartheta_{1,i}\, lnLAB_{t-i} + \sum_{j=p+1}^{dmax} \vartheta_{2,j} lnLAB_{t-j} + \sum_{i=1}^{p} \lambda_{1,i}\, lnINVIN_{t-i}$$

$$+ \sum_{j=p+1}^{dmax} \lambda_{2,j} lnINVIN_{t-j} + \sum_{i=1}^{p} \omega_{1,i}\, lnINVOUT_{t-i} + \sum_{j=p+1}^{dmax} \omega_{2,j} lnINVOUT_{t-j}$$

$$+ \varepsilon_{1t} \qquad (5.25)$$

$$lnINVOUT_{i,t}$$

$$= \propto_0 + \sum_{i=1}^{p} \beta_{1,i}\, lnY_{t-i} + \sum_{j=p+1}^{dmax} \beta_{2,j} lnY_{t-j} + \sum_{i=1}^{p} \theta_{1,i}\, lnKI_{t-i} + \sum_{j=p+1}^{dmax} \theta_{2,j} lnKI_{t-j}$$

$$+ \sum_{i=1}^{p} \vartheta_{1,i}\, lnLAB_{t-i} + \sum_{j=p+1}^{dmax} \vartheta_{2,j} lnLAB_{t-j} + \sum_{i=1}^{p} \lambda_{1,i}\, lnINVIN_{t-i}$$

$$+ \sum_{j=p+1}^{dmax} \lambda_{2,j} lnINVIN_{t-j} + \sum_{i=1}^{p} \omega_{1,i}\, lnINVOUT_{t-i} + \sum_{j=p+1}^{dmax} \omega_{2,j} lnINVOUT_{t-j}$$

$$+ \varepsilon_{1t} \qquad (5.26)$$

The hypothesis testing as follows: Granger causality from $lnINVIN_{i,t} \Longrightarrow lnY_{i,t}$ implies that $\lambda_{1,i} \neq 0 \forall_i$, Granger causality from $lnINVOUT_{i,t} \Longrightarrow lnY_{i,t}$ implies that $\omega_{1,i} \neq 0 \forall_i$ and Granger causality from $lnY_{i,t} \Longrightarrow lnINVIN_{i,t}$ implies that $\beta_{1,i} \neq 0 \forall_i$; Granger causality from $lnY_{i,t} \Longrightarrow lnINVOUT_{i,t}$ implies that $\beta_{1,i} \neq 0 \forall_i$.

Model 4: Granger Causality between Economic growth, Economic Institution Index, Political Institution Index and Social Institution Index

$$lnY_{i,t}$$

$$= \propto_0 + \sum_{i=1}^{p} \beta_{1,i}\, lnY_{t-i} + \sum_{j=p+1}^{dmax} \beta_{2,j} lnY_{t-j} + \sum_{i=1}^{p} \theta_{1,i}\, lnKI_{t-i} + \sum_{j=p+1}^{dmax} \theta_{2,j} lnKI_{t-j}$$

$$+ \sum_{i=1}^{p} \vartheta_{1,i}\, lnLAB_{t-i} + \sum_{j=p+1}^{dmax} \vartheta_{2,j} lnLAB_{t-j} + \sum_{i=1}^{p} \eta_{1,i}\, lnECO_{t-i} + \sum_{j=p+1}^{dmax} \eta_{2,j} lnECO_{t-j}$$

$$+ \sum_{i=1}^{p} \Psi_{1,i}\, lnPOL_{t-i} + \sum_{j=p+1}^{dmax} \Psi_{2,j} lnPOL_{t-j} + \sum_{i=1}^{p} \phi_{1,i}\, lnSOC_{t-i} + \sum_{j=p+1}^{dmax} \phi_{2,j} lnSOC_{t-j}$$

$$+ \varepsilon_{1t} \qquad (5.27)$$

$$lnECO_{i,t}$$

$$= \propto_0 + \sum_{i=1}^{p} \beta_{1,i}\, lnY_{t-i} + \sum_{j=p+1}^{dmax} \beta_{2,j} lnY_{t-j} + \sum_{i=1}^{p} \theta_{1,i}\, lnKI_{t-i} + \sum_{j=p+1}^{dmax} \theta_{2,j} lnKI_{t-j}$$

$$+ \sum_{i=1}^{p} \vartheta_{1,i}\, lnLAB_{t-i} + \sum_{j=p+1}^{dmax} \vartheta_{2,j} lnLAB_{t-j} + \sum_{i=1}^{p} \eta_{1,i}\, lnECO_{t-i} + \sum_{j=p+1}^{dmax} \eta_{2,j} lnECO_{t-j}$$

$$+ \sum_{i=1}^{p} \Psi_{1,i}\, lnPOL_{t-i} + \sum_{j=p+1}^{dmax} \Psi_{2,j} lnPOL_{t-j} + \sum_{i=1}^{p} \phi_{1,i}\, lnSOC_{t-i} + \sum_{j=p+1}^{dmax} \phi_{2,j} lnSOC_{t-j}$$

$$+ \varepsilon_{1t} \qquad (5.28)$$

$$lnPOL_{i,t} = \propto_0 + \sum_{i=1}^{p} \beta_{1,i}\, lnY_{t-i} + \sum_{j=p+1}^{dmax} \beta_{2,j} lnY_{t-j} + \sum_{i=1}^{p} \theta_{1,i}\, lnKI_{t-i}$$
$$+ \sum_{j=p+1}^{dmax} \theta_{2,j} lnKI_{t-j} + \sum_{i=1}^{p} \vartheta_{1,i}\, lnLAB_{t-i} + \sum_{j=p+1}^{dmax} \vartheta_{2,j} lnLAB_{t-j}$$
$$+ \sum_{i=1}^{p} \eta_{1,i}\, lnECO_{t-i} + \sum_{j=p+1}^{dmax} \eta_{2,j} lnECO_{t-j} + \sum_{i=1}^{p} \Psi_{1,i}\, lnPOL_{t-i}$$
$$+ \sum_{j=p+1}^{dmax} \Psi_{2,j} lnPOL_{t-j} + \sum_{i=1}^{p} \phi_{1,i}\, lnSOC_{t-i} + \sum_{j=p+1}^{dmax} \phi_{2,j} lnSOC_{t-j}$$
$$+ \varepsilon_{1t} \qquad (5.29)$$

$$lnSOC_{i,t} = \propto_0 + \sum_{i=1}^{p} \beta_{1,i}\, lnY_{t-i} + \sum_{j=p+1}^{dmax} \beta_{2,j} lnY_{t-j} + \sum_{i=1}^{p} \theta_{1,i}\, lnKI_{t-i}$$
$$+ \sum_{j=p+1}^{dmax} \theta_{2,j} lnKI_{t-j} + \sum_{i=1}^{p} \vartheta_{1,i}\, lnLAB_{t-i} + \sum_{j=p+1}^{dmax} \vartheta_{2,j} lnLAB_{t-j}$$
$$+ \sum_{i=1}^{p} \eta_{1,i}\, lnECO_{t-i} + \sum_{j=p+1}^{dmax} \eta_{2,j} lnECO_{t-j} + \sum_{i=1}^{p} \Psi_{1,i}\, lnPOL_{t-i}$$
$$+ \sum_{j=p+1}^{dmax} \Psi_{2,j} lnPOL_{t-j} + \sum_{i=1}^{p} \phi_{1,i}\, lnSOC_{t-i} + \sum_{j=p+1}^{dmax} \phi_{2,j} lnSOC_{t-j}$$
$$+ \varepsilon_{1t} \qquad (5.30)$$

In testing the hypothesis, Granger causality from $lnECO_{i,t} \Longrightarrow lnY_{i,t}$ implies that $\eta_{1,i} \neq 0\forall_i$, Granger causality from $lnPOL_{i,t} \Longrightarrow lnY_{i,t}$implies that $\Psi_{1,i} \neq 0\forall_i$, Granger causality from $lnSOC_{i,t} \Longrightarrow lnY_{i,t}$ implies that $\phi_{1,i} \neq 0\forall_i$ and Granger causality from $lnY_{i,t} \Longrightarrow lnECO_{i,t}$ implies that $\beta_{1,i} \neq 0\forall_i$; Granger causality from $lnY_{i,t} \Longrightarrow lnPOL_{i,t}$ implies that $\beta_{1,i} \neq 0\forall_i$ and Granger causality from $lnY_{i,t} \Longrightarrow lnSOC_{i,t}$ implies that $\beta_{1,i} \neq 0\forall_i$.

5.3 Findings

5.3.1 Unit Root Test

The process of econometrics testing begins by establishing the panel unit root of the individual variables. The thesis uses the Levin et al. (2002) test and Breitung (2001) t-test for the common unit root process and IM, Pesaran and Shin (2003) w-stat, ADF- Fisher Chi-Square and PP-Fisher Chi-Square for the individual unit root process. Table 5.1 shows the summary of the results of the unit root test. The test is conducted on both the common unit root process and individual unit root process. The order of integration is decided based on the majority of the outcome from both processes. The results show that the variables are stationary at arbitrary order between level I (0) and first order I (1). The index and ratios are mostly integrated at level I (0), as it may not have any drifting issue. However, the time series data based on value are mostly stationary at first order effect I (0).

As discussed in the previous chapter, since the unit root is integrated at an arbitrary order, a common process of panel cointegration testing and causality testing cannot be applied. More scrutiny is required to adopt an appropriate econometrics strategy to test for panel cointegration and causality test. In this thesis, we have adopted the panel Pooled Mean Group (PMG) ARDL model for panel cointegration test and Toda-Yamamoto (TY) for causality test. The advantage of both tests is that it can be applied to arbitrary order unit root data without compromising its results.

Table 5.1: Summary of Unit Root Tests*

	lnGNI	*lnKI*	*lnLAB*	*lnINNOV*	*lnININ*	*lnINOUT*	*lnINST*	*lnECO*	*lnPOLITIC*	*lnSOCIAL*
	All									
Individuall Intercept	I(1)	I(1)	I(1)	I(0)	I(0)	I(0)	I(1)	I(0)	I(0)	I(0)
Individuall Intercept & Trend	I(1)	I(1)	I(1)	I(0)	I(0)	I(0)	I(1)	I(0)	I(0)	I(0)
None	I(1)	I(0)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)
	High Income OECD Countries									
Individuall Intercept	I(1)	I(1)	I(1)	I(0)	I(0)	I(0)	I(1)	I(1)	I(0)	I(0)
Individuall Intercept & Trend	I(1)	I(1)	I(1)	I(0)	I(0)	I(0)	I(1)	I(0)	I(1)	I(1)
None	I(1)	I(0)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)
	Middle Income Countries									
Individuall Intercept	I(1)	I(1)	I(1)	I(0)	I(0)	I(0)	I(0)	I(1)	I(0)	I(0)
Individuall Intercept & Trend	I(1)	I(1)	I(1)	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)
None	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)
	Low Income Countries									
Individuall Intercept	I(1)	I(1)	I(1)	I(0)	I(0)	I(0)	I(1)	I(0)	I(0)	I(1)
Individuall Intercept & Trend	I(1)	I(1)	I(1)	I(0)	I(0)	I(0)	I(1)	I(1)	I(0)	I(1)
None	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)

** The summary of the results is decided based on majority of the outcome from both processes of common unit root and individual unit root.*

Source: Author

5.3.2 Results of Bivariate Causality Test

Table 5.2 presents the estimated output from the bivariate Dumitrescu-Hurlin (DH) causality test. The test indicates mixed results on the direction of causality between economic growth, innovation and institutions across different developmental stages. To maintain robustness of the results, the test is performed using three different lag periods given that a lag selection is an important bearing in influencing the outcome of the test (Lutkepohl, 2005).

Table 5.2: Dumitrescu-Hurlin (DH) Bivariate Causality test

Variables			All			HICs			MICs			LICs		
Lags			2	4	6	2	4	6	2	4	6	2	4	6
*ln*Y		*lnINV*	<=>	<=>	<=>	<=>	=>	=>	<=>	<=	<=>	=>		=>
lnY		*lnINVIN*	=>	=>	<=>	<=>	=>	<=>	=>		=>	=>		
lnY		*lnINV OUT*	<=>	<=>	<=>	<=>	=>	=>	<=>	<=>	<=	=>		=>
lnY		*lnINS*	<=>	<=>	<=>	<=>	<=	<=>	<=>	<=	<=		<=>	=>
lnY		*lnECO*	<=>	<=>	=>	=>		=>	<=>	<=>	=>	=>	<=>	<=>
lnY		*lnPOL*	<=>	<=>	<=	<=	<=	<=	=>			<=>	<=>	=>
lnY		*lnSOL*	<=>	<=>	<=>	=>		<=>	<=>	<=	<=>	<=>	=>	=>

Source: Author

The DH test alludes to a complex relationship between growth, innovation and institutions at different income level as most of the variables have at least one or more directions of causality with the other variables. Moreover, the direction of causality is also influenced by the income levels of the economy. The overall sample shows

bidirectional causality between growth and innovation as well as between growth and institutions. This relationship appears to be stronger in the high-income OECD countries and the middle-income economies. However, in low-income countries, the causality among the variables is mostly unidirectional.

Innovation and institutions exhibit bidirectional causality with economic growth in the HICs and MICs. Innovation and institutional strength support the per capita income growth, and higher per capita income promotes a higher innovation activity and demand for greater institutional strength. Therefore, the reciprocal relationship offers increasing returns to the economy.

In contrast, the condition in the LICs is less clear in the sense that there is no compelling case for the bidirectional relationship in both the innovation and institution index. The innovation index is influenced by the economic growth rather than the reverse. As income rises in LICs, the ranking of innovation index gets better. However, a higher innovation activity may not necessarily boost the per capita income significantly.

The relationship between institutions and per capita income is mixed and varies depending on the number of lags chosen. However, the economic institutions exhibit bivariate causality relationship with income growth. It means that when per capita income grows, transaction cost is expected to be lowered and the economy becomes more open for trade and financial intermediation improves. Likewise, when economic institutions improve, the per capita income of the society is also expected to increase.

While the DH test has provided useful information on bivariate causality, the inference of the thesis is primarily driven by empirical models based on the multivariate long-run

causality analysis. This model captures the direction of causality more systematically using the adjusted neoclassical production function rather than simply looking at the bivariate relationship.

5.3.3 Toda-Yamamoto Test Results

We find that the results of multivariate causality using the Toda Yamamoto (TY) test show a less complex relationship, where not all variables have one or more directions of causality unlike the DH test. The differences in the results between DH and TY method are predominantly reflected in the introduction of multiple variables in the models. Caines et al. (1981) find that as new variables are added in a multivariate test, the causal structure of the model will grow exponentially and change the pairwise causality structure.

Table 5.3: Lag Selection of the Models

Model	1		2		3		4	
Selection Criteria	SIC	HQ	SIC	HQ	SIC	HQ	SIC	HQ
All	4	5	4	8	4	6	3	5
HICs	6	6	6	6	3	6	2	6
MICs	2	4	2	4	2	4	3	4
LICs	2	2	2	2	2	2	2	2

Source: Author

Before testing the long-run causality, we have to determine the lag selection criterion in the model. It is pivotal to choose the optimal number of lags as they can influence the robustness of the results. For this thesis, we use two common criterions, i.e. Schwartz

Information Criterion (SIC) and Hannan-Quinn (HQ) information criteria which cater for large panel data. The TY test uses the optimal lags based on SIC and HQ criterions. The results of lag selection are presented in Table 5.3.

As mentioned in the previous chapter, the TY is the most suitable option to run the causality test especially when the variables are integrated on an arbitrary level. The TY test is run by artificially augmenting the true order of the VAR lag length. In this case, the unit root test from Table 4.3 confirms that the d_{max} value is one (1), given that the highest order of co-integration is at I (1). Meanwhile, the VAR lag length is chosen based on SIC and HQ separately.

The summary of the results of the TY test is presented in Table 5.4. For the overall sample, the causality direction between institutions and economic growth presents a more complex relationship than innovation and growth. The institutions-growth exhibits a bidirectional relationship compared to innovation and growth, where the causal direction of the latter just runs from growth to innovation. The finding is contradictory to the mathematical modelling applied in the neoclassical growth model, whereby the economic growth is treated as a function of the innovation factor and not otherwise. Countries that focus on innovation tend to generate a higher economic growth. Nevertheless, in the overall sample, we find that a higher per capita income drives an innovation-led activity but an increase in innovation does not significantly contribute to economic growth. The sub-indices of innovation, i.e. innovation input and innovation output also show no significant causal relationship with economic growth. However, the causality results between innovation and growth are not the same across the income levels.

Meanwhile, institutions and growth share a reciprocal relationship using the HQ criteria in the overall sample size. Countries with a higher growth in per capita income tend to have greater institutional changes and strong institutions which tend to boost per capita income of the country. Even by using the SIC criterion, growth is still significantly a driver of the institutional strength of an economy, but it is not mutually driving each other. Based on institution sub-indices, the social and political institutions do influence per capita income growth. In contrast, the economic institutions are driven by higher per capita income and not vice-versa. Similar to the relationship between innovation and growth, the relationship between institutions and economic growth also varies according to the developmental stages.

The output from the TY test is more interesting when the samples are segregated based on income levels. We find that causal relationship between institutions, innovation and growth are much stronger in HICs compared to MICs and LICs. Therefore, the economic growth in HICs tends to benefit from their position as a frontier in the innovation and institutions capabilities unlike the underdeveloped economies which suffer from a vicious cycle between these three factors. The variation in the direction of causality of innovation and institutions to economic growth could possibly support the growth divergence across the income levels. In this aspect, the thesis provides a better reasoning and complements past empirical work in explaining why growth divergence between different income levels occurs. However, further empirical testing is required to confirm this finding, which is not part of the research scope of this thesis. Indeed, the finding of this thesis could be the starting point for future research on growth convergence theory.

Table 5.4: Toda Yamamoto Causality Test by Different Stages of Development

Selection Criterion			All			High Income			Middle Income			Low Income	
			Lag	χ2	P-Value	Lag	χ2	P-Value	Lag	χ2	P-Value	Lag	χ2	P-Value
SIC	Model 1	*ln* Y → *ln* INV	4	9.03	0.060	6	16.76**	0.010	2	2.06	0.357	2	0.64	0.725
		ln Inv → *ln* Y		3.05	0.548		13.96**	0.030		0.20	0.904		0.87	0.647
HQ	Model 1	*ln* Y → *ln* INV	5	12.60**	0.027				4	6.08	0.193			
		ln Inv → *ln* Y		7.73	0.172					4.12	0.390			
SIC	Model 2	*ln* Y → *ln* INS	4	19.03*	0.001	6	8.73	0.189	2	1.50	0.473	2	4.30	0.117
		ln INS → *ln* Y		1.57	0.814		17.86*	0.006		3.16	0.206		1.83	0.400
HQ	Model 2	*ln* Y → *ln* INS	8	32.41*	0.000				4	4.90	0.298			
		ln INS → *ln* Y		16.39**	0.037					2.59	0.643			
SIC	Model 3	*ln* Y → *ln* INVIN	4	7.50	0.112	3	7.15	0.067	2	0.14	0.933	2	1.63	0.442
		ln INVIN → *ln* Y		0.97	0.914		13.74*	0.003		2.01	0.366		1.33	0.515
		ln Y → *ln* INVOUT		5.36	0.252		4.12	0.248		3.09	0.213		0.24	0.886
		ln INVOUT → *ln* Y		1.61	0.807		6.45	0.091		2.10	0.350		0.86	0.649
HQ	Model 3	*ln* Y → *ln* INVIN	6	7.75	0.256	6	20.79*	0.002	4	2.94	0.569			
		ln INVIN → *ln* Y		5.19	0.519		16.37**	0.012		5.44	0.245			
		ln Y → *ln* INVOUT		8.55	0.200		4.68	0.586		6.64	0.156			
		ln INVOUT → *ln* Y		4.42	0.620		2.16	0.903		4.79	0.309			
SIC	Model 4	*ln* Y → *lnECO*	3	32.78*	0.000	2	6.93**	0.031	3	17.29*	0.001	2	0.84	0.657
		lnECO → *ln* Y		1.48	0.688		3.07	0.214		0.67	0.881		0.32	0.854
		ln Y → *lnSOC*		3.24	0.357		6.11**	0.047		0.82	0.844		4.76	0.092
		lnSOC → *ln* Y		4.76	0.191		1.64	0.440		3.14	0.371		6.35**	0.042
		ln Y → *lnPOL*		4.48	0.214		2.41	0.299		8.47**	0.037		0.12	0.942
		lnPOL → *ln* Y		4.60	0.203		2.31	0.314		11.89*	0.008		1.60	0.449
HQ	Model 4	*ln* Y → *lnECO*	5	28.45*	0.000	5	8.50	0.131	4	16.92*	0.002			
		lnECO → *ln* Y		1.91	0.860		2.65	0.755		4.45	0.348			
		ln Y → *lnSOC*		6.39	0.270		15.75*	0.008		1.59	0.810			
		lnSOC → *ln* Y		15.33*	0.009		28.71*	0.000		5.39	0.249			
		ln Y → *lnPOL*		6.69	0.244		7.20	0.206		8.18	0.085			
		lnPOL → *ln* Y		11.53**	0.042		2.19	0.822		15.25*	0.004			

Note: (*), (**) and (***) represent the coefficient significance at 1%, 5% and 10% respectively.

Source : Author

In HICs, innovation and growth exhibit a mutual causal relationship where both factors are dependent on each other. The cumulative causation allows the HICs to enjoy the benefits of increasing return from innovation-led activities, which is missing in the underdeveloped economies. The explanation for the increasing return in HICs can be related to the work done by Arthur (1989) called the "founder effect". The founder effect claims that technological innovators gain an early lead by restricting the market of potential adopters and gaining market shares. The descriptive statistic in the previous chapter highlights the role of HICs as a technological frontier while most of the underdeveloped economies are technological users or technological adopters. The technological frontiers are able to improve the existing stock of knowledge by introducing new technology and maintaining its frontier position while others who have not adopted the new complex technology will be left behind. By taking the evolutionary approach, the HICs may continuously innovate which will eventually prevent the market from potential newcomers entering the market thus creating a monopoly. As a result, the frontier economy will benefit from monopoly pricing and contribute to higher value-added creations in the domestic economy. At the same time, a higher economic growth also enables the HICs to engage in continuous investment in new technology and remain in the technological frontier. Therefore, the virtuous cycle between innovation and growth may contribute to growth divergence in per capita income between the HICs and underdeveloped economies.

Even though we acknowledge the role of a founder effect in explaining increasing return in the HICs, at the same time, we also do not undermine the ability of newcomers (MICs and LICs) to challenge the economies of technological frontiers. The Asian economies such as Japan (after World War II), South Korea and Taiwan in the 1990s have

a proven model that underdeveloped economies could still emulate to break the barrier to catch-up, leap-frog and become HICs using this imitation and adaptation model. This may have been strongly moderated by the presence of institutions that enhance the innovation outcome. This notion is further explored in Chapter 6.

Meanwhile, between the sub-indices of innovation, the innovation input has a strong bidirectional causal relationship with economic growth. Human capital development and R&D activity are the main factors representing innovation input. The outcome from the causal direction is in line with an endogenous growth theory that accepts human capital and R&D activity as the core factors in a growth convergence argument. However, the endogenous growth theory does not emphasise the size of market in influencing the development of human capital and R&D investment. In HICs, the growth in per capita income allows the economy to invest substantially in human capital and R&D while the same may not be the case in the underdeveloped economies due to budget constraint. As expected, no significant causality direction can be traced between innovation input and growth in both MICs and LICs.

Unlike the innovation input, the innovation output does not show any significant causation with economic growth in all the income levels. While innovation output may have contributed to economic growth or vice versa, the causality test shows there is no clear direction to confirm if innovation output leads to economic growth or otherwise.

Besides innovation, the direction of causality for institutions-growth also depends on the developmental stages of the economy. Similar to innovation, the institutional strength influences the direction of economic growth in HICs. However, in MICs and LICs, there is no significant causality direction between institution index and economic growth.

Even though the institution index only shows significant causality direction in HICs, the sub-indices of institutions have significant causal relationship in MICs and LICs. Interestingly, it is not only the direction of causality which varies across the developmental stages but also the types of institution. For example, social institutions have a significant causal relationship in HICs and LICs, while economic institutions are driven by economic growth in HICs and MICs. Political institutions only have a significant causal relationship in the MICs.

In the MICs, political institutions have a pivotal role to play as they register bidirectional causality with economic growth. Good governance and a demand for democracy represent the political institutions. As such, the increase in governance and greater democracy in MICs are expected to influence economic growth and vice versa too. The virtuous cycle between political institution and economic growth helps the MICs to benefit from an increasing return when political institutions become better off. This result is in line with Barro's (1996) empirical evidence that suggests that economic growth and the demand for democracy will increase in tandem. However, Barro's study misses the point when he fails to capture the existence of the reciprocal relationship between political institution and growth as surmised by Chang (2010).

The social institution has no significant causal relationship with economic growth in the MICs. However, the economic institution presents a significant causality relationship with growth, but the direction of causality is from growth to economic institutions and not otherwise as often presented in past institutional researches. Hence, in the MICs, changes in political institutions provide a significant improvement to the economic growth, but changes in all other variables do not necessarily drive the economic growth.

Meanwhile, a higher economic growth supports better political and economic institutions in the MICs.

In the LICs, no significant causal relationship is found within all the variables except for social institutions. Improvement in the social institutions drives the income per capita growth in these economies. Moreover, if we accept relationship at a 90 percentage significant level, social institutions exhibit mutual causation with per capita income growth.

Social institution is represented by improvement in enrolment of basic education and strong connectivity. Blomstrom et al. (1992) find that secondary schooling is the major factor in enhancing economic growth rate in the low-income economies by creating an educated workforce. A similar argument is also echoed by Easterly and Rebelo (1993) who state that investment in education tends to increase per capita income growth. On the connectivity factor, the improvement in physical infrastructure, internet and communication infrastructure allow for greater mobility of factors and goods. The failure to provide basic infrastructure becomes a hindrance to economic growth as goods and services access will only be limited to the local market. Besides that, the internet also provides the necessary tools to encourage knowledge flows to low-income economies. A greater access to the internet helps to reduce knowledge gap in the LICs. Esfhani and Ramirez (2002) find that the contribution of infrastructure to GDP exceeds the cost of providing those services to society. Pradhan and Bagachi (2013) study the Indian transportation infrastructure and report bidirectional causality between transportation infrastructure and economic growth. The increasing return on infrastructure development in India contributes positively to a higher economic growth.

5.4 Conclusion

This chapter also emphasises the methodology for identifying causality direction between innovation, institutions and economic growth. The causality test is performed on bivariate and multivariate analysis. However, between the two, the primary focus is on the output presented by multivariate analysis using the Toda-Yamamoto (TY) (1995) approach. The test also conducts separately on each development stage to identify if the stages matter in influencing the relationship between innovation, institutions and economic growth.

The results on the causality test that this thesis produces may offer a new perspective to the study of growth theory going forward. Unlike the conventional way of thinking, where innovation and institutions are expected to deliver a higher economic growth, our thesis shows that the relationship is not uniform in all the income levels. In contrast, the role of innovation, institutions and their sub-indices varies significantly across the income levels.

The overall sample shows that economic growth drives innovation rather than the reverse as posited in the endogenous growth theory. However, the institution index has a reciprocal relationship with economic growth, whereby a country with stronger institutional capabilities tends to benefit from increasing return when it improves institutions.

Given that the data in the overall sample may suffer from severe heterogeneity related issues, a generalisation of the results may lead to inaccurate inferences. Hence, more interesting and meaningful results are provided when the thesis studies the causality of

individual income levels. The role of innovation is more significant in HICs due to the advantage of "founder effect". The innovation input has significant causal relationship with economic growth. However, the same is not true in the underdeveloped economies. The innovation index and its sub-indices have no significant causal relationship with economic growth in the MICs and LICs. This could explain the lack of incentives and higher transaction cost in the MICs and LICs as described in past researches.

Institution index also only registers significant causal relationship with economic growth in HICs and not in MICs and LICs. Nonetheless, the role of institutions becomes more pertinent in the underdeveloped economies when focusing on the different types of institutions. In the MICs, political institutions seem to have an important role in economic growth. Political institutions exhibit bidirectional causality with growth, which means the demand for good governance, the rule of law and democracy have an increasing return to the per capita income. The results from improving political institutions benefit the economic growth from higher government efficiency, eliminating unproductive rent-seeking behaviour and lowering the transaction cost. This is important to promote accumulation of capital and spur innovation activities in the domestic economy.

Finally, in the LICs, social institutions are the only factors that are significant in influencing the direction of economic growth. The LICs that invest in basic education and infrastructure development tend to enjoy higher economic growth in their per capita income. Improvement in the basic infrastructures improves the quality of labour forces and expands the size of markets by allowing to transport goods and services to a larger geographical coverage. The advantages from the positive changes in the social institutions are not limited only to higher economic growth but also the strengthening of other

macroeconomic variables such as current account, foreign direct inflows (FDI) and international reserves.

CHAPTER 6: **SHORT-RUN AND LONG-RUN DYNAMICS BETWEEN INSTITUTIONS, INNOVATION AND ECONOMIC GROWTH**

6.1 Introduction

In the previous chapter, we have established the causation between innovation, institutions and economic growth. The findings from the causality test confirm that income levelsare an important consideration in determining the direction of causation. The result is interesting as well as challenging given that a more sophisticated procedure is needed to solve econometrics-related issues, especially with regards to mixed order of integration and the presence of endogeneity in some of the models. In the Toda-Yamamoto causality test, there are some models which exhibit bidirectional causality between the economic growth and the explanatory variables. Hence, there are two issues to address in this thesis, namely the problem related to mixed order of integration and the presence of endogenity. The thesis employ the Autoregressive Distributed Lag (ARDL) approach which account for the mixed order of integration and endogenity in the long-run model. The ARDL approach provides unbiased estimates for the long-run regression output eventhough the model suffers from the problem of endogeneity (Harris and Sollis, 2003).

Meanwhile, it is necessary to understand that causation implies only the direction but not the interrelationship between the variables. To establish the inter-relationship between innovation, institutions and economic growth, it requires conducting multivariate regression analysis that explains the objectives of the thesis. In this chapter, we continue with more empirical testing on the short-run (SR) and the long-run (LR) relationship

between innovation, institutions and economic growth. We apply the Pooled Mean Group (PMG) ARDL approach to estimate the short-run and long-run panel relationship between the variables. The test is conducted across developmental stages to find out if the developmental stages influence the relationship between these variables differently.

6.2 Method: Panel Autoregressive Distributed Lag (ARDL)

The cointegration procedure is part of the requirement to establish the long-run relationship in the time series analysis. Two commonly used approaches to determine long-run relationships are the two-step residual based approach developed by Engle and Granger (1987) and system based reduced rank regression approach developed by Johansen (1991). However, both these approaches are insufficient and less robust to reject the null hypothesis for a panel data analysis. Therefore, more recently, the cointegration procedures developed by Pedroni (1999, 2004), Kao (1999) and Maddala and Wu (1999) are commonly applied on panel data analysis. It is expected to have a stronger power to reject the null hypothesis.

Despite the progress in technical development in analysing panel data, all the above mentioned cointegration techniques are not suitable to address our requirement. The principle requirement for a panel cointegration is to have the underlying variables to be integrated purely in order one (1) condition. In contrast, the result of panel unit root in our thesis confirms that the variables are stationary at an arbitrary order of between I(0) and I(1). This result has been reported in the previous chapter. Given the nature of the data in this thesis, an alternative approach is required to test for a panel cointegration. Only by performing the cointegration test, the thesis could still determine the long-term relationship between the underlying variables.

A condition of the mixed order of integration is that empirical research in the past commonly adopts the Autoregressive Distributed Lag (ARDL) procedure to obtain the short-run and long-run relationship between the variables (Pesaran et al. 1999; Christos et al., 2008; Asteriou, 2008; Njoupouognigni, 2010). The ARDL model is a standard least square regression model which includes the lags of both the dependent and independent variables in the regression model. This approach is capable of dealing with mixed order integration as long as no variables integrated at second order condition or I(2). The ARDL approach derives its asymptotic distribution regardless if the regressors are purely I (0), purely I (1) or mutual cointegrated (Pesaran et al., 1999; Pesaran et al., 2001). This thesis has fulfilled the condition mentioned above.

In the case of panel data, besides requirement for a unit root test, the choice of econometric techniques for panel cointegration is also hinged on the length of time series (T) and the number of cross-sections (N). When N is larger than T, the ARDL model will be biased due to the correlation between mean regressor and the error term. In this circumstance, the General Method of Moments (GMM) developed by Arellano-Bond (1991) is prefered. It is only when T is relatively larger than N that the bias in ARDL model will vanish.

The panel data used in our thesis consists of a relatively large number of time series (T) and a similar size of observation in the number of groups (N). The parameters of interest are to establish the long-run relationship and the speed of convergence. To test panel cointegration, we adopt the method used by Pesaran et al. (1999) which is known as the Pooled Mean Group (henceforth PMG). The PMG estimator is an intermediate alternative between the Mean Group (MG) estimator and fixed and random effects

estimators. It involves both pooling and averaging methods to produce the regression output.

The PMG estimator takes the cointegration form of the simple ARDL model which allows interception, short-run coefficiency and error variance to vary by country-specific, but fixes the long-run coefficiency to be the same. In the short run, heterogeneity among individual countries should be represented by the short-run slope coefficient of an individual country to understand the country-specific condition better. The PMG also allows the number of lags to differ across the groups. However, in the long run, the idea of heterogeneity among individual countries is not compelling. The long-run estimates are mostly unbiased in the business cycle and country-specific effects on all groups (Asteriou, 2008). This assumption is especially relevant to our thesis as we segregate the samples according to the income levels.

6.2.1 The PMG Model

The PMG model in this thesis is acquired based on work done by Pesaran, Shin and Smith (1999 and 2001). We used the unrestricted PMG ARDL (p,q,q,….,q) model with time periods of *t*=1,2,3,….,*T* and countries of i=1,2,3,…,N. The model is written as follows:

$$\Delta y_{i,t} = \phi_i ECT_{i,t} + \sum_{j=0}^{q-1} \Delta X_{i,t-j}{}' \beta_{i,j} + \sum_{j=1}^{p-1} \gamma_{i,j} * \Delta y_{i,t-j} + \varepsilon_{i,t} \quad (6.1)$$

Where Error Correction Term is written as:

$$ECT_{i,t} = y_{i,t-1} - X_{i,t}{}'\lambda \quad (6.2)$$

$y_{i,t}$ = GNI per capita

$X_{i,t}$= Explanatory Variables

Δ = Changes

In equation 5.1, we assume that both the dependent variables and the regressors have the same number of lags across the group. The model also assumes that regressor X has the same number of lags of q in each cross country. These assumptions are not mandatory but are just used for notational convenience. In actual case, the PMG model allows the lags between cross-country to vary. The model also can permit the inclusion of time trends and other types of fixed regressors.

The PMG model derives concentrated log-likelihood function in the long-run coefficient, $\boldsymbol{\lambda}$, and speed of adjustment coefficient, ϕ_i. The concentrated function is written as follows:

$$l_T(\varphi) = -\varphi\frac{T_i}{2}\sum_{i=1}^{N}\ln 2\pi\sigma_i^2 - \frac{1}{2}\sum_{i=1}^{N}\frac{1}{\sigma_i^2}(\Delta y_i - \phi_i ECT_i))'H_i(\Delta y_i - \phi_i ECT_i)) \quad (6.3)$$

Where,

$\Delta y_i = (\Delta y_{i,1}, \Delta y_{i,2} \ldots., \Delta y_{i,T})'$

$ECT_i = (ECT_{i,1}, ECT_{i,2} \ldots., ECT_{i,T})'$

$H_i = (I_T - W_i(W_i{}'W_i)^{-1}W_i{}')^{-1}$

$W_i = (\Delta y_{i,-1}, \ldots., \Delta y_{i,-p+1}, \Delta X_i, \Delta X_{i,-1}, \ldots., \Delta X_{i,-q+1})'$

$\Delta y_i = (\Delta y_{i,1}, \Delta y_{i,2} \ldots., \Delta y_{i,T})'$

The estimated parameters in PMG model are consistent and asymptotically normal for the stationarity of *I(0)* or *I(1)* (Pesaran et al., 2001; Asteriou, 2009). We run four different PMG ARDL models based on specification discussed in Chapter 4. The PMG ARDL model requires the selection of an appropriate lag length for the individual countries and pooled mean for the short-run and long-run model. We apply the Schwarz Criterion (SC) method to choose the optimal lag length, which is commonly used in practice to run the PMG model.

6.3 Results

The PMG model results for the short-run and long-run relationship are reported in this chapter. The short-run results capture both aggregated and individual countries, while the long-run results are restricted to the same across the group. We have avoided running the PMG ARDL model on the consolidated data considering the potential risk associated with heterogeneity problems occuring when using cross-country data without taking away the effects of income levels. The regression on each developmental stage is performed separately. It allows the thesis to fulfil its two objectives, i.e. first, to confirm the short-run and long-run relationship between the dependent variable and the regressors and second, to determine if the relationship significantly varies across the income levels.

6.3.1 Short-run Analysis

Tables 6.1, 6.2, 6.3 and 6.4 show the findings of the short-run analysis based on the pooled mean group ARDL and individual group (in this case referring to individual

countries). Based on the individual group, most countries in HICs, MICs and LICs are confirmed to have a long-run relationship between innovation, institutions and economic growth as presented by negatively significant ECT regressors.

Unlike the long-run, in the short run, the relationship between innovation and economic growth is mostly negative and insignificant. Changes in innovation output negatively affect economic growth in HICs and LICs whereas in the MICs, innovation input is negatively significant to economic growth in the short run. This relationship also appears across individual countries along the developmental stages. The negative relationship can be explained as externalities in the short run caused by the creative destruction process. For example, a major disruption in particular sectors or industries could lead to the displacement of workers and to a loss in income in the short run.

Meanwhile, institutional changes have no significant relationship to economic growth in the short run. The institutional changes happen rather more slowly and continuous in the short run (Manca, 2010). Hence, no significant relationship is shown in the short run. This argument is similar to what the charts have illustrated in Chapter 4.

Separately, political and social changes have a positive and significant relationship to economic growth in HICs. The result is contradictory to a negative relationship between the political institution and economic growth in HICs in the long run. It means that political changes such as a higher demand for democracy benefit the economy in the short run but not necessarily in the long run.

Table 6.1: Results Summary of the Short-run PMG ARDL Regression Across the Income levels

	HICs								MICs								LICs							
	Model 1		Model 2		Model 3		Model 4		Model 1		Model 2		Model 3		Model 4		Model 1		Model 2		Model 3		Model 4	
	Coefficient	S.E	Coefficient	S.E	Coefficient	S.E	Coefficient	S.E	Coefficient	S.E	Coefficient	S.E	Coefficient	S.E	Coefficient	S.E	Coefficient	S.E	Coefficient	S.E	Coefficient	S.E	Coefficient	S.E
ECT	-0.194*	0.018	-0.130*	0.020	-0.190*	0.019	-0.085*	0.016	-0.175*	0.021	-0.179*	0.021	-0.170*	0.021	-0.183*	0.022	-0.154*	0.021	-0.084*	0.021	-0.151*	0.022	-0.037*	0.015
D(ln Y(-1))	0.693*	0.024	0.666*	0.020	0.680*	0.024	0.640*	0.026	0.402*	0.034	0.413*	0.034	0.412*	0.035	0.426*	0.033	0.385*	0.058	0.416*	0.053	0.394*	0.061	0.392*	0.062
D(KI)	-0.408*	0.141	-0.790*	0.220	-0.505*	0.140	-0.769*	0.220	-0.510*	0.117	-0.502*	0.114	-0.542*	0.113	-0.502*	0.129	-0.132	0.135	0.058266	0.164	-0.144	0.139	-0.002	0.164
D(LAB)	0.219	0.206	-0.174	0.275	0.101	0.194	-0.154	0.261	0.450*	0.120	0.439*	0.116	0.446*	0.118	0.463*	0.119	0.696*	0.146	0.974*	0.162	0.756*	0.156	0.878*	0.169
D(INV)	-0.146	0.097							-0.007	0.015							-0.038***	0.021						
D(INVIN)					-0.021	0.102							-0.037*	0.014							0.009	0.018		
D(INOUT)					-0.224*	0.101							0.026	0.018							-0.026*	0.013		
D(INS)			0.079	0.138							-0.030	0.036							-0.049	0.049				
D(ECO)							-0.24*	0.076							-0.080	0.050							-0.087	0.053
D(POL)							0.261*	0.127							-0.023	0.019							0.028	0.029
D(SOC)							0.256*	0.093							0.016	0.025							0.028	0.022
C	-3.216*	0.307	-5.494*	0.844	-3.832*	0.387	-1.519	0.281	-0.284*	0.040	-0.310*	0.042	-0.398*	0.050	-0.300*	0.040	-1.455*	0.204	-0.316*	0.081	-1.535*	0.237	0.331*	0.120

Note: (*), (**) and (***) represent the coefficient significance at 1%, 5% and 10% respectively.

Source: Author

Table 6.2: Results Summary of the Short-run Analysis in HICs

Country	Model 1		Model 2		Model 3			Model 4			
	Cointegration	INV	Cointegration	INS	Cointegration	INVIN	INVOU	Cointegration	ECO	POL	SOC
Australia	-0.122*	-0.628	-0.096*	0.584	-0.128*	-0.153	-0.941**	-0.067*	0.000	0.348	0.363**
Austria	-0.185*	0.220	-0.086*	0.554*	-0.159*	0.763**	-0.404**	-0.125*	0.001	0.521	0.148**
Belgium	-0.244*	0.495**	-0.175*	0.481	-0.236*	0.067	0.188*	-0.165*	0.438**	0.089	-0.162
Canada	-0.055*	-0.368*	-0.015*	-0.278	-0.071*	-0.181*	0.582**	-0.012*	-0.481*	-0.144	0.220**
Chile	-0.033*	-0.028	-0.064*	-0.095	-0.013*	-0.320*	0.296*	0.059	-0.065	-0.064	0.179*
Denmark	-0.177*	-0.235	-0.157*	-1.024	-0.176*	-0.086*	0.278	-0.139*	-0.573*	2.172	0.164
Findland	-0.236*	-0.879	-0.261*	0.569	-0.181*	-0.449	-0.512	-0.121*	-1.022	0.861	-0.035
France	-0.311*	0.530	-0.232*	1.058	-0.301*	0.727*	-1.187	-0.105*	0.238	0.156	1.505*
Germany	-0.183*	0.323	-0.095*	0.053	-0.160*	0.473**	-1.026	-0.122*	-0.633	0.330	0.716
Greece	-0.194*	-0.252*	-0.085*	0.496	-0.168*	-0.127*	-0.119*	-0.039*	-0.158**	0.577*	0.178
Iceland	-0.124*	0.030	-0.074*	-0.361	-0.081*	0.062**	-0.028	-0.079*	-0.112	0.582	-0.183
Ireland	-0.384*	-0.744	-0.312*	0.639*	-0.417*	-0.425	-0.378	-0.260*	0.181	1.468**	-0.280
Israel	-0.024*	-0.375	0.018	-0.146	-0.041*	-0.378*	0.209	0.015	-0.062	-0.096	-0.046
Italy	-0.248*	-0.154	-0.109*	-0.245	-0.242*	-0.012	-0.293	-0.006**	-0.692*	-0.216**	-0.045
Japan	-0.140*	-1.575	-0.222*	-0.664	-0.137*	-1.697**	0.262	-0.178*	-0.574	-0.088	-0.023
Kore, Rep	-0.131*	0.153	-0.037*	0.466**	-0.101*	0.061	0.062	0.045	-0.671**	0.112*	0.984*
Netherland	-0.305*	0.341	-0.087*	1.500	-0.301*	0.492	-0.521	-0.072*	0.012	0.100	1.341*
New Zealand	-0.258*	-0.102	-0.049*	-0.268	-0.270*	-0.318	0.167	-0.063*	-0.248	-0.696	0.144
Norway	-0.156*	-0.092	-0.014*	0.573	-0.171*	-0.018	-0.158	-0.030*	0.397	-0.034	0.124
Portugal	-0.296*	-0.429*	-0.122*	-0.431	-0.297*	-0.121*	-0.543*	0.005	-0.701**	0.003	-0.272
Spain	-0.248*	0.312	-0.159*	-1.481**	-0.244*	0.514**	-0.219	-0.071*	-0.505**	-0.740*	0.671
Sweden	-0.182*	-0.451**	-0.077*	-0.548	-0.163*	-0.184*	-1.191	-0.112*	-0.355**	-0.270	0.142
Switzerland	-0.138*	-0.094	-0.124*	1.012	-0.176*	-0.023	0.562	-0.173*	0.147	1.070	0.336
United Kingdom	-0.323*	0.440	-0.221*	-0.010	-0.307*	0.824*	-0.543**	-0.129*	-0.242**	0.394	0.335**
United States	-0.155*	-0.086	-0.399*	-0.468**	-0.201*	-0.024	-0.162	-0.187*	-0.332	0.100	-0.083**

Note: (*), (**) and (***) represent the coefficient significance at 1%, 5% and 10% respectively.

Source : Author

Table 6.3: Results Summary of the Short-run Analysis in MICs

Country	Model 1		Model 2		Model 3			Model 4			
	Cointegration	INV	Cointegration	INS	Cointegration	INVIN	INVOU	Cointegration	ECO	POL	SOC
Bangladesh	-0.375*	-0.041*	-0.390*	0.066	-0.495*	-0.053*	0.031*	-0.482*	-0.199*	0.039*	-0.055*
Bolivia	-0.007	-0.0001	-0.010**	0.113	0.000	-0.070*	0.008	-0.026*	-0.363*	0.132*	-0.025*
Botswana	-0.346*	0.042**	-0.359*	0.425**	-0.349*	0.009	0.024*	-0.359*	-0.243**	-0.588	0.363*
Brazil	-0.137*	-0.143	-0.144*	0.398	-0.133*	-0.078	-0.072	-0.166*	0.014	-0.019	0.411*
Bulgaria	-0.073*	0.165	-0.060*	0.101	-0.047*	0.045	0.120	-0.044*	0.076	-0.025	0.292**
China	-0.006**	-0.034**	-0.012*	-0.206	-0.013*	-0.047*	0.035	-0.011*	-0.293*	0.014*	-0.003
Colombia	-0.129*	0.004	-0.121*	0.261	-0.100*	-0.182*	0.017*	-0.142*	-0.197*	0.065*	0.231*
Costa Rica	-0.319*	0.007	-0.328*	0.015	-0.284*	0.079*	0.002	-0.304*	-0.192*	-0.021	0.066*
Dominican Republic	-0.200*	0.032**	-0.232*	0.231	-0.212*	-0.051**	0.029*	-0.227*	0.057	0.064	0.063*
Ecuador	-0.172*	-0.092*	-0.153*	-0.178	-0.152*	-0.142*	-0.021*	-0.158*	-0.043	-0.211*	0.064*
Egypt, Arab Rep	-0.188*	-0.061**	-0.207*	-0.221	-0.192*	0.033*	-0.120*	-0.224*	-0.314*	0.005**	-0.110*
El Salvador	-0.421*	0.013*	-0.421*	-0.011**	-0.236*	0.002	-0.013*	-0.433*	-0.045*	-0.002	0.001
Ghana	-0.101*	-0.107*	-0.095*	-0.173	-0.103*	0.002**	-0.061*	-0.104*	0.096**	-0.132*	-0.022*
Guatemala	-0.074*	-0.007**	-0.055*	-0.029	-0.064*	0.015*	-0.055*	-0.051*	-0.062*	-0.004	-0.002
Honduras	-0.106*	-0.069*	-0.116*	-0.111	-0.112*	0.011	-0.049*	-0.115*	-0.325*	-0.016	-0.019**
India	-0.067*	-0.060	-0.080*	-0.265	-0.072*	-0.145**	0.005	-0.082*	-0.151*	-0.088*	-0.105*
Indonesia	-0.048*	0.093*	-0.073*	0.321	-0.045*	0.053*	0.042*	-0.080*	-0.014	-0.016*	0.227*
Iran, Islamic Rep.	-0.091*	-0.025	-0.099*	-0.281	-0.085*	0.030	-0.187	-0.133*	0.978*	-0.011	-0.305*
Jordan	-0.134*	0.014**	-0.105*	-0.131*	-0.142*	0.012	0.003	-0.100*	-0.730*	0.021*	0.007**
Kenya	-0.114*	-0.063*	-0.122*	-0.193*	-0.099*	-0.061*	0.031*	-0.095*	-0.464*	0.066*	-0.099*
Lesotho	-0.434*	0.067*	-0.450*	-0.287*	-0.430*	0.001	0.027*	-0.456*	-0.047	-0.172*	-0.039*
Malaysia	-0.103*	-0.243*	-0.103*	0.064	-0.101*	-0.152*	0.020	-0.128*	0.264*	-0.108*	0.018**
Mauritius	-0.182*	0.010**	-0.176*	-0.204**	-0.211*	-0.002	0.001	-0.155*	0.417**	0.012	-0.072*
Mexico	-0.255*	-0.170*	-0.234*	0.259*	-0.251*	-0.090*	-0.073	-0.239*	0.057	-0.007	0.155*
Namibia	-0.149*	0.132*	-0.252*	0.131	-0.153*	0.023*	0.081*	-0.248*	-0.048	0.096	0.034
Nigeria	-0.087*	-0.110*	-0.098*	-0.299*	-0.062*	0.077**	-0.100*	-0.034*	-0.074*	-0.009*	-0.212*
Pakistan	-0.049*	-0.021*	-0.050*	0.025*	-0.054*	-0.021*	0.009*	-0.051*	-0.111*	0.026*	0.001**
Panama	-0.520*	-0.074*	-0.523*	-0.080*	-0.537*	-0.232*	0.009**	-0.498*	-0.166	-0.030*	-0.002
Peru	-0.082*	0.003	-0.033*	-0.362*	-0.083*	0.036	-0.020*	-0.054*	0.212**	-0.061*	-0.212*
Philippines	-0.097*	0.053**	-0.138*	0.191*	-0.078*	-0.011**	0.127**	-0.160*	0.147*	0.059*	0.067*
South Africa	-0.174*	-0.019	-0.168*	-0.023	-0.188*	-0.285**	0.200*	-0.154*	-0.501*	0.069	-0.014
Sri Lanka	-0.173*	0.018**	-0.143*	-0.160*	-0.150*	-0.042*	0.062*	-0.152*	-0.161*	-0.053*	0.070*
Swaziland	-0.151*	0.117**	-0.162*	-0.329*	-0.155*	0.005767	0.202*	-0.182*	-0.400*	-0.027**	-0.065*
Thailand	-0.082*	0.030	-0.085*	0.103*	-0.058*	-0.117*	0.192*	-0.126*	0.549*	0.067*	-0.122*
Tunisia	-0.340*	0.017	-0.327*	-0.065**	-0.306*	0.007**	-0.031**	-0.333*	-0.292**	-0.010**	0.018**
Turkey	-0.262*	0.180*	-0.259*	-0.379**	-0.262*	-0.064**	0.474*	-0.240*	-0.141**	0.048**	-0.215*
Zambia	-0.243*	0.079*	-0.258*	0.160**	-0.276*	0.018*	0.030*	-0.221*	-0.254*	-0.011	0.197*

Note: (*), (**) and (***) represent the coefficient significance at 1%, 5% and 10% respectively.

Source : Author

Table 6.4: Results Summary of the Short-run Analysis in LICs

Country	Model 1		Model 2		Model 3			Model 4			
	Cointegration	INV	Cointegration	INS	Cointegration	INVIN	INVOU	Cointegration	ECO	POL	SOC
Benin	-0.369*	-0.139*	0.014**	-0.033	-0.384*	-0.112*	-0.030*	0.021*	-0.126*	0.053**	-0.090*
Burkina Faso	-0.066*	-0.081*	0.002	-0.312*	-0.053*	0.003	-0.054*	-0.013*	-0.053	-0.235*	0.061*
Burundi	0.008**	0.074*	-0.083*	-0.057**	0.011*	0.021*	0.032*	-0.053*	-0.073*	0.031*	0.085*
Ethiopia	-0.079*	0.058*	-0.013*	0.085	-0.074*	0.087*	0.018*	0.000	0.138**	-0.103*	0.197*
Gambia	-0.207*	-0.110*	-0.062*	0.144*	-0.232*	0.008*	-0.073*	-0.082*	-0.124**	0.038*	0.138**
Guinea	-0.112*	-0.075*	-0.115*	-0.067	-0.149*	0.095*	-0.127*	-0.084*	-0.314*	0.068*	0.018**
Madagascar	-0.163*	0.061*	-0.037*	0.148**	-0.182*	0.046*	0.038*	-0.094*	0.010	0.125*	0.065*
Malawi	-0.189*	-0.071**	-0.010*	-0.406*	-0.149*	0.095*	-0.127*	-0.011*	-0.297*	-0.096*	-0.088*
Mali	-0.166*	-0.058**	-0.047*	0.075*	-0.160*	0.107*	-0.050*	-0.008*	-0.180*	0.041*	0.062*
Mozambique	-0.206*	0.167*	-0.138*	-0.462*	-0.170*	0.173*	0.037*	0.022*	-0.146*	-0.115*	0.017
Nepal	-0.044*	0.035*	0.068*	0.015	-0.042*	0.006**	0.033*	0.052*	-0.141*	0.005**	0.053*
Niger	-0.181*	-0.028*	-0.135*	0.038	-0.185*	0.006*	-0.041*	-0.130*	0.004	0.034*	0.066*
Rwanda	-0.147*	-0.012**	-0.279*	-0.105**	-0.103*	-0.043*	0.045*	0.006**	-0.392*	0.072*	-0.014
Senegal	-0.159*	-0.079*	-0.101*	0.068	-0.178*	-0.037*	-0.038*	-0.074*	-0.321**	0.056*	0.106*
Sierra Leone	-0.071*	-0.117**	-0.098*	-0.233*	-0.053*	-0.029*	-0.086**	-0.035*	-0.143*	0.034*	-0.216*
Togo	-0.247*	-0.057*	-0.075*	0.276**	-0.235*	-0.011	-0.022*	-0.182*	0.398*	0.080*	0.071*
Uganda	-0.236*	-0.090*	-0.249*	0.192	-0.280*	-0.122**	-0.016**	0.037*	0.438**	0.367*	-0.048
Zimbabwe	-0.154*	-0.180*	-0.154*	-0.259*	-0.131*	0.026*	-0.131*	-0.050*	-0.237*	0.051*	0.020*

Note: (*), (**) and (***) represent the coefficient significance at 1%, 5% and 10% respectively.

Source : Author

Table 6.5: Results Summary of the Long-run PMG ARDL Regression Across the Income levels

	HICs								MICs								LICs							
	Model 1		Model 2		Model 3		Model 4		Model 1		Model 2		Model 3		Model 4		Model 1		Model 2		Model 3		Model 4	
	Coefficient	S.E	Coefficient	S.E	Coefficient	S.E	Coefficient	S.E	Coefficient	S.E	Coefficient	S.E	Coefficient	S.E	Coefficient	S.E	Coefficient	S.E	Coefficient	S.E	Coefficient	S.E	Coefficient	S.E
KI	0.608*	0.255	1.473*	0.190	0.666*	0.255	0.342	0.268	-0.504*	0.100	-0.518*	0.100	-0.43*	0.107	-0.541*	0.105	0.988*	0.267	0.646*	0.154	1.196*	0.278	0.902*	0.439
LAB	1.468*	0.308	3.240*	0.107	1.553*	0.319	2.366*	0.170	1.332*	0.076	1.309*	0.078	1.319*	0.076	1.304*	0.077	1.190*	0.313	0.301	0.197	1.202*	0.321	-1.654*	0.596
INV	1.475*	0.334							-0.065	0.052							0.392*	0.127						
INVIN					0.395***	0.231							0.0910***	0.050							0.203*	0.071		
INOUT					1.632*	0.316							-0.038	0.036							0.065	0.061		
INS			1.965*	0.265							0.039	0.082							1.376*	0.288				
ECO							1.586*	0.434							0.019	0.067							1.124*	0.432
POL							-1.660*	0.553							0.042	0.032							0.078	0.149
SOC							0.074	0.250							0.009	0.042							-0.006	0.154
Log likelihood	1346.356		1349.305		1374.701		1307.145		1992.568		2013.213		2013.871		2104.704		758.941		727.142		771.620		756.190	

Note: (*), (**) and (***) represent the coefficient significance at 1%, 5% and 10% respectively.

Source: Author

6.3.2 Long-run Analysis

Table 5.5 reports the summary of the PMG ARDL model for the long-run relationship. All models across the developmental stages have a significant long-run relationship given that the error correction term (ECT) is negatively significant. The coefficient of ECT indicates the speed of adjustment of correcting for disequilibrium in the short run and reaching a long-run steady state of equilibrium. All ECT coefficients in the regression model are within the desirable value of between -1<ECTi,< 0.

The long-run results vary significantly across the income levels. As suggested in past literature from both the neoclassical and Schumpeterian points of view, innovation activities have a significant role in contributing to economic growth over the long run. In this thesis, the PMG ARDL models have confirmed that innovation significantly contributes to the economic growth in the HICs and LICs. Further analysis of the coefficient finds the impact of innovation on economic growth stronger in the advanced economies than in the developing countries. When innovation improves by 1 percentage, the impact on economic growth in the HICs increases by 1.45 percentage while in LICs, the increase is only 0.39 percentage.

The result is in line with the argument of "founder effect" by Arthur (1989) that we have reported earlier in the previous chapter. The reciprocal causality relationship between economic growth and innovation as shown in the previous chapter has further supported our claim on increasing return in HICs. The impact from increasing return is reflected by a higher contribution of innovation activities to the economic growth in the HICs compared to MICs and LICs.

In contrast to HICs and LICs, the overall innovation index in the Middle-Income Countries (MICs) does not have significant relationship to the economic growth in the long run. However, it is important to note that innovation input still have a significant role to promote economic growth in the MICs. Innovation output, which represented mostly by IPR related variables such as patent and trade mark is not significant to economic growth in MICs. A similar result is also reported by Falvey et al. (2006) when they study the impact of Intellectual Property Right (IPR) on the economic growth. The IPR is often considered a proxy to innovation. They find that IPR contribution to economic growth is insignificant in MICs, unlike in the HICs and LICs. The strengthening of IPR protection will offset the opportunity for MICs to engage in the imitation-based growth model, which is the basis for innovation-led growth model in East Asian Countries.

In the LICs, innovation is positive and significantly contributes to economic growth, even though as discussed earlier, the rate of contribution to economic growth is smaller compared to HICs. The regression results show that the relationship between innovation and economic growth is inelastic in LICs compared to the elastic relationship in HICs. It means more innovation-led activities are required to generate a marginal increase in the per capita income in the LICs compared to HICs. Nevertheless, innovation still has an important role in LICs given that increase in the innovation flows enhances productivity and thus contributes to a higher economic growth.

Meanwhile, innovation inputs significantly contribute to the economic growth in all income levels. Higher investment in human capital, research intensity and knowledge accumulation are expected to increase the productivity that eventually contributes to higher per capita income (Griliches and Lichtenberg, 1984; Lucas, 1990; Romer, 1990;

Lichtenberg and Siegel, 1991; Akcigit, 2017; Choi and Yi, 2018). While all coefficients of innovation input are positively significant in economic growth, the elasticity of innovation input to economic growth is higher (based on the coefficient) in the HICs compared to MICs and LICs. This finding is also aligned with past empirical research by Peretto (1999) and Guloglu and Tekin (2012).

Unlike the innovation input, the innovation output only contributes significantly to the HICs but not in MICs and LICs. It reflects the lack of innovation output in the developing countries compared to the developed economies that could generate significant income from innovation output. A cross-country study conducted by Schneider (2005) finds that the impact of property rights on innovation and economic growth is only significant in the developed economies. In the developing countries, the outcome from innovation activity may not necessarily produce a direct impact on the per capita income, but it still helps the economy to expand indirectly. Lack of absorptive capacity and commercialisation of innovation output remains questionable in MICs and LICs (Grossman & Helpman, 1991; Hasan & Tucci, 2010; Castellacci & Natera, 2013). Moreover, issues like budget constraint, a higher incidence of innovation failure and weak institutions are some of the factors often quoted in past researches to explain this condition (Acemoglu et al., 2006).

Similar to innovation, the institutions are also positive and significantly contribute to economic growth in the HICs and LICs over the long run. However, there is no significant relationship found in the MICs. Unlike the relationship between innovation and economic growth, the impact of institutional strength on economic growth in HICs and LICs are both elastic. For every 1 percentage increase in institutional strength in HICs and LICs, the per capita income expands by 1.965 percentage and 1.376 percentage respectively. It

also reiterates results of past empirical researches on the role of institutions in promoting economic growth.

The relationship between institutions and economic growth becomes even more interesting as we analyse the sub-indices of institutions separately. Economic institutions, which represent the transaction cost, have registered positive and significant relationship to economic growth. When the transaction cost becomes lower, economic institutions are likely to improve. The improvement in economic institution will bring a higher growth in per capita income as the market, being a superior institution, becomes efficient (North, 1987). This empirical result echoes what Coase (1937) argues of the relationship between transaction cost and market efficiency which brings the formation of the New Institutionalism.

While social institutions have no significant relationship with economic growth over the long run across income levels, the political institutions register a negative relationship with economic growth in HICs in the long run. The demand for democracy, which is the key factor representing political institution ambiguously has a negative relationship with economic growth in HICs. The results may sound ludicrous and against the common belief among economic scholars on the importance of political institutions on economic growth. Nonetheless, there is evidence from past literature that links democracy negatively with the direct impact to economic growth, while the indirect impacts remain largely positive (see Sirowy & Inkeles,1990; Haggard,1990).

The negative relationship between political institutions and economic growth in HICs reminds us of the study done by Olson (1982) on the "collective action theory" where he argues that mature democracies are likely to suffer from a slowdown in growth as the

power of the special interest group reduces when incentives for free-rider groups increase. While this theory suffers from criticism, so far the systematic evidence produced to establish the relationship between democracy and economic growth remains scarce and mixed (Helliwell, 1994). Separately, in the MICs and LICs, the relationship between political institutions and economic growth remains positive, though the relationship is insignificant.

Besides innovation and institutions, the PMG ARDL models also include labour productivity and capital intensity as a control variable to fulfil the requirement of running a modified neoclassical production function model. Labour productivity is positively significant with economic growth in almost all models across the income levels. However, capital intensity produces mixed results. In HICs and LICs, increase in capital intensity improves economic growth, but the relationship turns negative in the MICs. The relationship in MICs is in line with the neoclassical argument of the diminishing return of capital. In HICs and LICs, the capital accumulation policy tends to benefit the economic growth in the long run. However, it is important to note that the role of capital in HICs and LICs could be different and this thesis does not focus on capturing the reasons for these differences.

6.4 Conclusion

In conclusion, based on the error correction term (ECT) in the PMG ARDL models, this thesis confirms that innovation and institutions have a significant role in determining economic growth in the long run. The impact of innovation and institutional changes is influenced by the income levels. Innovation activities appear to be more beneficiary to the economic growth in the HICs compared to MICs and LICs. Innovation output only

has a significant relationship to economic growth in HICs while innovation input is positively significant across the income levels.

Unlike innovation, the impact of institutional changes to economic growth is almost equal between the HICs and LICs. However, when analysing the institutions sub-indices, we find that the results are more telling and even some of them are ambiguous compared to commonly accepted arguments on the role of institutions. For example, in HICs, the political institution is negatively significant to economic growth. The additional demand for democracy is expected to ease economic growth in the long run. We refer to "collective action theory" to explain this event. Economic and social institutions mostly have a positive relationship to economic growth across income levels despite not all being significant relationship.

Meanwhile, in the short run, the impact of innovation and institutions is generally insignificant to economic growth. In most cases, the changes in institutions and innovation happen at a gradual pace and the actual impact of innovation and institutional changes on the economic growth is only noticeably significant in the long run.

CHAPTER 7: **INNOVATION AND ECONOMIC GROWTH: INSTITUTIONS AS A MODERATOR**

7.1 Introduction

The neo-Institutionalist argues that institutions have a central role in enabling the market to perform efficiently. Coase (1937) advances the idea of transaction cost and how it improves market efficiency and this is later developed by North (1990) and others. Without the presence of institutions, the market may have to deal with a higher transaction cost, in which could extend the potential risks of market failure. The role of political institutions in formulating economic and social policy influences the performance of the market, either in a positive direction or negative direction, depending on the quality of the policy (Knack & Keefer, 1995; Rivera- Batiz, 2002; Rodrik et al. 2004; Acemoglu et al. 2005).

The impact of institutional constraints on economic growth and innovation activity has been studied widely in the past. Most of these researchers suggest that either directly or indirectly, institutions have a role in influencing economic growth and innovation. The results often suggest that institutions support innovation activities in the high-income economy. In contrast, the lack of nstitutional strenght inhibits the expansion of innovation activity in the underdeveloped economies.

Hence, in this thesis, we include the interaction variable in the PMG ARDL model to examine the role of institutions as a moderating factor between innovation and economic growth. As a moderator, institutions are expected to enhance the effectiveness of

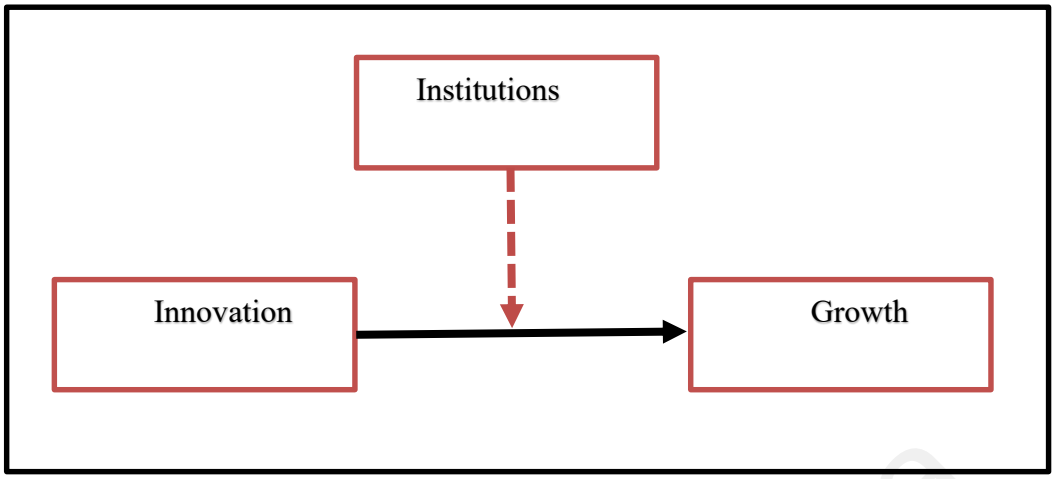
innovation activity on improving the economic growth. This exercise seeks to confirm if institutions have a moderating impact on economic growth or otherwise.

7.2 The Interaction Measures

It is common in the field of social science to test for interaction effects between two or more continuous variables before proposing a theory. The interaction testing exercise captures the interplay among predictors on the outcome of the dependent variable that is different from the sum of effects of individual regressors (Cohen et al. 2014). In the existence of moderating effects, the effectiveness of combined factors could lead to either a positive or a negative outcome on the dependent variable.

In the case of positive interactions, the predictors or regressors could synergistically sway on the final effects on the dependent variable. The combined effect of two variables is greater than the sum in parts. In contrast, when the interaction is negative, the combined regressors compensate one another, where the combined effects are less than the sum in parts of the individual regressors.

In this chapter, we have employed the PMG ARDL model once again to test the moderation effects of institutions in influencing the effectiveness of innovation activity on contributing to the economic growth. The reasons for the exercise is to compare the empirical outcome before and after the introduction of the interaction variable in the model. In the case where the interaction variable is significant, institutions are expected to have a moderating effect on innovation in influencing the relationship between innovation and economic growth. The framework to explain this relationship is presented in Figure 7.1.



Source: Author

Figure 7.1: Moderating Effect of Institutions

The PMG ARDL model that represents a moderating effect on institutions is tested as follows:

$$\Delta y_{i,t} = \phi_i ECT_{i,t} + \sum_{j=1}^{p-1} \gamma_{i,j} * \Delta y_{i,t-j} + \sum_{j=0}^{q-1} \Delta KI_{i,t-j}'\beta_{i,j} + \sum_{j=0}^{q-1} \Delta LAB_{i,t-j}'\beta_{i,j} + \sum_{j=0}^{q-1} \Delta INV_{i,t-j}'\beta_{i,j} + \sum_{j=0}^{q-1} \Delta Z_{i,t-j}'\beta_{i,j} + \sum_{j=0}^{q-1} \Delta \text{INV}.Z_{i,t-j}'\beta_{i,j} + \varepsilon_{i,t} \quad (7.1)$$

Four individual models derived from equation 7.1 test the moderating effects of institution index and its three sub-indices. The independent variables are KI_{it}, LAB_{it}, and INV_{it} which represent the capital intensity, labour productivity and innovation index of ith country at time t respectively. Log per capita income represents the independent variables (IV). The Z_{it} represents the institution index (Model 1) and the institution sub-indices, i.e. economic institutions (Model 2), political institutions (Model 3) and social institutions (Model 4) which are all classified as moderator variables. Finally, the product of moderator and innovation index represents the interaction variable that is $INV.Z_{it}$.

7.3 Results: The Moderating Role of Institutions.

The results in Table 7.1 and 7.2 show the role of institutions as a moderator of the relationship between innovation and economic growth in the short-run and long-run respectively. The interaction variable in the model implies a mean-centred value to minimise the problem associated with multicollinearity, although in theory, the ARDL model is not required to test for multicollinearity. The lag selection for the model is based on the Schwarz criterion with the lowest value which is preferred.

Before exploring the long-run relationship, it is worth noting that in the short run, the role of institutions in moderating the innovation activity is insignificant across the income levels. In the short run, interaction between institutions and innovation may not significantly contribute to the effectiveness of innovation activity in growing the per capita income. The condition is in line with past literature that institutional changes mostly happen in a gradual manner (Acemoglu et al., 2006; Manca, 2010). However, all the four models confirm the presence of a long-run relationship based on the error correction term (ECT) which is significant and has a negative sign. Most of the values of ECT are closer to zero, which explains that a smaller correction is needed to reach the long-run steady condition.

The model is tested across the income levels. In the High-income OECD countries (HICs), the interaction between innovation and institutions is significant, but the negative sign shows substitution effects between the two regressors. The institutional changes are significant and positively contribute to the economic growth in the HICs, which is similar to the earlier findings in the previous chapter. However, by adding the interaction

variable, we find that the institution's contribution to economic growth has improved, but the impact of innovation on economic growth has dropped substantially, and the variable is no longer significant. As such, the interaction variable explains that when the institution index strengthens, the impact of innovation on economic growth is expected to weaken. The result is interesting as well as challenging to explain as past researches mostly argue that innovation contributes significantly in the developed economies and not in developing economies due to the differences in institutional strength.

Nonetheless, the outcome of HIC's regression is more interesting when the analyse is conducted on sub-indices of the institutions. Interaction variable is significant in economic institutions and political institutions but not in social institutions. The negative moderating effects of the institution index is mainly attributed to a large and significant negative interaction between the political institutions and innovation activity. We have argued in the previous chapter that in political institutions, a demand for greater democracy may not necessarily benefit the economy, especially in countries within HICs. Similar results are also presented here, even though the political institutions do not have any significant direct relationship with economic growth after the interaction variable is introduced. Therefore, the increase in demand for democracy in the HICs will weaken the impact of innovation on economic growth.

Table 7.1: Results Summary of the Short-run PMG ARDL on Moderating Impact of Institutions

	HICs								MICs								LICs							
	Model 1		Model 2		Model 3		Model 4		Model 1		Model 2		Model 3		Model 4		Model 1		Model 2		Model 3		Model 4	
	Coefficient	S.E	Coefficient	S.E	Coefficient	S.E	Coefficient	S.E	Coefficient	S.E	Coefficient	S.E	Coefficient	S.E	Coefficient	S.E	Coefficient	S.E	Coefficient	S.E	Coefficient	S.E	Coefficient	S.E
ECT	-0.129*	0.021	-0.119*	0.021	-0.134*	0.021	-0.12*	0.019	-0.074*	0.019	-0.063*	0.013	-0.076*	0.017	-0.065*	0.022	-0.083*	0.021	-0.059*	0.018	-0.055*	0.017	-0.069*	0.018
D(LGNI(-1))	0.681*	0.019	0.665*	0.025	0.675*	0.023	0.681*	0.025	0.419*	0.036	0.395*	0.033	0.412*	0.037	0.444*	0.032	0.428*	0.059	0.401*	0.060	0.408*	0.057	0.403*	0.063
D(LKI)	-0.876*	0.219	-0.837*	0.235	-0.842*	0.225	-0.643*	0.236	-0.643*	0.148	-0.502*	0.120	-0.616*	0.146	-0.580*	0.134	0.110	0.182	0.040	0.150	0.150	0.179	0.039	0.178
D(LLAB)	-0.282	0.280	-0.152	0.302	-0.182	0.297	-0.016	0.289	0.537*	0.156	0.740*	0.109	0.562*	0.154	0.676*	0.144	0.997*	0.184	1.009*	0.157	0.932*	0.194	0.999*	0.204
D(LINV)	-0.013	0.325	-0.137	0.247	-0.087	0.334	0.013	0.170	0.044	0.058	0.042	0.109	0.016	0.068	0.125	0.155	0.004	0.030	0.037	0.044	0.025	0.030	-0.033	0.039
D(LINS)	-0.313	0.312							0.001	0.078							-0.044	0.055						
D(ECO)			0.017	0.123							0.071	0.108							-0.115**	0.049				
D(POL)					0.026	0.359							-0.078**	0.040							0.004	0.030		
D(SOC)							0.367	0.226							0.148	0.166							0.022	0.028
C	-5.618*	0.915	-5.700*	0.990	-5.851*	0.934	-4.972*	0.806	-0.359*	0.112	0.147*	0.038	-0.735*	0.187	-1.060*	0.371	-0.213*	0.059	0.299*	0.091	0.101*	0.030	0.441*	0.115
SR Moderation Effect																								
INV *INS	3.544	3.507							-0.132	0.241							-0.044	0.126						
INV*ECO			1.295	1.682							0.449	0.284							-0.118	0.166				
INV*POL					0.226	3.892							0.019	0.118							-0.067	0.054		
INV*SOC							2.093	2.420							-0.225	0.351							0.007	0.073

Note: (*), (**) and (***) represent the coefficient significance at 1%, 5% and 10% respectively.

Source : Author

Table 7.2: Results Summary of the Long-run PMG ARDL on Moderating Impact of Institutions

	HICs								MICs								LICs							
	Model 1		Model 2		Model 3		Model 4		Model 1		Model 2		Model 3		Model 4		Model 1		Model 2		Model 3		Model 4	
	Coefficient	S.E	Coefficient	S.E	Coefficient	S.E	Coefficient	S.E	Coefficient	S.E	Coefficient	S.E	Coefficient	S.E	Coefficient	S.E	Coefficient	S.E	Coefficient	S.E	Coefficient	S.E	Coefficient	S.E
KI	1.386*	0.208	1.914*	0.178	1.761*	0.179	1.664*	0.213	-1.452*	0.215	-1.265*	0.207	-1.141*	0.200	0.595*	0.136	0.567*	0.153	0.508**	0.217	0.273	0.303	0.502*	0.163
LAB	3.189*	0.117	3.742*	0.119	3.584*	0.124	3.567*	0.142	2.203*	0.078	2.357*	0.116	2.465*	0.067	2.278*	0.071	0.174	0.216	-0.444	0.265	0.625**	0.242	-0.526	0.346
INV	0.224	0.358	1.432*	0.250	0.707**	0.310	1.024*	0.332	0.674*	0.117	0.258***	0.150	0.561*	0.124	0.536*	0.121	-0.049	0.122	-0.130	0.137	-0.752*	0.252	0.381*	0.118
INS	2.288*	0.291							-0.38***	0.200							1.457*	0.294						
ECO			0.001	0.278							-2.282*	0.206							0.525	0.321				
POL					0.422	0.401							0.051	0.065							0.171	0.102		
SOC							-0.282	0.294							-0.107	0.093							-0.182	0.129
LR Moderation Effect																								
INV *INS	-8.488**	3.864							1.495*	0.395							-0.416	0.328						
INV*ECO			4.928*	1.024							-1.137*	0.419							1.786*	0.561				
INV*POL					-8.061*	2.895							1.051*	0.172							0.768**	0.349		
INV*SOC							-3.560	2.245							0.763*	0.266							0.184	0.164
Log likelihood	1327.953		1337.131		1337.448		1329.372		1949.686		1987.366		1947.280		1960.500		748.613		749.345		745.555		744.590	

Note: (*), (**) and (***) represent the coefficient significance at 1%, 5% and 10% respectively.

Source : Author

While interaction with the political institutions reduces the effectiveness of innovation activity in HICs, the role of economic institutions remains strong and positively significant in the economic growth. Besides that, economic institutions also enhance the effectiveness of innovation activity in influencing the economic growth. It is reflected by the positive and significant coefficient of economic institutions and interaction variable in Model 2 in the HICs. It is in line with past research on transaction cost which argues that a lower transaction cost increases the efficiency of the market and allows for innovation to flourish.

The role of the interaction variable in the growth model is also interesting in the middle-income economies (MICs). Looking back at the outcome of MICs' regression in the previous chapter, we find that there is no significant relationship between innovation, institutions and the economic growth. However, after adding the interaction variable, we find that innovation is independently significant and contributes positively to the economic growth in all the four models.

In Model 1, the interaction variable has a positive and significant contribution to the economic growth. The improvement in the institutional strenght enhances the effectiveness of innovation in increasing the per capita income, albeit institutions themselves independently have no significance in influencing the economic growth. Moreover, unlike in HICs, the contribution of political and economic institutions to the economic growth is completely the reverse in MICs. The economic institutions negatively interact with innovation while the political institutions interact positively with innovation.

The contradicting results produced is not something peculiar to our thesis, but similar results also have been reported in other past studies. The demand for promoting political freedom is expected to increase when an economy moves in the development trajectory from a developing economy to become a developed economy (Leftwich, 1993; Baum & Lake, 2003). During the middle-income stage, the causality direction between political institutions and economic growth mutually reinforces each other, which we have posited in Chapter 4 as producing an increasing return to the economy. Likewise, with the interaction variable which is positively significant, it suggests that the contribution of innovation further supports economic growth in MICs as political institutions strengthen.

Meanwhile, the results of negative interaction from economic institutions to innovation in influencing economic growth seem disconnected with the theory of transaction cost. Moreover, economic institutions also are found to have an independent negative significant relationship to economic growth. Given the contradictory results, we have further investigated the relationship of economic institutions by disaggregating the index based on three factors, namely transaction cost, domestic credit expansion and trade openness.

After testing the role of transaction cost separately, we found that the outcome of the regression is more sensible and in line with past literature. Transaction cost alone has a positive and significant relationship independently with economic growth. However, despite the positive sign, the interaction variable does not significantly moderate the 7relationship between innovation and economic growth in the long run (refer to Table 7.3). Given that the transaction cost is positively related to economic growth, we can conclude that the negative results of economic institutions in Table 7.1 could be mainly attributed to credit expansion and trade openness.

The credit expansion which is represented by domestic credit to GDP ratio is reflected on the degree of financial intermediation and the size of leveraging of the economy. The size of domestic credit could explain the process of leveraging in the economy. The role of domestic credit, especially in the developing countries is binomial where it could benefit the economy and at the same time could jeopardise the economic growth in the long run. This is necessarily true if the condition of over-leveraging in the long run is

Table 7.3: The Moderating Impact of Economic Institutions (Only Transaction Cost) in MICs

	Economic Institution (Transaction Cost)	
	Coefficient	S.E
KI	-0.652*	0.120
LAB	2.415*	0.112
INV	-0.602*	0.152
ECO	0.363*	0.110
ECT	-0.075*	0.012
LR Moderation Effect		
INV *INS		
INV*ECO	0.073	0.173
INV*POL		
INV*SOC		
SR Moderation Effect		
INV *INS		
INV*ECO	-0.314***	0.284
INV*POL		
INV*SOC		
Log likelihood	1934.010	

Note: (*), (**) and (***) represent the coefficient significance at 1%, 5% and 10% respectively.

Source : Author

prompted by erroneous investments that lead to the creation of bubbles in the economy. A prolonged period of leveraging in erroneous investments could eventually lead to a financial crisis. The risks to the formation of financial crisis become even higher when the economy borrows using the external currency (Kaminsky & Reinhart, 1999; Reinhart & Rogoff, 2010). By leveraging, the economy will experience economic expansion and subsequent correction lead to contraction as explained in the Schumpeterian business cycle model. The financial crisis caused by over-leveraging does not only lead to a collapse in the economic growth, but in many cases, it also erases the gain in per capita income made during the good times. The financial crisis in East Asia and Latin America in the 1990s suffered a substantial wipeout of GNI per capita gained during the pre-crisis period. Moreover, it took a prolonged period before the per capita income returned to the pre-crisis level (Prasad et al., 2005; Reinhart & Rogoff, 2014).

Separately, the role of trade openness with economic growth in the long run is something that remains unclear. Greenwald and Stiglitz (2006) argue that the conventional view on trade enhancing efficiency and thus expanding economic growth may not necessarily hold true in the case of developing countries. They find difficulty in accepting that market by itself is efficient and instead believe in trade-offs between patent protection and long-run economic growth. Meanwhile, Yanikkaya (2003) conducts a cross-country empirical study and finds that trade restrictions increase economic growth in developing countries. However, the impact of trade protectionism on economic growth depends on the size of the domestic economy and the comparative advantage of the sector which receives protection. Hence, the argument of negative interaction from trade openness to innovation and economic growth in MICs explains that the benefits of trade restrictions might outweigh the advantage of protecting innovation.

Meanwhile, the social institutions represented by basic education and connectivity significantly moderate the effect of innovation on economic growth in the MICs. Investment in social institutions in the MICs tends to increase the effectiveness of innovation in expanding the economic growth. In this model, innovation also independently contributes to the positive and significant per capita income growth in the MICs.

Finally, in the LICs, the role of institutions is positive and independently contributes to the economic growth. However, when testing for the interaction between institutions and innovation, we find that the relationship is insignificant. The role of institution index does not significantly moderate the impact of innovation on economic growth in the LICs.

Nonetheless, the institution sub-indices, namely the economic institutions and political institutions in LICs interact positively with innovation to enhance the effectiveness of innovation activity on the economic growth. Indeed, the institutional change required in LICs is not necessarily transformational but instead, small changes will provide sufficient benefits to the economy. For example, the study done by Grindle (2004) argues that "good enough governance" which is sufficient and more realistic goals increases per capita income and reduces poverty in the LICs. Therefore, strengthening the economic and political institutions is necessary to have economic kick-starts in the LICs.

While the role of institutions has reinforced the results presented in the previous chapter, the independent contribution of innovation to economic growth is no longer positive and significant in all models except for Model 4. It gets even complicated interpreting the interaction variable when the independent variable is negatively significant whereas the interaction variable exhibits a positive significant relationship

with economic growth. We see this in Model 3 where the political institutions enhance the role of contribution of innovation to economic growth while innovation itself reduces growth. Thus, the inference for Model 3 is explained as follows - when LICs introduce more political freedom, the negative impact of innovation on per capita income will become less destructive.

A similar interpretation is also valid for Model 2. Here, the interaction between the economic institutions and innovation is positive and significant to economic growth. The independent relationship between innovation and economic growth is negative. However, unlike Model 3, the negative direct relationship between innovation and economic growth is insignificant in Model 2.

Meanwhile, Model 4 explains the role of social institutions in moderating innovation impact on economic growth. In Chapter 4, we recall that only social institutions exhibit a significant causal relationship with economic growth while all other variables show an insignificant relationship. Despite the importance of social institutions in the LICs, we find no significant relationship between social institutions and economic growth in the PMG ARDL model presented in the previous chapter. Social institutions also do not show any significant direct impact. Nonetheless, in LICs, a direct impact of innovation on economic growth is only significant and positive in the presence of social institution. Social institutions moderate the role of innovation positively, although the relationship is insignificant.

As a conclusion, in the LICs, although the role of the institutional index as a moderator is insignificant, the direct impact of institutions on economic growth remains indisputable. The moderating role of institutions is only apparent when analysing the sub-

indices of institutions. The sub-indices of institutions have produced a significant direct and indirect impact on growth by reducing the negative implication of innovation activity to the economic growth. Innovation activity only becomes directly positive to the economy when social institution changes happen in the LICs.

7.4 Conclusion

In this chapter, we find that institutions do not only directly influence economic growth, but more importantly, they enhance the impact of innovation on the economic growth. Indeed, the role of institutions as a moderator is only meaningful in the long run, while no significant relationship exists in the short run. However, there are significant differences in which institutions have influenced the interaction across the income levelsin the long run.

In HICs, the economic institution plays a pivotal role in expanding the economic growth. However, the political institution has a negative interaction with economic growth. Hence, more democracy reduces the effectiveness of innovation. In contrast, in the MICs, positive changes in the political institution have a pivotal role in enhancing the effectiveness of innovation, but policy changes in economic institution are expected to reduce the effectiveness of innovation in expanding economic growth. After further investigation, we find that the role of transaction cost in enhancing economic growth in MICs remains intact. However, the other two factors, namely trade openness and credit expansion contribute to interaction negatively.

In LICs, after adding the interaction variable, we find that the role of institutions is primarily unchanged, but the direct relationship between innovation and economic

growth has turned negative in all models except for the model that examines the interaction of social institutions. Nevertheless, the negative relationship between innovation and growth is only significant in the political institution interaction model. Therefore, as demand for democracy and governance increases in the LICs, the negative impact of focusing on innovation activity becomes less destructive.

Finally, improvement in the social institutions could lead to positive changes in the effectiveness of innovation activity in enhancing economic growth. However, we find that the indirect moderating factor is only significant in the MICs.

In conclusion, our thesis produces empirical evidence that supports the theoretical argument posited in past researches. The outcome of the study confirms the role of institutions as a moderator in enhancing the contribution of innovation to the economic growth either directly or via interaction variables. However, the types of institutions and their interaction are varied across the developmental stages. Therefore, as a policy recommendation, the thesis would encourage the policy makers to understand the impact of institutions and their sub-indices as moderating factors that are unique and distinct across the income levels.

CHAPTER 8: **SUMMARY, IMPLICATIONS AND LIMITATIONS**

8.1 Introduction

This thesis aims to establish the dynamic links between institutions, innovation and economic growth between the income levels. Although economic scholars in the past have attempted to develop theories and solutions on how global economies should converge, the reality remains the opposite. The global growth has been diverging and not converging as envisaged by scholars from various schools of thought. The neoclassical suggests that economic growth will be prosperous when an economy manages to accumulate capital. However, Abromovitz's (1956) landmark study on the US historical growth rate shows that capital accumulation only partially explains the historical growth rate in the US while the rest are unknown. The unknown or black box is termed as a technical change in the neoclassical growth framework. The post-neoclassical period promotes knowledge accumulation embedded in human capital and R&D activity as an alternative to capital accumulation policy. In the new approach, technical change is no longer consider exogenous and therefore, many economic scholars attempt to endogenise these factors.

In the process of endogenising technical change, innovation has become the centre of discussion for growth policy. The Schumpeterian idea of "creative destruction" is embedded in the neo-Schumpeterian growth model to explain the convergence process. The idea sounds promising, but the critics opine that the mathematical model proposed by the neo-Schumpeterian lacks the true spirit of the Schumpeterian approach. In contrast, the evolutionary scholars have taken the non-equilibrium approach by combining the idea

of Schumpeterian's innovation capabilities and Vebelan's institutional capabilities to promote economic growth. The evolutionary scholars no longer aim at determining the convergence rate. Instead, the focus is on catching up and the accumulating capabilities as experienced by successful latecomers like Taiwan and South Korea.

While these economies have successfully graduated to become HICs, the majority of underdeveloped economies remain poor. Worse still, the per capita income gap between HICs, MICs and LICs continues to widen. The HICs experience higher per capita income growth although neoclassical argument on capital-labour ratio suggests otherwise. The major factors that keep HICs growing are their roles as a frontier in innovation and institutional capabilities. In contrast, the lack of innovation and institutional capabilities are most commonly cited reasons for the failure of MICs and LICs to converge.

However, an intersting question to pose is, why are the contributions of innovation and institutions to economic growth less significant in the MICs and LICs? Is it simply because of the lack of innovation and institutional capabilities in MICs and LICs or issues related to choosing wrong type of institutions and innovation strategy? Otherwise, could it be like what Ragnar speculated where the poor stay poor just because they are poor? These are questions that motivate this thesis.

The concept of a virtuous cycle in HICs and the vicious cycle in the MICs and LICs between institutions, innovation and growth could explain why the advanced economies remain rich while the underdeveloped economies stay poor. The HICs do not only invest heavily in building innovation and institutional capabilities but the large size of their market with a higher effective demand also allows them to consume new innovative outputs even at a higher cost. In contrast, budget constraint limits the ability of

underdeveloped economies to invest in innovation and institutional capabilities and to consume technologically-advanced products, especially the expensive patented products. The concept of virtuous cycle and vicious cycle raises doubts as to whether innovation and institutions influence economic growth or otherwise or whether it works both ways simultaneously. This doubt has led the thesis to perform a causality test to establish the direction of causality between institutions, innovation and economic growth. The empirical results produced in this thesis provide an understanding of the dynamic relationship between these factors. Moreover, the thesis also conducts empirical testing by separating the sample by income level to confirm if the dynamic links between these factors is uniform or unique to each income level.

After establishing the direction of causality, the thesis continues with testing for the short run and long run relationship between institutions, innovation and economic growth. The test is not limited to finding the relationship between institutions, innovation and economic growth but also the inclusion of the relationship between the subindices of innovation and institutions on the economic growth. The results show the importance of sub-indices on the economic growth and if the significance of these sub-indices is the same across the income levels or otherwise.

Finally, the thesis also studies the role of institutions in enhancing the impact of innovation on the economic growth. The role of institutions is established using the moderator analysis methodology. The test is conducted on each development stage separately to establish if the role of institutions as a moderator applies across income levels. This finding produces an indirect impact of institutions on economic growth which complements the earlier findings on the direct impact of institutions on the growth.

8.2 Recapitulation of Main Findings

This thesis consists of three analytical chapters whereby the findings could lead to the understanding of the dynamic link between institutions, innovation and economic growth. The empirical testing on a cross-country aggregated data is conducted by separating the countries based on their income levels using the World Bank definition of GNI per capita based on the atlas method. The findings confirm if the results produced on each analysis is influenced by the income levels or otherwise. The findings of the analytical chapters are summarised and presented in Table 8.1.

The causality test is performed to establish the dynamic link between institutions, innovation and economic growth. The institutions and innovation factors represented by broad-based indicators which consist of the main index and sub-indices. The direction of causality is tested by employing two methods, i.e. the Dumistrue-Hurline (DH) bivariate causality test and Toda Yamamoto (TY) multivariate long-run causality test.

The DH method determines the bivariate causality between the institutions-growth and innovation-growth. The results allude to a complex relationship between institutions, innovation and economic growth across the income levels. Institutions and innovation mostly express a bidirectional relationship with economic growth in HICs and MICs.

Table 8.1: Summary Results of the PMG ARDL

Income levels	TY Causality Test	ARDL Test	Moderator Test
HICs	*ln* Y ⇔ *ln* INV *ln* Y ⇐ *ln* INS *ln* Y ⇔ *ln* INVIN *ln* Y ⇒ *ln* Eco *ln* Y ⇔ *ln* Soc	Positively Significant Contribution to Growth in the long run: I. *ln* INV II. *ln* INVIN III. *ln* INVOUT IV. *ln* INS V. *ln* ECO Negatively Significant Contribution to Growth in the long run: I. *ln POL*	Positively Significant Interaction with Innovation in the long run: I. *ln* ECO Negatively Significant Interaction to Growth in the long run: *I.* *ln INS* II. *ln POL*
MICs	*ln* Y ⇒ *ln* Eco *ln* Y ⇔ *ln* Pol	Positively Significant Contribution to Growth in the long run: I. *ln* INVIN	Positively Significant Interaction with Innovation in the long run: I. *ln* INS *II.* *ln POL* *III.* *ln SOC* Negatively Significant Interaction to Growth in the long run: I. *ln ECO*
LICs	*ln* Y ⇐ *ln* Soc	Positively Significant Contribution to Growth in the long run: I. *ln* INV II. *ln* INVIN III. *ln* INS IV. *ln* ECO	Positively Significant Interaction with Innovation in the long run: I. *ln* ECO *II.* *ln POL*

However, in LICs, causality among the variables is mostly unidirectional. While the DH test provides useful information on causality direction, the TY analysis is more robust in addressing our research objectives to establish the dynamic link between the three factors.

For a multivariate causality testing, the TY method provides more powerful results when the variables are integrated at an arbitrary level. Unlike the DH test results, the TY test shows a less complex relationship between the factors in MICs and LICs. Nonetheless, there are several factors that show bidirectional relationship with economic growth in the HICs. Firstly, innovation index and the sub-indices only exhibit a significant causality direction in HICs. No significant causality direction between innovation and economic growth is found in MICs and LICs. The innovation index and innovation inputs index show a significant bidirectional relationship with economic growth in HICs. The cumulative causation between innovation and growth alludes to the increasing return of innovation in HICs. The same does not happen in the MICs and LICs.

Meanwhile, the institution index is also found to have a significant causality relationship in HICs and not in MICs and LICs. Institutional changes in the HICs drive economic growth. Interestingly, the institutional sub-indices are found to have significant causality in all income levels. In HICs, the economic institution and social institution are found to have a significant causality direction with economic growth. In MICs, the political institution has a significant role in economic growth considering the factor exhibits a two-way causality with economic growth. Hence, a better political institution will contribute to an increasing return to economic growth in MICs. Finally, in LICs, the social institution is the only variable that has a significant causality relationship with economic growth, whereby the social institution is expected to drive economic growth.

In summary, innovation provides an increasing return to HICs and political institutions provide an increasing return to economic growth in MICs. The social institution drives economic growth in HICs and LICs, but no significant causal direction is found in MICs. Economic growth drives economic institution in HICs and MICs and not otherwise, as suggested in past literatures. While the causality study provides a clear direction on how a factor influences the others, the actual interrelationship between the factors requires further analysis using the multiple regression methods.

This thesis conducts the short run and long run analysis using the panel Pool Mean Group (PMG) ARDL regression approach. The PMG ARDL model is capable of handling mixed order integrated variables, similar to the TY approach for causality. All other standard panel cointegration procedures cannot be applied in this thesis given that the data is not uniformly stationary at I (0) or I (1).

Unlike the causality test, we have avoided running the regression on the consolidated samples, due to the severe risk of heterogeneity which is common in a cross country study. In particular, the data we examine has demonstrated problems associated with heterogeneity and endogeneity which are already explained in Chapter 3 and Chapter 4. Instead, the regression for the short-run and long-run analysis is examined on the segregated samples based on the developmental stages. Besides that, the thesis also avoids using the OLS method to minimise the risk of endogeneity.

The hypothesis is tested on a modified neoclassical production function by adding institution and innovation factors in the function. In the short run, the relationship between innovation and economic growth is mostly negative and insignificant across the income

levels. The changes in the innovation output are negative for economic growth in HICs and LICs whereas changes in the innovation input are negative to economic growth in the MICs. Changes in the innovation activity are likely to drain resources and cause uncertainty in the short run while the benefits to the firms and the economy are only realised in the long run. Likewise, institutional changes too have shown no significant relationship to economic growth in the short run. Past literature suggests that institutional changes happen at a slower rate and therefore, the impact to economic growth is only realised in the long run.

Meanwhile, the Error Correction Term (ECT) results show that all models across the income levels have a significant long-run relationship between the economic growth and the explanatory variables. In the long run, innovation is positively significant to economic growth in the HICs and LICs. However, between the two income levels, the return on innovation is higher in HICs based on the coefficient which is at 1.45 per cent compared to 0.39 per cent in LICs. The cumulative causation between innovation and economic growth explains why innovation provides an increasing return in HICs. Moreover, the innovation output is only significant to economic growth in HICs, unlike the innovation input which is significant to economic growth across the income levels. The contribution of innovation to economic growth is more pertinent in HICs than MICs and LICs. These results allude to the "founder effect" argument posited by Arthur (1989), which explains the advantage of HICs being in the innovation frontiers.

Similarly, institutions also contribute significantly to economic growth in HICs and LICs. However, unlike the innovation index, the impact of institutional changes to economic growth in HICs and LICs are almost the same. Meanwhile, institution sub-indices have shown some interesting relationships between income levels and the types

of institutions. The economic institution contributes positively to the economic growth in the HICs and LICs in the long run. The lower transaction cost and greater openness of the economy contribute to a higher economic growth in HICs and LICs.

In contrast, the political institution is negatively correlated with the economic growth in HICs. The increase in demand for democracy is likely to reduce the economic growth in HICs. Several past literatures also encounter similar results, where the contribution of political institutions is non-linear to the economic growth across income levels.

In conclusion, the empirical findings contribution of innovation and institutions to the economic growth only happens in the long run while the relationship is mostly insignificant in the short run. The innovation input contributes to the economic growth across the income levels, but the contribution of the innovation output and overall innovation is only limited to the HICs. The increasing return from the innovation activity only occurs when the economy is in the innovation frontier. Meanwhile, institutions contribute significantly to economic growth in the HICs and LICs. More interestingly, the role of the economic institution positively contributes to growth in HICs and LICs whereas political institution contributes negatively to the economic growth in HICs.

The role of institutions in the economic growth is often ambiguous. However, in general, the economic scholars agree that institutions contribute either directly or indirectly to the economic growth. On the one hand, the mainstream scholars seem to accept New-Institutionalism where the market is deemed a superior institution. On the other hand, the alternative scholars accept the Vebelenism ideology where institutional change is a process of evolution and the market is only a part of the institutions. There

are other institutions which are equally important such as the role of the meso-organisation, training and education institutions, culture and social norms.

In Chapter 5, we have discussed the direct role of institutions to economic growth. But, as mentioned earlier, institutions also have an indirect effect on the economic growth. This has been agreed upon in past researches although empirical evidence to support the claim remains scarce. This thesis tests the role of institutions as a moderator to enhance the impact of innovation on economic growth. The results show that the institution index and the sub-indices interact differently with innovation across the income levels. The findings confirm that some types of institutions interact positively with innovation while others negatively affect innovation's contribution to growth.

In HICs, improvement in institutions benefits economic growth directly but after introducing the interaction variable, the impact of innovation on economic growth is no longer significant. By examining the sub-indices, we understand that economic institutions continue to contribute positively to economic growth by enhancing the output of innovation activity. In contrast, the negative interaction signs between political institutions and innovation suggest that improvement in political institutions in HICs could lead to a lower contribution of innovation to the economic growth. The substitution effect between political institutions and innovation is also in line with the negative direct contribution of political institutions to economic growth in Chapter 5. Increase in demand for democracy will lead to more free riders in the economy via social programs and income distribution (Barro, 1996).

The interactional relationship between economic and political institutions and economic growth is reversal in MICs unlike that in the HICs. The political institution

positively contributes to economic growth by enhancing innovation activity while the economic institution negatively affects innovation. This confirms the nonlinear relationship between economic and political institutions across the income levels. An increase in demand for democracy is good for the economic growth and innovation activity as seen in them flourishing in MICs, but the same will contribute to a slowdown in the economic growth in HICs due to the changes in government policies which are more towards income redistributions.

Meanwhile, the economic institution negatively interacts with innovation. This requires further analysis, when we run the role of transaction cost separately. The result shows that the transaction cost is directly significant to economic growth and interaction between transaction cost and innovation is positive but not significant. Hence, the negative interaction between the economic institution and innovation could be driven by two other factors, i.e. the size of domestic credit and openness of the economy. Too much credit expansion could result in erroneous investments which can cause a decline in the business cycle as explained by the Schumpeterian model. For example, an over expansion of investments in the 1990s created an economic bubble that caused the LATAM crisis and Asian financial crisis. The crisis had caused massive losses in per capita income. Besides that, the openness of trade may benefit the HICs and LICs, but not necessarily in MICs, especially in innovation output. This is in line with the growth strategy in successful latecomer economies, which have started to adopt innovation using the imitation model. Too much openness is not necessarily good to the MICs' economic growth in the long run.

Finally, institutions positively and independently contribute to economic growth in LICs. However, the interaction with innovation is insignificant. The institution sub-

indices, namely the economic and political institutions interact significantly and positively with innovation to contribute to economic growth. Meanwhile, the social institution interacts positively with innovation, but this relationship is insignificant. However, innovation which directly contributes to economic growth is only significant in the social institution interaction model.

In conclusion, the moderating effect of institutions has led to pertinent discussions on the role of institutions on the economic growth, both directly and indirectly. The institution index contributes positively to economic growth in the HICs and LICs. The relationship of interaction between institutions and innovation is clearer when the thesis analyses the sub-indices. The thesis finds that the relationship is nonlinear across the income levels.

The thesis findings contribute to the extant literature in growth theory and development economics. The empirical evidence from the study is useful in revisiting the methodological approach to growth theory especially in analysing the growth convergence across income levels. As for the alternative approach, measurement of the catch-up rate at the macro level is still possible by taking into account the dynamic link between institutions, innovation and economic growth across the income levels by using the non-equilibrium approach. The thesis finds no Pareto Optimality between institutions, innovation and economic growth as economies in the frontier of innovation and institutions continue to innovate and expand their institutional capabilities without foregoing growth. Indeed, it is important for HICs to continuously expand innovation and institutional strength to maintain a steady increase in per capita income and remain in the frontier.

8.3 Theoretical Implications

This thesis provides a more detailed understanding of the dynamic links between institutions, innovation and economic growth. The dynamic link is established by focusing on three different research objectives: first, focusing on the causality dynamics between institutions, innovation and economic growth, second, establishing the short-run and long-run relationship between institutions, innovation and economic growth and finally, confirming the moderating role of institutions in enhancing innovation's contribution to economic growth.

Scholars have been investigating the growth theory for decades including specifying different functional forms in order to understand the issues of convergence and what matters for economic growth. This thesis begins by highlighting the failure of the converging hypothesis given that growth takes different dimensional paths based on the developmental state of the nation. Also, the thesis recognises that global growth is indeed diverging. As mentioned in the first chapter, this thesis does not attempt to produce a policy panacea, but it primarily aims to develop a better understanding of the growth functions. As such, one of the theoretical implications are that the current understanding of the growth theory is inaccurate considering the failure to acknowledge the dynamic relationship between institutions, innovation and economic growth. The thesis empirically shows the dynamic link between these factors and how it contributes to economic growth across the income levels and as such the empirical evidences guide the future research on growth theory.

Growth theory often assumes that the growth functions work uniformly across the income levels. It describes the relationship as a linear function across the income levels. In this thesis, we confirm that the relationship between the factors is non-linear when modelled across the income levels. For example, the political institution contributes positively to economic growth in MICs, but the same has a negative impact on growth in HICs. Likewise, the economic institution affects innovation positively in HICs and LICs but an increase in the economic institution negatively moderates innovation activity in the MICs. Hence, we recommend that future studies on the growth theory should incorporate a non-linear approach when using institutions and innovation as a factor in the economic growth, or to separate the samples to avoid non-linearity issues.

The empirical testing is conducted by identifying a broad-based index to represent the institutions and innovation factors. In past researches, cross-country studies on innovation and institutions are mostly conducted using a single proxy or narrowly-defined variables. For example, in the endogenous growth theory, the focus of innovation is limited to human capital accumulation and R&D activity. Each of the following variables has its advantages and disadvantages. In comparison, this thesis has developed indexes and the sub-indices using multiple proxies identified based on past literature from the various schools of thought. The relationship between institutions, innovation and economic growth is not only tested using the main indexes but also at the sub-indices level. By conducting a comprehensive analysis, the understanding of the dynamic relationship between the factors has become more robust.

The role of institutions as part of the growth theory is often subjected to criticism. The mainstream scholars remain divided in accepting institution as a part of growth function.

However, the role of the market as an institution is more acceptable in the mainstream economics. They accept the argument on transaction cost posited by Coase (1937). Meanwhile, other forms of institutions which the evolutionary scholars focus on are also important in our view. Hence, in this thesis, we employ three different institutional sub-indices identified by North (1990): the economic institution, political institution and social institution. Segregating institutions by their sub-indices allow the thesis to differentiate the role of each institution separately across the income levels.

Furthermore, many past researchers have noted that institutions do not only directly influence economic growth, but also indirectly support economic growth via enhancing innovation activity. The moderator analysis conducted in this thesis identifies the role of each type of institution at a different level of development stage separately. For example, the economic institution enhances innovation impact on economic growth in HICs, but the same strategy produces a negative impact on economic growth in MICs. The comprehensive understanding of how and which type of institution works at various stages of income would further enhance the extant literature of institutions, innovation and economic growth.

8.4 Policy Implications

Finally, for policy recommendation, the thesis suggests that the pro-growth policy should prioritise the types of institutions and innovation based on the income levels. To kick-start the development process, LICs should focus on economic and social institutions. Innovation input produces significant results for economic growth in all income levels. However, overall innovation and innovation output are only significant to HICs due to the increasing return of innovation activity. The economic growth in HICs

continues to expand due to the nature of HICs which is at the frontier of innovation and institutional capabilities. Hence, for countries in MICs and LICs, they have to leapfrog to become frontiers similar to what were experienced by Korea and Taiwan in the past. In MICs, the expansion of political institutions benefits the economy via its interaction with innovation activity. Innovation flourishing as democracy is introduced in MICs. In conclusion, any change in institutions and innovation is likely to benefit the economic growth in the long run and the relationship is mostly insignificant in the short run.

As a consequence, one-size-fits-all policy should not be adopted without taking into consideration the local context where policy replication may have its limitations due to the differentiated effect of institution and innovation on growth. In other words, emulating policy requires policy makers to consider the context in which the policy will be implemented. In addition, to be specific, within the realm of Science, Technology and Innovation Policy as well as Industrial Policy, targeting specific goals of innovation and institutional setting could provide a better synergy to propel growth. And, as the economy progress, the targeting should follow suit. In this aspect not only one needs the broader policy (e.g. horizontal policy) but also certain amount of targeting given the budget constraint that nations face. This will also allow for learning and catch up to take place since the right support institutions are in place at the right context.

8.5 Limitations of the Study

While the thesis produces empirical evidences to support a dynamic link between institutions, innovation and economic growth, some limitations need to be highlighted. The limitations of this thesis will be guidance for improvement on future researches in the growth theory area.

Firstly, this is a macro level study; thus, all common limitations associated with macro-level studies also apply to this thesis. For example, the thesis tests the hypothesis using the aggregated cross-country data. To reduce the problem with heterogeneity, the sample size is divided based on developmental stages. Although segregation of the data to some extent helps to minimise the heterogeneity errors, it may not eliminate those errors completely. Even though path dependency is key notion within the evolutionary economics, it also recognises that growth success depends on the policy uniqueness of an individual country. Copying exactly the same strategy may not guarantee the same return. Hence, the evolutionary scholars often prefer to analyse innovation and institutional capabilities on a micro level or the firms' specific analysis.

Secondly, the thesis develops innovation and institution index using multiple factors. The aim is to produce indexes which are capable of expressing the abstract nature of innovation and institutions on a broader basis amidst the constraint of the availability of the secondary cross-country panel data. The indicators used in this thesis are selected based on growth literatures which include the mainstream and alternative schools of thought. Although we believe that the thesis has captured the critical ingredients to build the innovation and institution index, we are fully aware that it will still be subjected to criticism. For example, the institution index is developed based on North's (1990) seminal work on institutions where he emphasises three types of institutions, namely the economic institution, political institution and social institution. The thesis has ignored other elements of institutions that are often captured in past researches including culture, religion, geographical location and colonialist history. The thesis avoids these indicators as they may not provide any meaningful information in a panel study considering the

information is mostly static and there is no significant change over the past thirty-four years.

Finally, the thesis is limited to problems associated with data quality, especially in the LICs. The sample size used in the thesis is limited to 80 despite a total of 189 countries listed in the World Bank database. Two criteria are excluded in this thesis: i. Non-OECD high-income countries and ii. Countries with more than 90 per cent missing data in the HICs and MICs and 85 per cent in the LICs. The Non-OECD high-income countries with small, rich and resource-based economies are excluded to avoid the results being skewed. The missing data within the limit mentioned above is replaced with Honaker and King's (2010) multiple imputation using Expected Maximization Bootstrap (EMB) algorithm.

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