博士学位論文

Roles of Human Capital Growth
on Industrial Development in Thailand

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Roles of Human Capital Growth on Industrial Development in Thailand

Dissertation

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ABSTRACT

Although Thailand has advanced the industrial and socioeconomic development but turned to delay the necessary investment on human capital. Thus, this study hypothesized that transitional of human capital development in Thailand during 1980-2010 was inactive to support advanced industries and yields higher growth. Firstly, this study applied the neoclassical augmented human capital Solow-Swan Growth Model. We concentrated human capital investment intensity in key industries; agricultures, light manufacturing, heavy manufacturing, public utilities and constructions and trade and services sector. Empirically, it ensured that the more education and competence labor has, the more efficiency and sectoral growth industry obtains. In addition, we applied the panel analysis and benchmarked the development of Thailand with forerunner countries in East Asia and found that the counterfactual growth if Thailand would growth similar to Taiwan economy during 1970s-1990s, the suboptimal level of the mean years of schooling of Thailand should be 6.9 years at the year 2000 and rapidly increased to 8.3 years at the year 2015. It is implied that the employed labor in Thailand should better graduate at least the junior high school. Furthermore, we constructed the Macroeconomic and Input-Output Model integrated supply and demand of human capital in Thai economy while distinguished human capital level with two-level nested-CES functions by education levels and skills. The counterfactual analysis confirmed that human capital accumulation has robustly and significantly shifted up the labor supply and productivity which lead to the growth of real wage, total employment, real aggregate demand-supply and economic expansion. Besides, the raise in real wage, employment and aggregate demand and supply also leads to growth of human capital accumulation simultaneously. Therefore, this study encouraged that Thai government should take into serious consideration to prepare the human capital since earlier decades through the national population and educational planning in order to upgrade labor productivity through additional years of higher education and learning by doing, such that worker will be able to handle advance equipment and utilize new production technologies. Even though, rapid extending the year of schooling of the worker seems challenges, government should improve and provide the ecosystem enhancing the accessibility of higher education for labor, such as on-line learning as part-time education along with other key factors such as saving and capital accumulation. Lastly, it is seriously needed to improve the quality of education such as quality of schools, teachers, teaching materials, education development policy and efficiency of the public spending.

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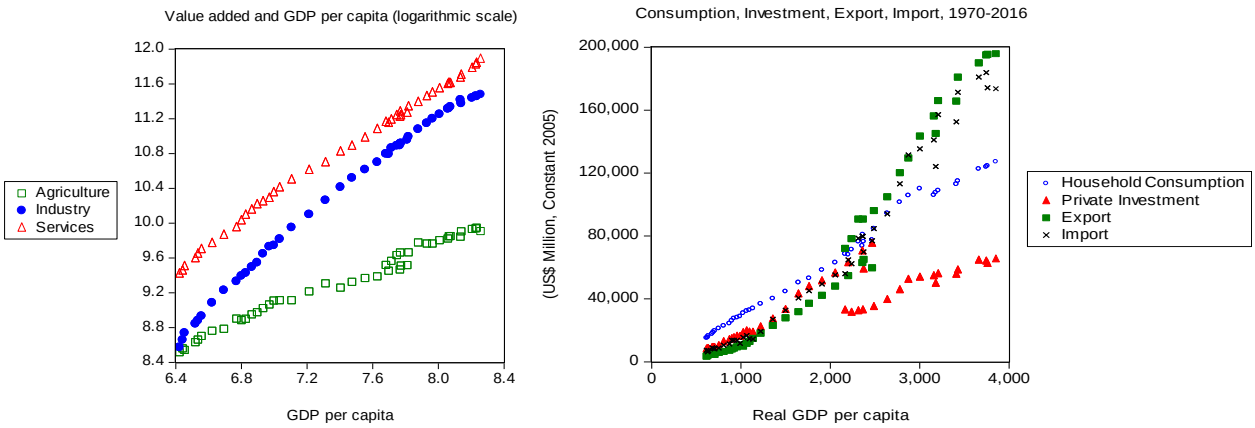
Chapter 1
Introduction

1.1) Significance of the study defined

Since 1960s Thailand has developed industrial focusing on driving the economy through agriculture from the abundance of natural resources and biodiversity. After the promulgation of the Investment Promotion Act in 1960 to promote the industrial production, light industry was developed as import substitution. Investors started to apply for investment promotion and invested in manufacturing to assemble products. Foreign companies of electronics and motor vehicles and parts were numerous. Most of the investment was the joint venture between Thai and foreign companies. In 1970s, there was new promulgation of the Investment Promotion Act. 1972 which has given additional rights and benefits to businesses produced for export. During this decade, there were foreign investments such as the manufacture of circuit boards (IC) and automobile parts from Japan started to invest for export. The growth of export reached almost 25% in 1975/76. (Figure 1-1) The structural change in terms of value-added share has shifted from agriculture to manufacturing and service sectors. However, the development of the manufacturing and supporting industries in this period was still limited. (Office of Industrial Economics, 2012)

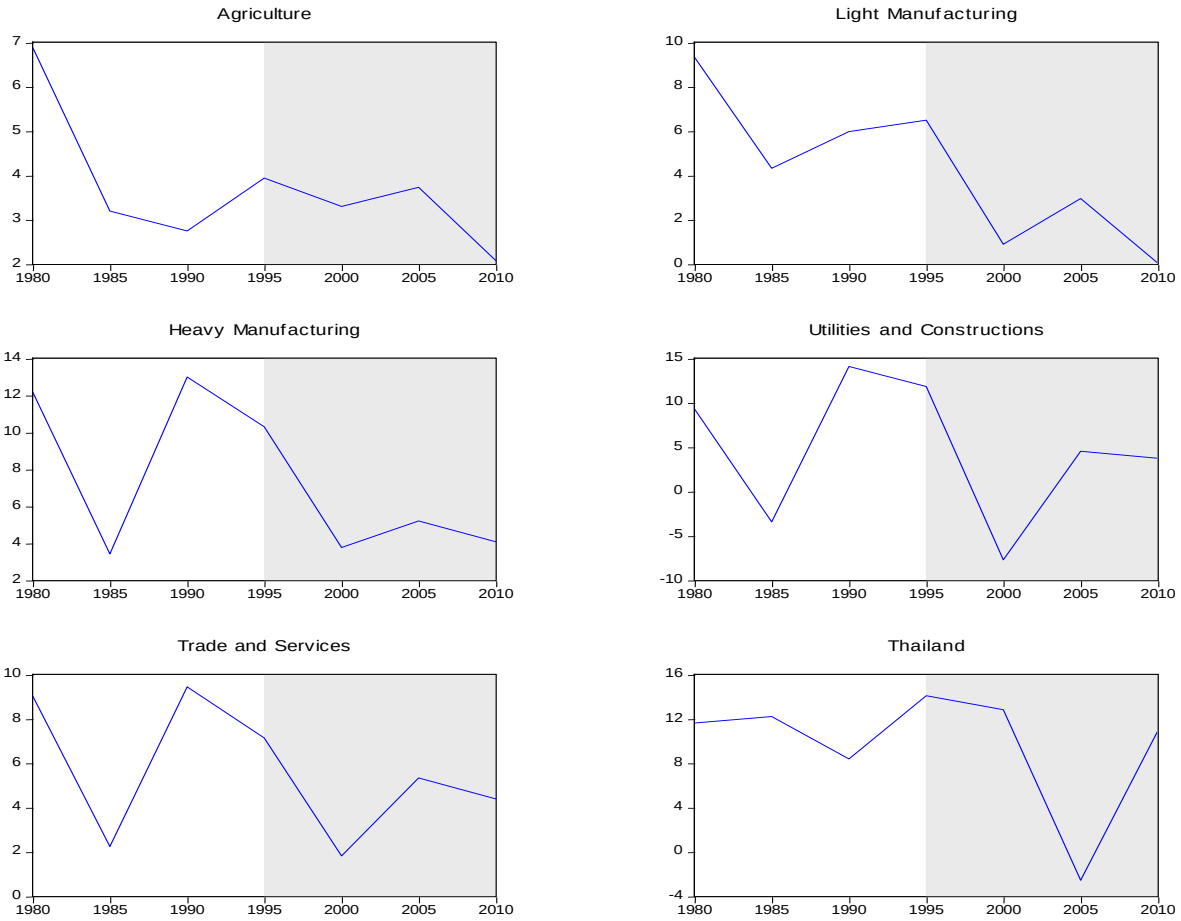
During the 5^{th} – 7^{th} National Economic and Social Development Plan (1982-1996), Thai government enhanced the export promotion policy with amendments of the Investment Promotion Act. After the Plaza Accord in 1985, industrial districts and large manufacturing within Japan were affected by the internationalization of their economy and Yen appreciation. there was a huge influx of Japanese and foreign direct investment into Southeast Asia and Thailand. High value added and advanced technological work was done in Japan, but the medium value added and labor -intensive works expanded oversea through Thailand and Southeast Asia. (Whittaker, 1997) Medium-sized electronics and automobile manufacturers and subcontractors also followed their parent and customer companies and relocated their production bases into Thailand. Foreign investment in this period was higher than in the past. Private investment growth of 20-30% and export growth of 29% were observed in Thailand. The sources of growth were mainly from the capitalization deepening rather owing to the growth of Total Factor Productivity (TFP). (Limskul, 2001)

Fig. 1-1. Epoch of economic development in Thailand during 1970-2016



Source: Compiled data from UNCTAD-Stat, accessed July 2018.

Fig. 1-2. Real GDP growth of key industries, 1980-2010, at constant price 2000 (Year % change)



Note: Compiled by Author and Bowonthumrongchai (2019)

Source: Input-Output Tables of Thailand, 1975-2010, NESDB.

Thai economy had outstandingly been stimulated growth and improved economic performance. Industry enjoyed the abundant workers and performed the average growth at 10 percent per annual during 1970s – 1990s. (Figure 1-2) The foreign exchange earning industrial sectors became the main national revenue instead of the agricultural-based sector. Especially during the 1990s under the 7th National Plan and technological change has induced development in capital deepening industries. Thai manufacturer steps up to the global value chains with foreign partners, especially the Japanese firms. Thailand, as a production base for export in many industries, the production line was becoming more complex by switching from producing low value-added products for the domestic market to value-added and processing products to export. Even though, industry have begun policy to adopt higher local contents, but it did not as much because domestic supporting industries that are owned by Thais still had technology development and upgrading problems, the overall economy and real GDP growth were remarkable, growth almost 10% average per annual during 1985-1995.

The study of Ketsawa (2019) clearly shown that sources of industrial growth from the demand side of Thailand during 1980-1995, or before the Asian Financial Crisis in 1997 (AFC), were mainly determined by the *'domestic demand expansion'* rather than export expansion and import substitution. The electronic and electrical machinery, transport equipment, rubber and plastic, and textile mainly contributed manufacturing growth in Thailand. The growth of gross output of these capital deepening industries was 17.4, 13, 9.4 and 8.6 percent, respectively. These industries had shown significant backward linkage benefited from the rising of their comparative advantage. The *'export expansion'* became the main sources of industrial growth which contributed almost 60 percent of the aggregate gross output of Thai economy. The sources of growth and causes of structural change have significantly shown a declining competitiveness in labor intensive sectors but strong in the new technological oriented sectors. The output growth of almost industries was deteriorated. The aggregate gross output growth of all industries was declined from 8.2 to 4.7 percent after the AFC crisis.

During the structural change period of Thai economy, the overall employment growth in Thai industry has been increasing to 3 percent in 1990 but has diminished to under 0 percent after the AFC in the year 2000. On the other hand, employment in agriculture has been rising after the AFC since agriculture sector has absorbed the reversing unemployed labor from industry sector in urban to rural area. Limskul (2020) mentioned that services and heavy manufacturing sector have also been a shock absorber of the Thai economy after the crisis. The light manufacturing is

suffering from the competitiveness and could not absorb employment which showing a declining trend since 1990.

Furthermore, the productivity growth of labor input measured by the growth of real GDP per employed labor has been improved significantly especially during the high growth era 1985-1990 excepted for the light manufacturing industry. The light manufacturing in Thailand which is labor intensive, small-medium sized industry has various constrains and mostly decided to utilize unskilled labor with low wage, low education and low productivity. However, after the crisis, labor productivity growth of all industries was undoubtedly dropped. The overall labor productivity growth was 4 percent on average after 1995 and declined to 2-3 percent during 2000-2010. Wage cost measured by wage bill over gross output ratio increased excepted services industry. Real wage rate of all key industries has increased significantly. Limskul (2020) pointed out that all industries have reached their turning point with the scarce labor supply and facing a rising real wage rate. Growth of real wage of light manufacturing and services industry has declined after 1995. The real profit rate of all sectors has shown a declining trend during 1980-2010. This is the result of the deepening of real capital stock over time. The rising wage rate and increasing of return to labor inputs have suppressed the growth rate of the real profit rate over the real wage. The capital deepening occurred correspondingly with the rising wage bill. This signifies the cost-effectiveness of the sector to produce output which implies a *losing competitiveness and structural changed*.

Though, in term of the quality of labor, World Development Report (2019) stated that by improving human capital; skills, health, knowledge and resilience, people can be more productive, flexible and innovative. Investment in human capital have become more and more important as the nature of work has evolved in response to rapid technological change. Markets are increasingly demanding workers with higher levels of human capital, especially advanced cognitive and socio-behavioral skills. World Bank (2019) also suggested that to build a better future for all Thais, an emphasis on *'Human Capital Investment'* and *'Quality of Education'* are the significant challenge. Investment in human capital and pursuing economic reform is critically important for Thailand to become a high-income nation.

Regarding to the term of *"Human Capital Growth"*, there was the discussion of concept of the human capital from various scholars. Spengler (1977) discussed the nature of human capital in the Adam Smith's Wealth of Nations which considered that in addition to buildings, machines, and lad improvements the concept of "fixed capital" should also include "the acquired and useful abilities of all the inhabitants or members of the society. The acquisition of such talents, by the

maintenance of the acquirer during his education, study, or apprenticeship, always costs a real expense, which is a capital fixed and realized, as it were, in his person". According to Smith, one source of human capital was experience gained as labor became more specialized according to the principle of the division of labor.

The most wide-ranging application of the human capital concept during the post-World War II period was discussed by many scholars and awakened in the late 1950s to 1960s. Kiker (1966) acknowledged the importance of incorporating human being in the concept of capital. Raising and educating human beings entails a real cost which increases productivity and adds to national wealth.

Theodore Schultz (1960, 1961) discussed the role of human capital in accounting for the *"unexplained"* portions of increases in national income after accounting for the growth of man-hours worked, physical capital and land. Schultz estimated the unexplained components of the increase in U.S. national income between 1929 and 1956 to be 60 percent of the total; and of that, human capital accumulation accounted for 30-50 percent (of 60 percent). Possible explanations were increasing returns to scale and improvements in the quality of inputs.

Subsequently, he identified 5 categories of activities directed at improving human capital: (1) health facilities and services, (2) on-the-job training, (3) formally organized education at the primary, secondary and higher levels, (4) study programs for adults not organized by firms and (5) migration of individual and families to adjust to changing job opportunities. In addition, Schultz (1962) pointed out again that investment in human being is important because its large magnitude changes the usual measures of saving and capital formation. It also changes the structure of wages and salaries and the amount of earnings relative to property income.

Afterwards, Gary S. Becker (1962) sets forth a theory of investment in human being and the relation between earnings, the rate of return, and the amount invested. Becker and Chiswick (1966) touched on the neglect by economists of discussion of the issue of the distribution of income because of a lack of economic theory able to explain differences in income distribution across regions, countries, and time. They stressed the importance of investment in human capital as a determinant of distribution of income. Becker (1994) exhibited that education and training are the most important investments in human capital. The earnings of more educated people are almost always well above average, although the gains are generally larger in less-developed countries. The outstanding economic records of Japan, Taiwan, and other Asian economies in recent decades

dramatically illustrate the importance of human capital to economic growth. They grew rapidly by relying on a well-trained, educated, hard-working and conscientious labor force.

Even though human capital is a driver of sustainable growth and poverty reduction, policy makers often find it hard to make the case for human capital investment. The benefit of investing in people will take a long time to materialize. Investing in the human capital of young children will not deliver economic returns until those children grow up and join the workforce. *Therefore, government always underinvest in human capital, then missing an opportunity to create a virtuous cycle between physical-human capital, growth and poverty reduction*.

Then, the current Thai economy should have performed better and faster stepped out of the 'middle-income trap' if the former Thai government and private sectors during the high growth era payed further consideration to realize the roles of human capital investment and the importance of its growth and accumulation. Since the prior study of Ketsawa (2019) on demand side analysis was necessary but not sufficient to response and address to the importance and role of human capital in the diverse economy. Consequently, this dissertation *intends to examine growth determinants and roles of human capital in accordance with the integrated demand-supply of human capital and economic growth in Thailand during 1980-2010*. Ultimately, author hopes that this study achievements and empirical findings would be contributed for policy makers, practitioners and academic researchers.

1.2) Objectives and scopes of the study

1) To comprehensibly investigates the growth determinants by human capital along with the counterfactual scenarios of human capital growth and the potential growth path of Thai economy throughout 1980-2010

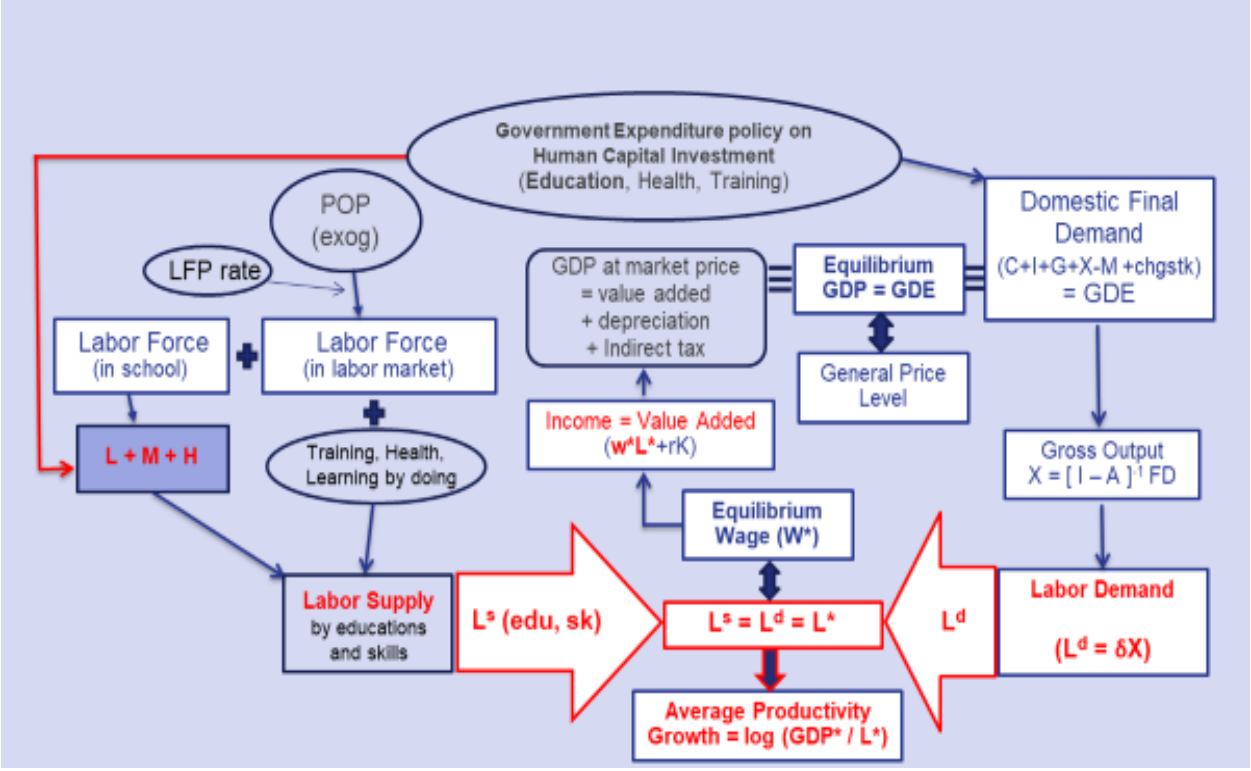
2) To distinctly examine role of human capital and sources of growth demand-supply side integration within the Macroeconomic input-output framework in Thailand during 1980-2010.

3) To deliberately provide empirical evidences, analysis, policy intelligences to support academic researchers, practitioners, policy makers, and government.

1.3) Research Hypothesis

As figure 1-3, theoretically at equilibrium, given the population structure, labor force participation rate, physical capital stock and technological advances, enhancing the human capital such as obtaining higher education would positively affects the growth of the average real wages, average productivity and aggregate demand of the economy while general price level has been adjusting and converting product market to the equilibrium. Upgrading of human capital may lead to higher overall labor productivity and real wages growth. Given the elasticity of substitution between high-educate and low-educated workers is greater than one, an expansion in the educational attainment and supply of high-educated workers lowers relative wage rate, and subsequently increase the demand for high-educated workers, leading to the equilibrium in the labor market. The increase in the supply of higher-educated labor may lead to growth of human capital accumulation simultaneously. Therefore, following the theoretical framework on integrated demand-supply of human capital and growth. This study hypothesized that *will increasing human capital accumulation during 1980-2010 likely raising the performance and potential growth path of Thai economy?*

Fig. 1-3. Theoretical framework on integrated demand-supply of human capital and growth



Source: Author

1.4) Organization of the study

This dissertation examines the growth determinants by human capital along with the role of human capital and sources of growth demand-supply side integration within the input-output macroeconomic framework and its impacts on structural change of key industries in Thailand during 1980-2010.

The organization of the dissertation is as follows. Chapter 2 reviews past literatures related to development and revolution of Thai industry, education and supply of human capital in Thailand, role of human capital and economic growth which including supply and demand side integration.

Chapter 3 comprehensibly provides a theoretical concept, mathematical models, econometric models, estimation, hypothesis testing and empirical findings of growth determination from the supply side. This section applies Solow-Swan growth model and human capital augmented growth model to examine counterfactual scenarios of human capital growth on economic development and the growth potential of Thai economy.

Chapter 4 distinctly observes the role of human capital and sources of growth from demand-supply side integration within the macroeconomic input-output framework. We synthesis necessary parameters to provide counterfactual scenarios of economic growth and structural change and estimate impact of human capital growth on Thai economy using macroeconomic input-output models and experiments.

In addition, to improve understandings and clear interpretation of the estimated results and policy implications, we ensure findings with sampling surveys and in-depth interviews of key manufacturing and facet of the National Economic and Social Development Plans emphasized on human capital and educational development.

Chapter 5 deliberately provides a conclusion of this dissertation, policy implications and recommendations as well as discusses on suggestions of further work. Lastly, appendices contain the mathematical solving, econometrical estimation results, national plans emphasized on human capital and educational development, reference figures and tables, questionnaires and interpretation.

Chapter 2

Review of Literatures

2.1) Industrial Development in Thailand: Inter-Industry Analysis

To make clearly understand the historical path of development, linkages and structural changes in multi-sectoral industrial development in Thailand, the Inter-Industry analysis or forward-backward linkage analysis is one of the powerful technique with make use of the Input-Output Tables (I-O Tables) while applying the "Leontief Inverse Matrix" [1] (Miller and Blair, 1985; Syrquin, 1999; Kofoworola, 2008; Shintani, 2012; Anatsuksomsri, 2015; Sadjaphand, 2015; Jarungrak, 2015, Kuroiwa, 2016; Bhongchirawattana, 2017)

To cite and instance, Kofoworola and Gheewala (2008) found that during 1995, 1998, 2000, manufacturing sectors in Thailand was one of leading sectors which had the power of dispersion index 1.058, 1.062, 1.048, respectively. Shintani (2012), followed Syrquin Model (1999), factor analysis by industry, used Input-Output Tables of Thailand of 1975-2005. He found that there was a high level of imports and exports in electrical and electronics sector and intermediate goods sector. Anatsuksomsri, et.al. (2015), used Global Input-Output Table, found that the Japanese automotive industry had high linkages domestically, but highly imported from international suppliers. Sadjaphand J., et.al. (2015) calculated backward and forward multiplier of motor vehicle sector (I-O Sector No.125) from Input-Output tables of Thailand during 1990-2010, 180x180 sectors. His studied found increasing trend of backward (input) multipliers (1.6134, 1.5837, 1.6574, 1.8079, 1.9924, 1.9868, respectively) and steadily high forward (output) multipliers (2.4219, 2.1246, 2.2933, 2.9249, 2.3674, 2.4698, respectively). Jarungrak (2015) used Thailand's Input-Output table year 2010, 180x180 sectors, and computed forward-backward linkages and dispersion index of motor vehicle sector (only I-O Sector No.125). She found that, within 180 sectors, motor vehicle sector had the highest of both direct backward and forward linkage (0.303). Computed total forward linkage equals 2.532, and total backward linkage equals 3.786 (which was quite different from Sadjaphand (2015) that was 1.9868) Kuroiwa (2016) concentrated on how the automotive industry and its value chain involved in Thailand since 1990s, by using Asian Input-Output Tables (1990-2005).

[1] Wassily Leontief (1905-1999) won the Nobel Prize in Economics in 1973 and well known for his research in Input-Output Analysis and applying the "Inverse Matrix" to show how changes in one economic sector may affect other sectors

He found that domestic linkages and dependency on domestic content of automotive industry started to decline after 2000. He assumed that trade liberalization and regional integration efforts after the early 1990s might have affected the trend in domestic procurement and the benefits of specialization and exchange have outweighed those of agglomeration in recent decades. He suggested more detailed analysis is necessary. Bhongchirawattana, et.al. (2017) computed forward-backward linkages and dispersion index of electronics industry (I-O Sectors No. 116-122) of Thailand, using I-O table year 2010 (180x180 sectors), found that the electronics industry (electrical machinery and apparatus) provided higher direct forward linkages than direct backward linkages. The power and sensitivity of dispersion index were 1.44 and 1.22 respectively.

Ketsawa (2019) concluded that after the Asian financial crisis in 1997, even though total industrial output was decreasing, foreign and Japanese dominated manufacturing sectors had progressively improved in both of backward & forward linkages within domestic upstream - downstream supply chains which significantly advanced in the electrical and electronics industry. The automotive industry had high improvement in backward linkages with domestic suppliers, however, moderate in forward linkages since export proportion was high. The chemical industry had been developed in forward linkages with downstream industries. In addition, it was observed that these industries became higher dependence on inter-industry supply and demand domestically. In term of employment multiplier, although these industries contributed in employment only 5% of the total, increasingly provided multiplier effects throughout the whole economy especially in electrical and electronics, and chemical industry. Rubber and plastics, and machinery industry had ever contributed high employment multiplier effects, unfortunately, sharply dropped after the crisis until the present day. Thai industries' deepening policy and usage of local contents were continued and expanded. Establishment of ties between local suppliers and multinational firms were an important channel of technology transfer from multinational firms to local suppliers. Industrial linkages could upgrade and diversify the industrial structure by stimulating the development of upstream industries and component suppliers. If there was without the desirable performance of Foreign and Japanese, manufacturing and overall Thai economy would not have promptly recovered from the severe crisis and sustained economic growth. Hence, not only manufacturers inside the industry, because of input-output and employment multiplier effects, overall economy had also obtained benefits from the massive influx of Japanese and foreign investment. Ketsawa suggested that Thai government and ministries in concerned should prioritize strategy to encourage foreign

and especially Japanese investment and provision local Thai manufacturing to concentratedly and promptly improve technology and productivity in order to sustain and expand linkages with Japanese and foreign production networks.

2.2) Sources of Growth and Structural Change from the Demand Side

Chenery (1960) has estimated the *Pattern of Industrial Growth* of 38 countries during 1950-1956. Later, Akrasanee (1973), Chenery and Syrquin (1975, 1986), Dervis, De Melo, and Robinson (1982), Chen and Fujikawa (1992) had attempted to analyze the pattern of industrial growth. Haraguchi (2015) illustrated patterns of structural change in Thailand during 1963-2007 with panel data analysis, fixed effects, of 75-110 countries, 18 manufacturing industries, representing two sub-periods (1963-1980 and 1991-2007). The study has applied real manufacturing value-added per capita with real GDP per capita and employment. He concluded that low-technology and labor-intensive industries (such as food and beverages, textiles and apparels) rapidly develop at a relatively early stage of development. As a country moves through the upper middle to the high-income range, the dominant industries change from early to middle industries (such as basic metals) and then to late industries (such as electrical machinery and apparatus) with an increasingly capital and technology intensity in manufacturing production as a whole.

In addition, Limskul (1999) investigated situation and structure of leading supporting industries in Thailand in 1996 by conducting questionnaire surveys and in-depth interviews. He stated that the roles of transport equipment and electrical machinery and supplies were very important supporting industries of Thailand in terms of output, value added share and employment. This study also described major problems concerning industrial structural change after the Crisis 1997, one problem was low quality and irregularity of supplies and law materials both supplied domestically and imported from abroad. Nguyen and Chen (2016) applied composition methodology with 14 production sectors in Vietnam during 2 sub-periods of 1996-2000 and 2000-2007. Author concluded that machinery; mining and financial sectors were newborn industry of Vietnam after 2000, which caused intermediate demand to shift toward a direction in favor of these industries. However, some other important sectors of the economy continued to lag behind or occasionally decrease such as textiles, agriculture service, travel services, trade, and rice processing.

National Economic and Social Development Board of Thailand (2017) applied Inter-Country Input-Output 2011 (ICAO) of OECD's 18 production sectors and compared mean of labor productivity and forward-backward index to observe status of Thai manufacturing in Global Value Chains (GVCs). This study revealed that most of manufacturing in Thailand are in downstream of the global GVCs. However, comparing among 8 newly industrial developing countries in Asia (Asia-8): Thailand, South Korea, Taiwan, China, Malaysia, India, Indonesia and Vietnam), some industries such as food manufacturing and textile and apparels industry are upstream of the Asia-8 GVCs. Machinery and textile and apparels industry have their labor productivity, ability to develop and upgrade for further industrial growth.

The study of Ketsawa (2019) clearly shown that sources of industrial growth from the demand side of Thailand during 1980-1995, or before the Asian Financial Crisis in 1997 (AFC), were mainly determined by the *'domestic demand expansion'* rather than export expansion and import substitution. The electronic and electrical machinery, transport equipment, rubber and plastic, and textile mainly contributed manufacturing growth in Thailand. The growth of gross output of these capital deepening industries was 17.4, 13, 9.4 and 8.6 percent, respectively. These industries had shown significant backward linkage benefited from the rising of their comparative advantage. The *'export expansion'* became the main sources of industrial growth which contributed almost 60 percent of the aggregate gross output of Thai economy. The sources of growth and causes of structural change have significantly shown a declining competitiveness in labor intensive sectors but strong in the new technological oriented sectors. The output growth of almost industries was deteriorated. The aggregate gross output growth of all industries was declined from 8.2 to 4.7 percent after the AFC crisis.

2.3) The Roles of Human Capital and Economic Growth

Human Capital and Economic Growth

Initiation by the Adam Smith in 1776 [2] that enhancing division of labor could cause economic prosperity, supported boom to thoughts on the human capital. Schultz (1961) initiated that human capital plays an important role towards economic growth and development. Numerous attempts have been studied to simplify how human capital contributes to socio-economic development (Alexander, 1996; Grubb and Marvin, 2004;) For instance, Rosen

[2] Adam Smith (1776) would probably the first who mentioned and put forward this significance of labor and human capital.

(1983) stated that investment in people make in themselves to increase their productivity. Romer, P. (1990) refers to human capital as a fundamental source of economic productivity. Fuente & Domenech (2004) believed that knowledge and skills embodied in human directly raise productivity and increase an economy's ability to develop and to adopt new technologies.

Human capital is also defined as the aggregation of investments in such as education, health, on-the-job training which enhance a worker's productivity in the labor market. Investment on education, training and skills development showed very influential effects on their output and economic growth. Higher productivity of education yields higher marginal product of labor. Human capital theory views schooling as an investment in skills and hence as a way of augmenting labor productivity. There were several studies on economic growth and determinants of human capital especially using many proxies of education level. It has numerically quantified that education has positively and significantly contributed to the progress in human capital growth and economic development. (Mincer, 1958; Schultz, 1971; Griliches, 1970; Becker, 1975 and 1994, Romer, 1990; Mahbub, 1990; Srinivasan 1994; Wolff, 2000; Jesperson, 2011; World Development Report, 2019)

Some examples, Mincer J. (1958) has been well familiar as the *Mincerian* equations that estimated the time spent in education and training constitutes a postponement of individual income and earnings to a later age. The assumption of rational choice means an equalization of present values of life-earnings at the time the choice is made. This equalization implies higher annual pay in occupations that require more training. Griliches (1970) estimated that the increased educational attainment of the U.S. labor force accounted for one-third (1/3) of the Solow residual, which means the portion of the growth of output that could not be attributed to the growth in unadjusted labor hours or capital stock between 1940 and 1967. Gary S. Becker (1994) pointed out that education and training are the most important investments in human capital. The earnings of more educated people are almost always well above average, although the gains are generally larger in less-developed countries. The outstanding economic records of Japan, Taiwan, and other Asian economies in recent decades dramatically illustrate the importance of human capital to growth. They grew rapidly by relying on a well-trained, educated, hard-working and conscientious labor force.

Recently, World Development Report (2019) indicates that differences in human capital have large implications for the productivity of the next generation of workers. They measured the productivity as a future worker of a child born in 2018 by constructed the overall

Human Capital Index (HCI) which consisted of 3 components: (1) Survival: probability of survival to age 5, (2) School: expected years of school, (3) Health: fraction of children not stunted, and adult survival rate. Singapore got the highest score at 0.88 and ranked at the 1st. Among 10 Asian countries, excepted Singapore, Vietnam shown the high HCI score at 0.67 and ranked at the 48th, then Malaysia and Thailand. Thailand obtained HCI score at 0.60 ranked at the 4th in Asian countries and the 65th of total 157 countries.

Concurrently, it has been affirmed by various international institutes that being knowledgeable and accessibility to proper education are key dimensions of human development. Since Human Development Index (HDI) [3] has been provided index and their mega cross-countries determinants. Since that a number of studies were conducted to provide a more accurate measure of HDI and economic growth with various proxies and areas of study instead. By way of illustration, Mahbub ul Haq (1990) measures the achievement of a country via social and economic dimensions based on their people's health, their level of education attainment and their standard of living. It is seen as the best tool to keep track of the level of development of a country. Srinivasan (1994) posited that surely socio-economic-political processes, rather than low levels of income and lack of knowledge about the feasibility of achieving substantial improvement. Education likely has a more significant effect on HDI than income related factors, however, school enrollment data are not internationally comparable, since quality of schools, drop-out rates, length of school year, and so forth vary substantially between and within countries. Jesperson E. (2011) of UNDP stated that education has significantly contributed to progress in the HDI over the past 40 years. Education is critical to strengthening people's capabilities and freedoms. The complex knowledge societies raised the bar for education. However, quality of education is a critical challenge, as measured by PISA, with same years of schooling children in developed countries learn more than children in developing world. Moreover, UNDP (2011) detailed that most developed countries have good education facilities and provide better health services to their citizen leading them to achieve a high score of HDI. However, majority of the developing countries focuses less spending on education facilities, consequently limit the poor to have access of their children's education.

[3] According to the United Nations Development Programme (UNDP), the Human Development Index (HDI) is a summary measure of average achievement in key dimensions of human development: a long and healthy life, being knowledgeable and have a decent standard of living. The HDI is the geometric mean of normalized indices for each of the three dimensions. (www.hrd.undp.org)

Commonly, the developing countries only put emphasis on increasing economic growth while the development of socio economy holds less priority to the country's development strategy.

Added to that, one of the useful techniques is the Panel Analysis and Pooled Regression with many variables with cross-countries data. For instance, pioneer by the Barro (2000) using panel data for more than 80 countries during disaggregated three 10-year time periods during 1965-1995. The main education variable is the average years of school attainment at the secondary and tertiary levels for male aged 25 and over. The model is estimated three-stage least squares, using instrumental variables. In the overall sample, the education variable turns out significantly positive. The estimated coefficient implies that an additional year of schooling raises the growth rate on impact by 0.44% per year. Barro considers additional dimensions to the years of schooling and female attainment in secondary and higher level of education become insignificant when added to the basic model. Arbak E. (2012) estimated the earning functions of each individual by using the Mincerian Model with a large micro-level dataset from the surveys which were conducted between 1999 and 2002 of 12 countries in the Mediterranean (SMC), and all the EU-MED countries except Cyprus are included. The results for the pooled regressions provide evidence of clear differences in the returns to schooling and the incomes of households across the Mediterranean. The linear element for the returns to schooling show that an additional year of schooling results in approximately an 11% increase in the incomes in the EU-MED. For the six SMC included in the study, the returns are even greater, around 13 to 14% per year of schooling. In both cases, the returns diminish with increasing schooling, as indicated by the negative square-terms. Grzech, Patel and Walker (2016) using panel analysis and pooled regression with data of 188 countries found that life expectancy and education gives the most impact on HDI values implying these elements are the main contributors of HDI improvement. Education-related factors would have the most impact on the HDI value. Factors like literacy rate, government expenditures towards education, and the percentage of the population with secondary education would have the largest positive impact on the overall development of that country. Jalil and Kamaruddin (2018) examined the relationship between Human Development Index and socio-economic variables with a Panel Data Analysis in 15 selected developing countries (including Thailand and Malaysia) within a 5-year period (2010-2014) based on data from the Human Development Data and World Bank 2017. They found that the Panel Fixed Effects Model has proven to be the best model. They stated that in these 15 selected nations despite education and higher GDP are essential to achieve a higher level of HDI, life expectancy is also perceived as a vital indicator to imply a

better level of HDI. The mean years of schooling has shown a direct significant relationship with HDI verifying that for developing countries to improve their HDI is through providing sufficient facilities for their education system. As a result, the panel analysis with data set from HDI seems to be proved as the proper technique to examine the relationship between education and economic development, therefore, in the second half of the chapter 3 of this study will try to apply the panel analysis to examine the determinants of mean years of schooling for the case of Thailand as well.

Furthermore, as fundamental frameworks for the simulation, regarding to the estimation by applying the macroeconomic models with integrated demand and supply of labor and human capital to examine effects of human capital growth on economic growth, there are some selected studies. Deme, et.al. (2005) develops a general equilibrium model for Lesotho. The results of the skill-acquisition function shown *small infusions* of human-capital investment that can not break out of its low-growth traps. Welfe (2011) constructed the macro econometric model of a knowledge-based economy to launch long-term forecasts and scenario analyses the impact of long-run increase in investments, domestic R&D expenditure, growth of human capital stimulated by larger expenditure allocations to the tertiary and post-graduate education. The characteristics of human capital are designed as the weighted sums of employees with different educational levels. The simulation results show that potential GDP shows all the time positive rates of growth, the rate of growth of employment is declining but unemployment rates go down because of the high increase in human capital and labor productivity which responded through the Total Factor Productivity (TFP). Qadri et.al. (2014) applied small-sized macroeconomic model for Pakistan economy focusing the impact of investment in human capital on the key macroeconomic variables. They generally proxied the human capital through an education stock and flow by 'gross enrollment rate in secondary education' during 1980-2010 which is modeled as function of domestic income and government spending on education as percentage of GDP. The study resulted that the link between human capital and labor market is *weak* however a change in education spending affects output through enhancing productivity. Wongpunya (2015) inspected the role of human capital accumulation to avoid the middle-income trap in Thailand by using the dynamic stochastic general equilibrium approach. The two sectors endogenous growth model is driven by human capital accumulation which based on the Uzawa (1965) and Lucas (1988) framework for Thai economy quarterly during 2005-2012. The study shows that output performs monotonically increasing when there are favorable disturbances in both of two sectors. Its results that the three-time consistent increases in

standard deviation of the disturbances for 60 quarters in the educational sector and production sector could possibly drive the Thai economy above the middle-income level in 16 years.

Related Literatures on East Asian Economies and Thailand

Thus, related studies on East Asian economies including Thailand, several studies have concentrated much more in term of total factor productivity (TFP) includes the quality of labor inputs and human capital. Various proxied variables were introduced and mostly shown *positive and significant* relationship to the gross domestic output and economic performances. There were many interesting academic researches, for instance, in prior to the modern economic growth theory, Tinakorn and Sussangkarn (1994) examined the sources and determinants of productivity growth of Thailand as one of Asia's most rapidly industrializing country at that time. They estimated sources of growth for Thailand during 1978 to 1990 and found that about 20 percent growth from the improved quality of labor. The remaining 15.8 percent was the contribution of the total factor productivity such as human capital, R&D and innovations which were not be able to quantify at that time. They left the conclusion that other important determinants of TFP that they cannot measure include the expertise of workers acquired through the process of learning by doing and etc. Later, Kim and Lau (1995) recent research on growth in East Asia. They concluded that high rates of investment in physical capital and in human capital explain essentially all of the rapid per capita growth on the Pacific Rim.

Mcmahon (1998) applied panel data analysis for East Asia countries during 1965-1990 using gross enrollment rate of primary, secondary and higher education as proxy of human capital stock without regard to their quality. This study concluded that heavy initial investment in human capital by households and governments, as well as high investment in physical capital, and probably not "technical progress", is largely responsible for the high per capita growth in East Asia. In East Asia (and in most of the developing economies) the amount of physical capital per worker is considerably lower than in the industrial economies. The amount of human capital per worker is also much lower: the average worker has received only 4 years of education in Indonesia and Thailand, and 9 years in South Korea, compared to 10 years or more in the OECD countries. More importantly, primary enrollments in the initial period are highly significant. A skilled labor force at the secondary level can be regarded as fundamental to the successful production and export of manufactured goods.

Jimenes, et al.; World Bank (2012) pointed out that, in 2009, Thailand's gross secondary enrollment rate was 76 percent, respectively, compared to the average of 83 percent for upper middle-income countries and 101 percent for high-income OECD countries. Tertiary gross enrollment rate was 45 percent which remained below the high-income OECD average (72 percent) and considerably below Korea (100 percent) Thailand has successfully provided schooling access to children and young adults, particularly at primary levels, but the quality of education remains an issue. Quality has also deteriorated over time with mean math and reading scores from PISA and TIMSS declining between 1999 and 2007. Thailand has improved slightly in 2009 but not enough to return to 1999 levels.

Romprasert (2015) applied Solow Growth Model for Thailand, Malaysia and Singapore during 1990-2013. The studied variables are real GDP and per-capita GDP, gross fixed capital formation and savings rates as proxy of physical capital, and literacy rates as proxy of human capital. The study shows results as higher savings rate and higher gross fixed capital formation per worker lead to higher investment per person, and pull up steady-state level of capital. Moreover, increasing on literacy rate represents human capital that leads to growth of gross domestic product.

World Bank (2015) revealed that over the past two and a half decades, Thailand has made great progress in expanding basic education, closing the gap in attendance between socioeconomic groups, and putting more focus on the quality of education. However, the examination of PISA scores shows that many Thai students still do not have the skills and competencies needed in an increasing number of jobs. They were "functionally illiterate," lacking critical skills for skilled jobs. Functional illiteracy is not an isolated challenge and can be seen across the various types of schools in Thailand. The situation appears to be particularly acute for one group of students: students enrolled in village schools or small schools, especially the lowest-performing 40 percent among them.

Though, some studies had tried with different proxy variables, group of sample countries and explored the motivating consequences, for example, Michael, A. et.al. (2017) empirically examine the effect of human capital spending on economic growth in the low-middle-high income households of Philippines and Asia by applying the Mankiw, Romer and Weil (1992) and following Mason, Lee and Jiang (2016). The results of their empirical analysis indicated that human capital investment promotes both output growth and income inequality in Asia. Thus, poorer households experience a relatively larger increase in their labor income

which enables them to narrow the income gap with richer households. The growth impact is larger for poor Asian countries than for richer countries. Public spending on human capital fosters greater equality of opportunity. Soejoto, et al. (2017) applied Solow neoclassical growth model of Mankiw, et al. (2014) and used regression analysis to determine the impact of labor, investment, human capital, natural resources, and technology toward economic growth during 2006-2012 of Southeast Asia countries including Thailand. The quality of human capital proxy by using the 'tertiary gross enrollment ratio of both sexes (%)'. The results of this study shown that countries like Thailand, Malaysia, Philippines and Cambodia, the quality of human resources have not significant effect on economic growth. Kraipornsak (2009) constructed human capital index for 3 economic sectors of Thailand (agriculture, industry and services) by using the Mincerian approach of wage regression of wage (real earnings per month) on education (years of school attainment), age (a proxy of experience), and Gender of the quarterly data during 1993Q1 to 2006Q4. He applied Vector Error Correction Mechanism (VECM) and found that physical capital and human capital were significantly contributing to growth of agriculture sector. However, human capital was positively but insignificantly contributing to growth of industry and service sector. In addition, Rukumnuaykit (2015) empirically investigated human capital and its linkages on the labor demand side by regression equation using firm-level data from the Thai manufacturing sector. This study concluded that hiring workers who have higher education as well as providing them with in-services training has a statistically and significantly positive impact on an increase in labor productivity. However, hiring workers who have higher education yield less benefit than costs which come from higher average wage expenditure. Providing training should contribute more benefit than cost. Firms implements in-house training tend to have higher labor productivity and pay higher wages than do firms not providing in-house training.

However, Wolff and Gittleman (1993) summarized that, in most studies, primary and secondary school enrollment rates were both statistically significant as factor in explaining economic growth, but the tertiary or university enrollment rate often appeared statistically insignificant. In addition, the use of enrollment rates in productivity growth regressions has been criticized because they are not indices of the educational attainment of the current labor force but of the future labor force. Later, Thienprasert (2017) estimates production function with both of linear function and Cobb-Douglas to analyze the impact of human capital to GDP growth of Thailand, Malaysia and Indonesia in yearly during 1998-2013. This study categorized workforce into low and high level of human capital. High level of human capital

is an amount of workforce who graduated at tertiary level while the low level of human capital is labor who finished at secondary, primary and none. The results from both linear and the Cobb-Douglas function shows that only capital stock positively affects economic growth in Thailand. Human capital in both cases are not significant.

As a result, several studies have used educational attainment at the particular point in time instead of educational enrollment rates in which growth in GDP per capita is the dependent variable. However, measures of the direct educational attainment of the labor force often produce weaker results than the use of enrollment rates. Consequently, in the next chapter of this study will try to use level of educational attainments of the Thai labor force during the particular period as a proxy of human capital of Thailand.

Chapter 3

Research Methodology on Growth Determination by Human Capital

The main objective of this chapter aims to quantitatively examine the contribution of education investment intensity on economic growth of Thailand. In this study, we assumed that human capital stock can be accumulated from the investment on education merely whereas ignores the investment on health, training and others. We foresee that Thailand will need to earnestly enhance the effectiveness of education and human capital development in order for students to obtain higher skills and competencies to achieve better productivity and outcomes. Investment on education both of private and public will yield higher quality for future labor market to support industrial development and economic growth.

We hypothesized that human capital development in transition of labor in term of quality improvement from low to higher education investment in Thailand was inactive to support advanced industries to yields higher growth. It is broadened understand that the higher education labor has, the more industry yields. Therefore, in prior, it is essential to reviews current socioeconomic situation on human capital related aspects such as labor supply, students, education and learning outcome of Thai student and also understands significant causes and how fundamental resources has constrained the human capital growth in Thailand. Then, we will appropriately apply the Solow Growth Model augmented with Human Capital and Nested Human Capital Model to examine the contribution and role of human capital and the education investment intensity in the long-run economic development of Thailand during 1980-2010 and some counterfactual scenarios. We differentiate the level of human capital by the investment intensity on education which disaggregates into 3 levels from low, moderate and high education investment intensity level.

Adding for policy implications, at the end of this chapter, we will also try to benchmark the improvement of education and human development in Thailand with developed countries. Addition to policy implications, we estimate the potential years of schooling of Thailand to yields similar economic growth with benchmarked countries. Panel data cross-countries analysis with pooled regression will be appropriated to investigate the relationship between years of schooling and epoch of economic advancement.

3.1) Education and Human Capital in Thailand

In term of achievement of the human development in Thailand, World Bank (2015) revealed that over the past two and a half decades (1986-2010), Thailand has made great progress in expanding basic education and narrowing inequities in schooling access between socio-economic group and putting more focus on the quality of education. Thailand's success in achieving near-universal primary education and significantly raising secondary enrolment comes from sustained efforts to expand school coverage and compulsory education. Thailand's National Education Plan 2017-2037[1] reported that the percentage of working-age population completing primary and lower secondary education was relatively stable, while there was a tendency to increase in general upper secondary and tertiary levels. During 1990-2015, the labor force in Thailand particularly obtained a higher education level. The average year of schooling of the working-age population has been improving from 4.6 years in 1990 expanded to 8.9 years in 2009 and 10.0 years in 2015 then slowed and fluctuated in recent. Literacy rate of Thailand has also been improved. Ratio of population aged 15 and above who cannot read was decreasing from 5.9% in 2007 to 3.3% in 2015. The Office of Education Council of Thailand (OEC) has revealed that there would be two main reasons why there has been an increase in workers with higher education. Firstly, Thailand has been industrialized and workers shifted from agricultural sector to manufacturing and service sectors which would require higher educated and skilled workers. Secondly, forced by the Compulsory Education Act. 2002, the government should provide 9 years of the compulsory basic education from elementary to lower secondary (or junior high school). Moreover, specified by the National Education Act. 1999, all students could receive free of the basic education for at least 12 years from elementary to upper secondary (or high school) and it was extended to 15 years included kindergarten level in 2016.

However, demography and population structure of Thailand has been changing. Thailand has been facing the gradually decrease in fertility rate even in recent years. The average number of children per childbearing age woman or woman at the reproductive age has decreased from 4.9 persons in year 1974 to approximately 1.6 persons in year 2013. It is estimated to reduce to 1.3 persons in the year 2037. As a result, the school age population has been continuously decreasing from 15.1 million students in 2010 to 14.2 million students in 2015. (see Table 3-1) These decreasing of fertility and supply of students will affect the supply of labor force in the near future.

[1] The National Education Plan 2017-2037 was published by the Office of the Education Council (OEC), Ministry of Education, Thailand, on March 2017.

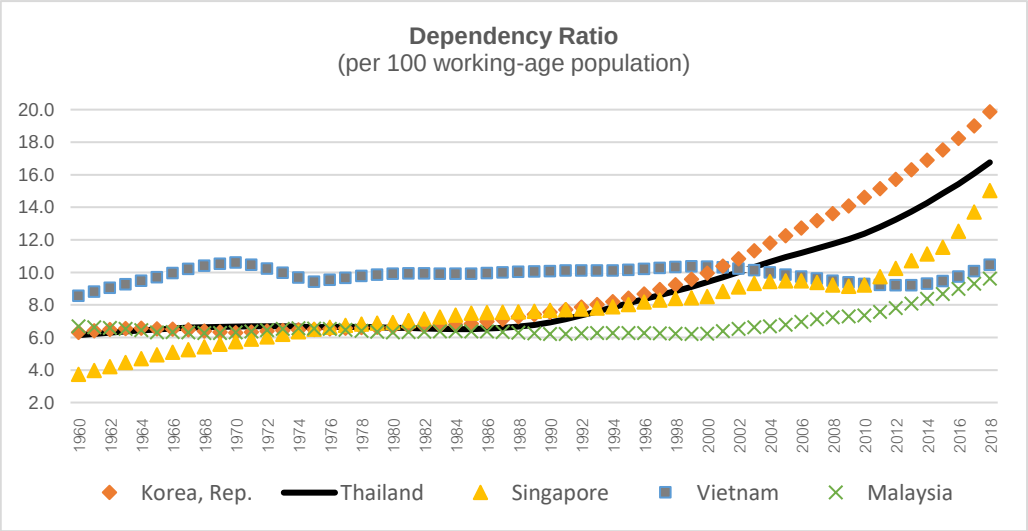
Table 3-1. Number of students by education level, academic year 1990/91-2015/16

Unit: Thousand person

Education Level	*1990/91*	*1995/96*	*2000/01*	*2005/06*	*2010/11*	*2015/16*
Pre-school	n.a.	n.a.	2,706	2,503	2,755	2,701
Elementary	6,472	5,858	6,056	5,968	5,044	4,866
Secondary	2,227	3,591	4,059	4,503	4,833	4,307
Tertiary	n.a.	n.a.	1,797	1,891	2,470	2,409
Total	**n.a.**	**n.a.**	**14,618**	**14,865**	**15,102**	**14,283**

Source: National Education Statistic of Thailand, OEC, various years.

Fig. 3-1. Dependency ratio, 1960-2018 (Unit: per 100 working-age population)



Source: The World Bank, 2019. (access January 2020)

Table 3-2. Ratio of Working-age population by education, 2009-2015

Unit: Thousand persons

Education Level	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Elementary	22.55	22.82	22.63	22.99	24.11	22.89	22.29
Lower Secondary	15.48	15.75	16.04	16.19	16.58	16.05	15.82
Upper Secondary	18.15	18.05	19.18	19.8	19.92	20.22	21.2
General	9.63	10.4	10.64	11.26	11.55	11.66	12.28
Vocational	8.22	7.65	8.54	8.54	8.37	8.56	8.92
Tertiary	8.72	7.37	9.63	10.08	10.49	12.88	13.33
* Lower Secondary and above	44.4	45.59	46.92	47.86	48.86	51.04	52.25

Remark: According to the definition of OEC, the working-age population ages 15-60 years.

Source: Office of Education Council of Thailand (OEC)

The Office of Education Council of Thailand (OEC) has mentioned that Thailand has been encountering with aged society or rising of elderly dependences which shown by a rapidly increasing of dependency ratio[2] from 6.59 in 1980 to 16.76 in 2018, which higher than Singapore, Vietnam and Malaysia. Working-age population (ages 15-64) must bear the higher burden of taking care of the increasing elderly dependences. (ages above 64 years) (Figure 3-1) The number of children who were not able to enroll in the lower secondary education has been in increasing. The labor force who completed vocational upper secondary or vocational certificate was less than 10 percent. There was the scarcity and insufficient of skilled technician to support advanced technology in production. (see Table 3-2) As the result, human development or improving the quality of labor has recently been taken into serious consideration for especially the developing countries.

According to Table 3-3, the Human Development Index (HDI) [3] in 2018, during 1990-2015, World Bank (2018) reported that Thailand has shown improvement and accomplishment in key dimensions of human development, such as (1) having a long and healthy life, (2) being knowledgeable and (3) having a decent standard of living. An average of HDI Index of Thailand was effectively improved from 0.57 in 1990 to 0.74 in 2015 which was better than of South East Asian countries and the world, but still following the OECD countries even back in 1990.

Though, Human Capital Index (HCI)[4] of the World Bank quantitatively illustrates the key stages in this path and their consequences for the productivity of the next generation of workers, with 3 components: (1) survival, (2) school and (3) health. For the index report of Thailand, it can be interpreted that if children born in Thailand in 2018, they will be 60 per cent as productive when they grow up as they could have been if they had obtained a complete education and full health care. For education, the children can expect to obtain 12.4 years of schooling by age 18, but when adjusted with quality of learning, it seems that their productivity are only equivalent to 8.6 years of schooling. The learning gap was 3.8 years compared with 3.1 and 2.1 of Malaysia and Vietnam respectively. (see Table 3-4)

[2] According to the World Bank definition, old age dependency ratio is the ratio of older dependents (people older than 64) to the working-age population (ages 15-64). Data are shown as the proportion of dependents per 100 working-age population.

[3] According to the United Nations Development Programme (UNDP), the Human Development Index (HDI) is a summary measure of average achievement in key dimensions of human development: a long and healthy life, being knowledgeable and have a decent standard of living. The HDI is the geometric mean of normalized indices for each of the three dimensions. (www.hrd.undp.org)

[4] World Bank (2019) Human Capital Index (HCI) measures the human capital that a child born today can expect to attain by age 18, given the risks to poor health and poor education that prevail in the country where she lives. The components of HCI are combined 3 components of survival, school and health into a single index. HCI is measured in units of productivity relative to a benchmark corresponding to complete education and full health. HCI ranges between 0 and 1.

Quality of education and learning outcome seem to stagnant. According to OECD who promoting the PISA[5] Test as one of the international benchmarks to evaluate an outcome of the education and knowledge in different countries in 3 core subjects; Science, Reading and Mathematics. Students in Thailand scored lower than the OECD average in all subjects. The Average score of PISA 3 subjects of Thai students was lowered from 433 in year 2000 to 415 in 2015. PISA score in year 2015 of Thai students ranked 55 out of 72 countries, which was lower than Singapore and Vietnam, that were ranked 1 and 8 respectively. (see Table 3-5)

The educational management and development of teaching and learning curriculum to integrate with the lifelong learning was one of the big challenges. The decreasing of the number of children and students affects the productive educational management and maximize efficiency of the resources and financial administration. Government's educational management and budgeting variables are correspondingly vital but insignificantly reformed. The major amount of government's annual budget has been allocated for education which is the highest proportion among other administrations. As table 3-7, ratio of government budget on education was rather consistent at 20-22 per cent of the total budget, or around 4 per cent of the Gross Domestic Product (GDP). However, approximately 85 per cent of these budget was fixed for teacher's salary and expenses in the compulsory education system.

Table 3-3. Human Development Index (HDI) of Thailand and the World, 1990-2015

Year	*Average of Human Development Index*			
	Thailand	*S/E Asian*	*World*	*OECD*
1990	***0.57***	0.54	0.60	0.77
1995	***0.61***	0.58	0.61	0.79
2000	***0.65***	0.61	0.63	0.83
2005	***0.69***	0.65	0.65	0.85
2010	***0.72***	0.68	0.68	0.87
2015	***0.74***	0.71	0.70	0.89

Remark: South East Asian, World and OECD group consists of 10, 189 and 36 member countries respectively.
Source: Compiled from the Human Development Index (HDI) 2018, UNDP (accessed November 2019)

[5] Programme for International Student Assessment (PISA) conducted by OECD. Score obtained in testing of skills and knowledge of 15-year-old students in mathematics, reading and science.

Table 3-4. Learning gap and HCI of Thailand and Asian counties, 2018

Economy, (Rank)	*Expected years of school (A)*	*Learning-adjusted years of school (B)*	*Learning Gap (years) (A)-(B)*	*Human Capital Index (HCI)*
Singapore (1)	13.9	12.9	1.0	0.88
Vietnam (48)	12.3	10.2	2.1	0.67
Malaysia (55)	12.2	9.1	3.1	0.62
Thailand (65)	***12.4***	***8.6***	***3.8***	***0.60***
Indonesia (87)	12.3	7.9	4.4	0.53

Remark: HCI data are reported for 157 World Bank member countries. Years of learning gap complied by author.

Source: Human Capital Index 2019, World Development Report 2019, World Bank. (accessed January 2020)

Table 3-5. Score of the programme for international student assessment (PISA) 2015

Unit: score

Rank	*Countries*	*Science*	*Reading*	*Mathematics*
1	Singapore	556	535	564
2	Japan	538	516	532
4	China (Taiwan)	532	497	542
6	China (Macau)	529	509	544
8	Vietnam	525	487	495
9	Hong Kong	523	527	548
10	China	518	494	531
11	Korea	516	517	524
	Average OECD	493	493	490
55	**Thailand**	**421**	**409**	**415**
63	Indonesia	403	397	386

Source: PISA score of 67 countries, HDI 2018. (accessed on November 2019)

Table 3-6. Government expenditure on education of Thailand and East Asia countries, 1990-2015

Unit: per cent

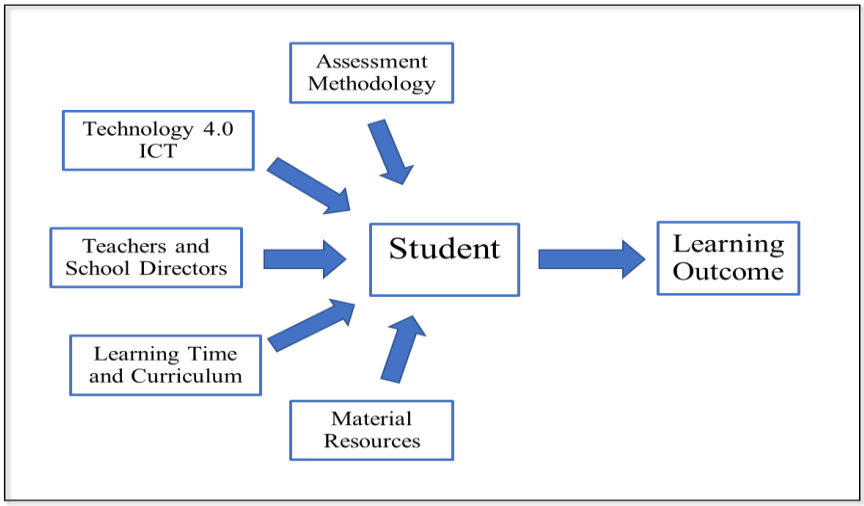
HDI Rank (2015)	*Country*	*1990*	*1995*	*2000*	*2005*	*2010*	*2011*	*2012*	*2013*	*2014*	*2015*
5	Singapore	n.a.	n.a.	3.3	3.2	3.1	3.1	3.1	2.9	n.a.	n.a.
17	Japan	n.a.	3.5	3.5	3.4	3.6	3.6	3.7	3.7	3.6	n.a.
18	South Korea	3.1	3	n.a.	3.9	n.a.	n.a.	4.6	4.9	5.1	5.1
59	Malaysia	n.a.	4.3	6	n.a.	5	5.8	5.7	5.5	5.2	5
87	**Thailand**	n.a.	**3.1**	**5.3**	**3.9**	**3.5**	**4.8**	**4.5**	**4.1**	n.a.	n.a.
113	Indonesia	n.a.	0.9	n.a.	2.7	2.8	3.2	3.4	3.4	3.3	3.6
115	Viet Nam	n.a.	n.a.	n.a.	n.a.	5.1	4.8	5.5	5.7	n.a.	n.a.

Source: HDI database 2018, UNDP.

Critical constrains of education achievement

As students perform academically today will determine the roles to play in the future of Thai economy and society. Low academic achievement would have negative consequences for students' future labor-market and income prospects and for their capacity to participate fully in society. It is essential, additionally, to reviews some significant causes of low quality and poor outcome and how fundamental resources has constrained the human capital growth. (Figure 3-2)

Fig. 3-2. Factors of student's learning performance and outcome



Source: Author, compiled from OECD/UNESCO (2016) "Education in Thailand: An OECD-UNESCO perspective"

1) Technology 4.0 and ICT

PISA (2018) revealed that the amount of time spent online outside of school increased between 2012 and 2018 by an average of more than 1 hour per day. Student in average spent about 3 hours online outside of school on weekdays and 3.5 hours online on weekend days. Similar to Thai people especially students, the digital world is becoming a sizeable part in the real world.

According to the Information and Communications Technology (ICT) Survey in Thailand[6] in 2015, internet usage ratio has increased in all age groups even elderly. During 2011-2015, the ratio of internet usage of students ages 6-14 was increased from 38.3 to 58.0 per cent while ages 15-24 was rapidly raised from 51.9 to 76.8 per cent, and mostly 81.7 per cent of them were using

[6] ICT Survey was conducted by the National Statistical Office of Thailand, 2015.

at outside school though their smartphone, tablet and notebook, and only 34.9 per cent were utilizing internet at school.

Improving access to new technologies provides unprecedented opportunities to be proficient in reading and learning. Students growing up with a better smartphone but a poor education will face critical risks. The smartphone has transformed the ways in which people read, learn and exchange information. Regrettably, the ICT Survey also reported that 88.6 per cent of internet users in Thailand addicted to the social network, and 87.4 per cent downloaded entertainment medias, instead of access to the knowledge or online learning portals.

Another current issue that should be taken into account is, even though internet and smartphone provide more opportunity and convenience to access to the information and knowledge. In the past, students could find clear and often singular answers to their questions in carefully followed government-approved textbooks, and they could generally trust those answers to be true. Though, today, they will find thousands of answers to their questions online, and it is up to them to figure out what is true and what is fake, what is right and what is wrong. When reading online news or information sites, readers must regularly assess the quality and reliability of the information and inputs, based on implicit or explicit signs related to the content, format or source of the information.

2) Learning time and curriculum

Mortifyingly, PISA (2018) was comparing the learning time that students invest. Learning outcomes are the product of the quantity of learning time, the quality of learning and the instructional environment. In Finland, students spend the least time learning about 36 hours per week, student performance is comparatively high at almost 520 points, whereas in Thailand, countries at the opposite quarter with the long study hours about 55 hours per weeks, but learning outcomes are comparatively low at only 390 points or the 2nd lowest rank. (see Figure 3-3)

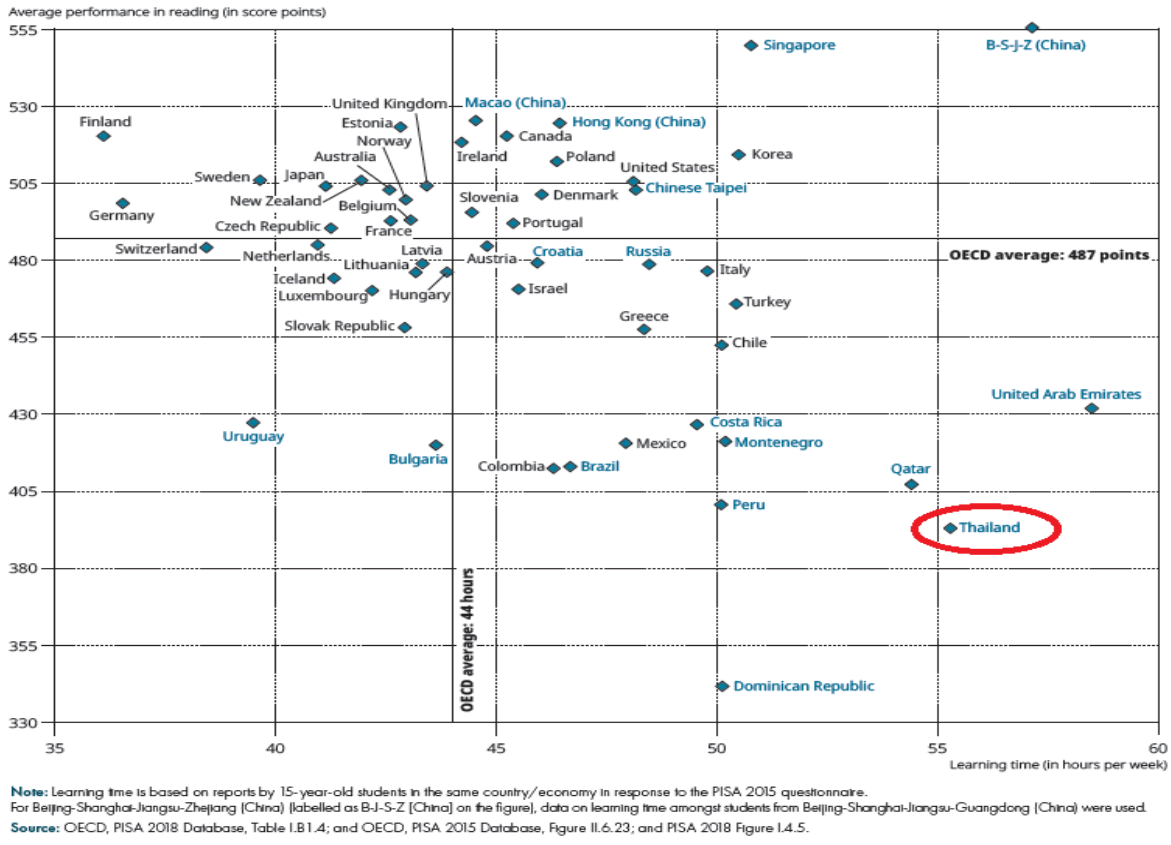
OECD/UNESCO (2016) stated that since Thailand shifted its content-based curriculum to a modern standards-based approach after the education reforms in 2001 and 2008. The new curriculum is intended to support more learner-centered teaching strategies. However, implementation has been challenging. The decentralization of responsibility inherent in a new approach has not been matched by adequate support to local officials and teachers. Thailand will need to conduct thorough and consultative curriculum review process to address these issues and to provide a grounding for changes to teaching and learning practices in order to improve student outcomes.

3) Teachers

According to the World Bank (2012) reported that PISA (OECD, 2007b) surveyed a lack of qualified teachers in key subjects that seriously hindered student learning. Teacher quality includes different indicators of teacher qualifications, in particular characteristics of teachers' educational background, amount of experience in teaching, and participation in professional development, as well as personality characteristics such as teachers' self-efficacy.

They constructed the Teacher Shortage Index, index in Thai schools was 0.65, which was much higher than the OECD average index (0.00), while the indexes for Japan and Korea were -0.51. Chinese Taipei and Hong Kong-China were -0.31 and -0.20 respectively. On average in the OECD, teacher shortages have been proven to have a strong negative effect on student performance, with a 1-unit change in the teacher shortage index being associated with 9 points decrease in science test scores. In Thailand, this relationship is twice as large, with a 1-unit increase in the index being associated with an 18.2 point negatively change in science test scores.

Fig. 3-3. Reading performance and total learning time per week, 2015



Remark: Y axis is average performance in reading (in score points), X axis is Learning time (in hours per week)
Source: PISA 2018: Insights and Interpretations, OECD.

Importantly, OECD/UNESCO (2016) stated that Thai teachers are not being prepared well enough through initial teacher education or continuing professional development to support the country's education reform efforts. Teachers in rural and urban schools alike, need to be able to spend more of their time actually teaching, rather than performing administrative duties. Above all, they require the support of a more professionalized school leadership.

In fact, a recent international assessment revealed that computer and ICT hardware are sufficiently supplied and internet access in all regions of the country is stable, but the proficiency of Thai students were still low and Thai teachers lacked skill in their own ability to utilize internet and ICT networking system to support their teaching. Thai government should focus on the important role of the teacher by building educators' capacity to make benefit from ICT technologies in their teaching to foster students' development of computer skills and online learning.

4) Inadequate of material resources

Material resources included science laboratories and equipment, instruction materials such as textbooks, computers, internet connectivity, computer software for instruction, library materials, and audio-visual resources are found positive effect to student's achievement. World Bank (2012) stated that among OECD countries, only a minority of students attended schools where principals reported that a shortage of these educational resources had hindered learning (OECD, 2007b). In Thailand, however, the principals reported that over one-half of students were attending such schools.

5) Student Assessment

Similar to the assessment by PISA, a non-biased student's assessment methodology allows policy makers to continuously improve the education system management, instruct teachers' strategies and help students improve their own learning. Thailand has applied use of standardized tests after the educational reform since 2005, called the Ordinary National Education Test (O-NET)[7] which is the assessment system for some level of educations. There are only useful if they are methodologically constructed. It is essential that Thailand need to focus on building capacity support the effective design and implementation of assessment procedures at all levels of the education system and should balance its use of standardized tests. (OECD/UNESCO, 2016)

[7] Aligned with the Basic Education Core Curriculum B.E.2551 or A.D.2008, the Ordinary National Education Test (O-NET) is administered annually by the National Institute of Educational Testing Service (Public Organization) to grade 6 (ISCED 1), grade 9 (ISCED 2) and grade 12 (ISCED 3) students in both public and private schools. The O-NET was first administered to grade 12 students in 2005, and then was extended to grade 6 students in 2007, and to grade 9 students in 2008. The final score which determines promotion to the next grade is based on this O-NET score and the score obtained on school-based assessments held during the usual academic year.

As above-mentions, population structure of Thailand has been shifting under higher dependences but lower fertilities effected to decreasing of students and labor force in the future. Thailand has enacted major education reforms and invested a significant proportion into educating its youngest citizens. Participation rates in the education system are high particularly at the primary levels, and continue on higher education. However, performance is particularly poor especially in those who live in rural areas. Diffusion of the technology 4.0 and ICT, low quality of learning time, shortage of skilled teachers with too much administrative duties, lack of learning materials and not yet thoroughly applied standardized assessment in all levels, are critical causes of poor academic outcome. Thus, low academic achievement passes negative consequences for students' future labor-market and income prospects. As a result, the next section tries to quantitatively examine the contribution of education and human capital growth on economic development of Thailand under the hypothesize that Thailand could not get out of the middle-income trap was mainly the retard in human capital quality and the constraint of education achievement. We will appropriately apply the *Solow Growth Model augmented with Human Capital and Nested Human Capital Model* to examine the contribution of human capital and the roles of education investment intensity in the long-run economic development of Thailand during 1980-2010.

3.2 Roles of Human Capital and Economic Growth

3.2.1 Theoretical Concept and Mathematical Model

Fundamentally, the Neoclassical growth model is known as Solow-Swan Growth Model of Robert M. Solow (1956) and Trevor Swan (1956) which could explain economic growth due to accumulation of capital stock. They claimed that the capital-output ratio of the Harrod-Domar model should not be regarded as exogenous. In fact, they proposed a growth model where the capital-output ratio was precisely the adjusting variable that would lead a system back to its *Steady-State growth path*. As a result, once capital stock grows, economy moves toward a higher steady stead. Obviously, savings rate and per-worker capital stock both play important roles in falling and rising in an economy's steady state.

Solow-Swan Growth Model can explain economic growth due to accumulation of capital stock. Once capital stock grows, economy moves toward a higher steady stead. Obviously, savings rate and per-worker capital stock both play important roles in falling and rising in an economy's steady state.

Firstly, we assumed that there is one good, which is produced with two factors of production, capital (K) and labor (L), and which can be either consumed in the same period or invested as capital for the next period. The technology for producing the good is given by;

$$Y_t = F(K_t, L_t) \qquad \text{---------- (1)}$$

Where; we say that the technology is "Neoclassical" if F satisfies a series of technical conditions:

(1) Constant returns to scale (CRS) or linear homogeneity:

$$F(\lambda K_t, \lambda L_t) = AF(K_t, L_t) \ , \ A>0$$

(2) Positive and diminishing marginal returns to each factor:

$$F_K(K,L) \equiv \frac{\partial F(K,L)}{\partial K} > 0 \ , F_L(K,L) \equiv \frac{\partial F(K,L)}{\partial L} > 0$$

$$F_{KK}(K,L) \equiv \frac{\partial^2 F(K,L)}{\partial K^2} < 0 \ , F_{LL}(K,L) \equiv \frac{\partial^2 F(K,L)}{\partial L^2} < 0$$

where; the labor market clearing condition:

demand for labor (L_t) = supply of labor ($\overline{L_t}$)

the capital market clearing condition

supply of capital (K_t^s) = demand for capital (K_t^d)

The firm optimization:

$$\max_{L\geq 0, K\geq 0} F[K_t, L_t, A_t] - w_t \ L_t - \ R_t \ K_t$$

where; w_t = wage rate at time *t*, R_t = rental price of capital at time *t*

Since F is differentiable, first-order necessary conditions imply:

$$w_t = F_L[K_t, L_t, A_t] \text{ and } R_t = F_K[K_t, L_t, A_t]$$

Suppose this assumption holds, then in the equilibrium of the Solow growth model, firms make no profits, and in particular,

$$Y_t = w_t \ L_t + R_t \ K_t$$

(3) Inada conditions, ensuring the existence of interior equilibria:

$$\lim_{K\to 0} F_K = \infty, \text{ and } \lim_{K\to\infty} F_K = 0 \quad \text{for all } L>0 \ \text{ all } A$$

$$\lim_{L\to 0} F_L = \infty, \text{ and } \lim_{L\to\infty} F_L = 0 \quad \text{for all } K>0 \ \text{ all } A$$

Also, F_K and F_L are homogeneous of degree zero or the marginal products depend only on the ratio $\frac{K}{L}$

and $F_{KL} > 0$ that capital and labor are complementary.

Finally, all inputs are essential: $F(0, L) = F(K, 0) = 0$ and

Technology in intensive form:

Let $y = \frac{Y}{L}$ *and* $k = \frac{K}{L}$

where; y = output per worker

k = capital-labor ratio

Then, the production function by CRS is;

$$y = f(k) \qquad \text{---------- (2)}$$

where; $f(k) = F(k, 1)$

That is *the production unit are always motivated to start accumulating the capital, but will not accumulate capital endlessly.*

The Resource Constraint and the Law of Motion for Capital and Labor

The sum of aggregate consumption and aggregate investment cannot exceed aggregate output. That is, the following *resource constraint*:

$$C_t + I_t \leq Y_t \qquad \text{---------- (3)}$$

In per-capita terms: $c_t + i_t \leq y_t$ ---------- (4)

Suppose that population growth is $n \geq 0$ per period. The size of the labor force then evolves over time as follows:

$$L_t = (1+n) L_{t-1} = (1+n)^t L_0 \qquad \text{---------- (5)}$$

The Law of Motion for Capital

Suppose that existing capital depreciates over time at the fixed rate $\delta \in [0, 1]$.

The capital stock in the beginning of next period is given by

the non-depreciated part of current period capital, plus (+) contemporaneous new investment.

$$K_{t+1} = (1\text{-}\delta)\, K_t + I_t \qquad \text{---------- (6)}$$

Equivalently, in per-capita terms:

$$(1+n)\, k_{t+1} = (1\text{-}\delta)\, k_t + i_t$$

We can approximately write the above as

$$k_{t+1} \approx (1\text{-}\delta\text{-}n)\, k_t + i_t \qquad \text{---------- (7)}$$

Then, the sum $\delta+n$ can be interpreted as the *'effective'* depreciation rate of per-capita capital.

The Dynamic of Capital and Consumption

Combining the law of motion for capital (6), the resource constraint (3) and the technology (1), we derive the difference equation for the capital stock.

Recall: Equation (1.1) $Y_t = F(K_t, L_t)$

Equation (1.3) $I_t \leq Y_t - C_t$

Equation (1.6) $K_{t+1} = (1\text{-}\delta)\, K_t + I_t$

$$K_{t+1} - K_t \leq -\delta K_t + I_t$$
$$K_{t+1} - K_t \leq Y_t - \delta K_t - C_t$$
$$K_{t+1} - K_t \leq F(K_t L_t) - \delta K_t - C_t \qquad \text{---------- (8) *}$$

We get equation (8) that is *the change in capital stock is given by aggregate output, minus (-) capital depreciation, minus (-) aggregate consumption*.

Feasible and Optimal Allocations

(8) in per-capita terms: $k_{t+1} - k_t \leq f(k_t) - (\delta+n)\, k_t - c_t$

$$k_{t+1} \leq f(k_t) + (1\text{-}\delta\text{-}n)\, k_t - c_t \qquad \text{---------- (9)}$$

A feasible allocation is any sequence that satisfies the resource constraint. An allocation to maximize welfare, in particular, consumption is, by assumption, a fixed fraction (*1-s*) of output:

$$C_t + I_t \leq Y_t$$
$$C_t = Y_t - I_t$$
$$C_t = Y_t - sY_t$$
$$C_t = (1-s)\, Y_t \qquad \text{---------- (10)}$$

Similarly, in per-capita terms, (6), (4), (2) give the dynamic of capital whereas consumption is given by

$$c_t = (1-s)\, f(k_t) \qquad \text{---------- (11)}$$

The Policy Rule

Combining (9) and (11), we derive *the fundamental equation of the Solow Growth model*:

$$k_{t+1} - k_t = s\, f(k_t) - (\delta+n)\, k_t$$

Or

$$\dot{k}_t = s\, f(k_t) - (\delta+n)\, k_t \qquad \text{---------- (12) *}$$

Steady State

A *Steady State* of the economy is defined as any level k^* such that, if the economy starts with $k_0 = k^*$, then $k_t = k^*$ for all t ≥1. That is, a steady state is any fixed point k^* of (equation 12). Equivalently, a steady state is any fixed point (c^*, k^*) of the system (9), (10) and (11).

Suppose $\delta+n \in (0, 1)$ and $s \in (0, 1)$. A steady state $(c^*, k^*) \in (0, \infty)^2$ for the dictatorial economy exist and is unique. k^* and y^* increase with s and decrease with δ and n, where c^* is non-monotonic with s and decrease with δ and n. Finally, $\frac{y^*}{k^*} = \frac{(\delta+n)}{s}$ as following;

k^* is a steady state if only if it solves:

$$s\, f(k^*) - (\delta+n)\, k^* = 0$$

Equivalently;

$$\frac{y^*}{k^*} = \phi(k^*) = \frac{(\delta+n)}{s} \qquad \text{---------- (13) *}$$

where $\phi(k) \equiv \frac{f(k)}{k}$

The function ϕ gives the output-to-capital ratio in the economy. The properties of *f* imply that ϕ is continuous (and twice differentiable), decreasing and satisfies the Inada conditions at k=0 and k=∞:

$$\phi'(\mathrm{k}) = \frac{f'(k)k - f(k)}{k^2} = -\frac{F_L}{k^2} < 0$$

$$\phi(0) = f'(0) = \infty \quad \text{and} \quad \phi(\infty) = f'(\infty) = 0$$

where the latter follow L'Hospital's rule. This implies that equation (13) has a solution if and only if $\delta + n > 0$ and $s > 0$ and the solution unique whenever it exists. The steady state of the economy is thus unique and is given by

$$k^* = \phi^{-1}\left(\frac{\delta+n}{s}\right) \qquad \text{---------- (14) *}$$

On the other hand, consumption is given by

$$c^* = (1-s) f(k^*) \qquad \text{---------- (15) *}$$

If follow that c^* decreases with $\delta + n$, but s has an ambiguous effect.

As equation (14), since $\phi' < 0$, k^* is a decreasing function of $\left(\frac{\delta+n}{s}\right)$, which determine how fast capital per worker depreciates in the economy, k^* is increasing in the saving rate s which determines the amount of investment in the economy.

Then, Mankiw, Romer and Weil (1992) extended Lucus (1988) and Barro (1990) presented the *Human Capital augmented Solow Growth Model* of economic growth. They investigated whether real income is higher in countries with higher saving rates and human capital accumulation, and lower in countries with higher value of depreciation. They estimated the Textbook Solow Model of 3 samples of cross countries during 1960-1985; Non-Oil (98 countries), Intermediate (75 countries) and OECD (22 countries) while log GDP per working-age person in 1985 as dependent variable,

and measure n as the average rate of growth of the working-age population and s as the average share of real investment (including government investment) in real GDP, Y/L as real GDP in 1985 divided by the working-age population in that year, and proxied human capital accumulation (s_K) with the percentage of the working-age population that is in secondary school (SCHOOL). Their study concluded that human capital measure enters significantly (at 10% level) in all three samples. It also greatly reduces the size of the coefficient on physical investment and improve the fit of the regression. The results strongly support the augmented Solow Growth Model shows that the augmented model predicts that the coefficients on ln(*I/Y*), ln(*SCHOOL*) and ln($n+g+\delta$) sum to zero. Therefore, adding human capital to the Solow model improves its performance.

Later, the Mankiw, Romer, and Weil (1992) which presented the human capital augmented Solow model of economic growth. Followed Bluedon (2002), assume that the economy produces one good, Output (Y). It is produced according to:

$$Y_t = K_t^{\alpha} H_t^{\beta} [A_t L_t]^{1-\alpha-\beta} \quad \text{---------- (16)}$$

Where $\alpha,\beta \in [0,1]$, $\alpha+\beta \in [0,1]$, and t denotes time.

This implies that the production function exhibits constant returns to scale in its three factors: physical capital (K), human capital (H), and productivity-augmented labor (AL). Specifically, it is a Cobb-Douglas Production Function. All markets (both input and output markets) are assumed to be perfectly competitive. All firms are assumed to be identical. The economy can then be described by a representative agent.

Physical capital and human capital are assumed to be accumulating factors; i.e., the representative agent saves the output to have more capital (either physical or human). Their equations of motion are:

$$\dot{K}_t = s_K Y_t - \delta K_t \quad \text{---------- (17)}$$

$$\dot{H}_t = s_H Y_t - \delta H_t \quad \text{---------- (18)}$$

where s_K is the saving rates for physical capital

s_H is the saving rates for human capital

Noted that notational, $\dot{K}_t = \frac{\partial k}{\partial t}$

They are exogenously given. Notice that both physical capital and human capital are assumed to depreciate at the same rate, δ. It simplifies the algebra tremendously. The equations of motion for labor (L) and labor-augmenting productivity (A) are:

$$L_t = L_0 e^{nt} \quad \text{---------- (19)}$$

$$A_t = A_0 e^{gt} \quad \text{---------- (20)}$$

where n and g are exogenously given growth rates.

With these equations (16) - (20), we solve for the balanced growth paths of output, physical capital, and human capital. Then, in the Solow model, we transform the system so that everything is expressed in per "effective" worker terms. This means that we divide each variable by $A_t L_t$, or the number of effective workers (productivity-augmented workers) in the economy at time *t*. This is also called putting the system into an *intensive* form

Define $y_t = \frac{Y_t}{A_t L_t}$, $k_t = \frac{K_t}{A_t L_t}$, $h_t = \frac{H_t}{A_t L_t}$

(** intensive form and ignore the written subscript *t*.)

$$y = \frac{Y}{AL} \qquad k = \frac{K}{AL} \qquad h = \frac{H}{AL}$$

The production function and equations of motion for physical and human capital become:

$$\frac{Y}{A\,L} = \frac{K^{\alpha} H^{\beta} [A\,L]^{1-\alpha-\beta}}{A\,L}$$

$$y = \frac{K^{\alpha} H^{\beta} [A\,L]^{1-\alpha-\beta}}{[A\,L]^{\alpha}[A\,L]^{\beta}[A\,L]^{1-\alpha-\beta}}$$

$$\mathrm{y} = k^{\alpha} h^{\beta} \qquad \text{---------- (21)}$$

$$\dot{k} = \frac{\dot{K}}{A\,L} - \frac{K}{[A\,L]^2}\left[\dot{A}\,L + A\,\dot{L}\right]$$

$$= \frac{s_K Y - \delta K}{A\,L} - \frac{K}{A\,L}\frac{[\dot{A}\,L + A\,\dot{L}]}{A\,L}$$

$$= s_K y - \delta k - k[g + n]$$

$$\dot{k} = s_K y - [n + g + \delta]k$$

$$\dot{k} = s_K y - [n + g + \delta]k \qquad \text{---------- (22)}$$

$$\dot{h} = \frac{\dot{H}}{A\,L} - \frac{H}{[A\,L]^2}\left[\dot{A}\,L + A\,\dot{L}\right]$$

$$= \frac{s_H Y - \delta H}{A\,L} - \frac{H}{A\,L}\frac{[\dot{A}\,L + A\,\dot{L}]}{A\,L}$$

$$= s_H y - \delta h - h[g + n]$$

$$\dot{h} = s_H y - [n + g + \delta]h \qquad \text{---------- (23)}$$

In a steady-state, physical and human capital per effective worker must be constant. This implies that we can solve the steady-state by finding the values for k and h which set the above equations of motion to zero (other than the trivial steady-state given by setting either k or h equal to zero). The steady-state conditions are then:

$$s_K y = [n + g + \delta]k \quad \text{---------- (24)}$$

$$s_H y = [n + g + \delta]h \quad \text{---------- (25)}$$

Then, we also need the production function definition which holds at all point in time,

$$y_t = k_t^{\alpha} h_t^{\beta}$$

We can substitute this production function into the above 2 equations (24 and 25). With 2 equations and 2 unknowns (k and h), we can find the exact solution for this system. First, we solve for one of the variables in terms of the other. Let us solve for h in terms of k by substitute equation (21) into (22).

$$s_H k^{\alpha} h^{\beta} = [n + g + \delta]h$$

$$h^{\beta-1} = \left[\frac{n+g+\delta}{s_H}\right] k^{-\alpha}$$

$$h = \left[\frac{s_H}{n+g+\delta}\right]^{\frac{1}{1-\beta}} k^{\frac{\alpha}{1-\beta}} \quad \text{---------- (26)}$$

Then, we substitute this expression (26) into the other steady-state condition (24) and solve for k

$$s_K k^{\alpha} \left[\left[\frac{s_H}{n+g+\delta}\right]^{\frac{1}{1-\beta}} k^{\frac{\alpha}{1-\beta}}\right]^{\beta} = [n + g + \delta]k$$

$$k^{\alpha-1} \left[\frac{s_H}{n+g+\delta}\right]^{\frac{\beta}{1-\beta}} k^{\frac{\alpha\beta}{1-\beta}} = \left[\frac{n+g+\delta}{s_K}\right]$$

$$k^{\frac{(\alpha-1)(1-\beta)}{1-\beta}+\frac{\alpha\beta}{1-\beta}} = \left[\frac{s_K}{n+g+\delta}\right]^{-1} \left[\frac{s_H}{n+g+\delta}\right]^{\frac{-\beta}{1-\beta}}$$

$$k^{\frac{(\alpha-\alpha\beta-1+\beta+\alpha\beta)}{1-\beta}} = \left[\frac{s_K}{n+g+\delta}\right]^{-1} \left[\frac{s_H}{n+g+\delta}\right]^{\frac{-\beta}{1-\beta}}$$

$$k^{\frac{(\alpha+\beta-1)}{1-\beta}} = \left[\frac{s_K}{n+g+\delta}\right]^{-1} \left[\frac{s_H}{n+g+\delta}\right]^{\frac{-\beta}{1-\beta}}$$

$$k = \left[\frac{s_K}{n+g+\delta}\right]^{-\left(\frac{1-\beta}{\alpha+\beta-1}\right)} \left[\frac{s_H}{n+g+\delta}\right]^{\left(\frac{-\beta}{1-\beta}\right)\left(\frac{1-\beta}{\alpha+\beta-1}\right)}$$

$$k^* = \left[\frac{s_K}{n+g+\delta}\right]^{\left(\frac{1-\beta}{\alpha+\beta-1}\right)} \left[\frac{s_H}{n+g+\delta}\right]^{\left(\frac{\beta}{1-\alpha-\beta}\right)} \quad \text{-------- (27)}$$

The asterisk (*) denotes the steady-state value of a variable. Now, we can substitute this equation (27) back into our expression for h in equation (26)

$$h^* = \left[\frac{s_H}{n+g+\delta}\right]^{\frac{1}{1-\beta}} k^{\frac{\alpha}{1-\beta}}$$

$$h^* = \left[\frac{s_H}{n+g+\delta}\right]^{\frac{1}{1-\beta}} \left[\left[\frac{s_K}{n+g+\delta}\right]^{\left(\frac{1-\beta}{\alpha+\beta-1}\right)} \left[\frac{s_H}{n+g+\delta}\right]^{\left(\frac{\beta}{1-\alpha-\beta}\right)}\right]^{\frac{\alpha}{1-\beta}}$$

$$= \left[\frac{s_H}{n+g+\delta}\right]^{\frac{1}{1-\beta}} \left[\frac{s_K}{n+g+\delta}\right]^{\left(\frac{\alpha(1-\beta)}{(1-\alpha-\beta)(1-\beta)}\right)} \left[\frac{s_H}{n+g+\delta}\right]^{\left(\frac{\alpha\beta}{(1-\alpha-\beta)(1-\beta)}\right)}$$

$$= \left[\frac{s_H}{n+g+\delta}\right]^{\frac{1-\alpha-\beta}{(1-\alpha-\beta)(1-\beta)}+\frac{\alpha\beta}{(1-\alpha-\beta)(1-\beta)}} \left[\frac{s_K}{n+g+\delta}\right]^{\frac{\alpha}{(1-\alpha-\beta)}}$$

$$= \left[\frac{s_H}{n+g+\delta}\right]^{\frac{1-\alpha-\beta+\alpha\beta}{(1-\alpha-\beta)(1-\beta)}} \left[\frac{s_K}{n+g+\delta}\right]^{\frac{\alpha}{(1-\alpha-\beta)}}$$

$$= \left[\frac{s_H}{n+g+\delta}\right]^{\frac{(1-\alpha-\beta)(1-\alpha)}{(1-\alpha-\beta)(1-\beta)}} \left[\frac{s_K}{n+g+\delta}\right]^{\frac{\alpha}{(1-\alpha-\beta)}}$$

$$= \left[\frac{s_H}{n+g+\delta}\right]^{\frac{(1-\beta)(1-\alpha)}{(1-\alpha-\beta)(1-\beta)}} \left[\frac{s_K}{n+g+\delta}\right]^{\frac{\alpha}{(1-\alpha-\beta)}}$$

$$h^* = \left[\frac{s_H}{n+g+\delta}\right]^{\frac{1-\alpha}{1-\alpha-\beta}} \left[\frac{s_K}{n+g+\delta}\right]^{\frac{\alpha}{1-\alpha-\beta}} \quad \text{---------- (28)}$$

With these expressions for k^* and h^*, we can now solve for y^*, by a substitute (27) and (28) into (21)

$$y^* = k^{*\alpha}\, h^{*\beta}$$

$$= \left[\left[\frac{s_K}{n+g+\delta}\right]^{\left(\frac{1-\beta}{\alpha+\beta-1}\right)} \left[\frac{s_H}{n+g+\delta}\right]^{\left(\frac{\beta}{1-\alpha-\beta}\right)}\right]^{\alpha} \left[\left[\frac{s_H}{n+g+\delta}\right]^{\frac{1-\alpha}{1-\alpha-\beta}} \left[\frac{s_K}{n+g+\delta}\right]^{\frac{\alpha}{1-\alpha-\beta}}\right]^{\beta}$$

$$= \left[\frac{s_K}{n+g+\delta}\right]^{\frac{(1-\beta)\alpha}{1-\alpha-\beta}} \left[\frac{s_H}{n+g+\delta}\right]^{\frac{\alpha\beta}{1-\alpha-\beta}} \left[\frac{s_H}{n+g+\delta}\right]^{\frac{(1-\alpha)\beta}{1-\alpha-\beta}} \left[\frac{s_K}{n+g+\delta}\right]^{\frac{\alpha\beta}{1-\alpha-\beta}}$$

$$= \left[\frac{s_K}{n+g+\delta}\right]^{\frac{\alpha-\alpha\beta+\alpha\beta}{1-\alpha-\beta}} \left[\frac{s_H}{n+g+\delta}\right]^{\frac{\beta-\alpha\beta+\alpha\beta}{1-\alpha-\beta}}$$

$$y^* = \left[\frac{s_K}{n+g+\delta}\right]^{\frac{\alpha}{1-\alpha-\beta}} \left[\frac{s_H}{n+g+\delta}\right]^{\frac{\beta}{1-\alpha-\beta}} \quad \text{---------- (29) **}$$

Hence, it can be said that more investment in two types of this investment increases k, h, and y in the long-run, but n, g, δ lowers long-run productivity. Relative contributions of the saving rates depend on the shares of physical and human capital, the larger is α, the more important is s_K and the larger is β, the more important is s_H.

3.2.2 Econometric Model, Estimation and Hypothesis Testing

From (2.14), we take logs, then we get:

$$log\left[\frac{Y_t}{L_t}\right] = log\,A(0) + g_t - \frac{\alpha+\beta}{1-\alpha-\beta} log\,(n+g+\delta) + \frac{\alpha}{1-\alpha-\beta} log\,(s_K) + \frac{\beta}{1-\alpha-\beta} log\,(s_H) \text{ ------- (30)}$$

There is an alternative way to express the role of human capital in determining income in the model. Combining (30) with the equation for the steady-state level of human capital given in (27) and (28) yields an equation for income as function of the rate of investment in capital, the rate of population growth, and the **level** of human capital:

$$log\left[\frac{Y_t}{L_t}\right] = log\,A(0) + g_t - \frac{\alpha}{1-\alpha} log\,(n+g+\delta) + \frac{\alpha}{1-\alpha} log\,(s_K) + \frac{\beta}{1-\alpha} log\,(h^*) \quad \text{------ (31) **}$$

where, $logA_t = logA_0 + g_t$, $logA_0 = constant$

Then, we formulated as a regression model:

$$log\left[\frac{Y_t}{L_t}\right] = \beta_0 + \beta_1\, log\,(n+g+\delta) + \beta_2 log\,(s_K) + \beta_3\, log\,(h^*) \quad \text{---------- (32) **}$$

with $\beta_1 = \frac{\alpha}{1-\alpha}$, $\beta_2 = \frac{\alpha}{1-\alpha}$, $\beta_3 = \frac{\beta}{1-\alpha}$

Research Question: Is human capital augmented to the Solow growth model significantly positive??

Null Hypothesis (H_0): There is no relationship between y and β_1, β_2, β_3

($\beta_1 = 0$, $\beta_2 = 0, \beta_3 = 0$)

Data for the Empirical

This section applied macroeconomic data from the United Nations Conference on Trade and Development (UNCTAD Stat) in constant prices of 2005 and the National Accounts Statistics published by the NESDB[8], various issues, and the Labor Force Survey (LFS), 3rd quarter of the year 1977-2015, published by the NSO[9]. It is assumed that the price of value added i.e., wage and rental rate and the unit value of total input or producer price of gross output are moving in the same direction at equilibrium.

Table 3-7. Data for the empirical analysis

Variables	*Unit*	*1980*	*1985*	*1990*	*1995*	*2000*	*2005*	*2010*
GDP (Y)	USD Million, Constant 2005	41,767.1	54,452.8	88,923.9	134,468.2	137,515.4	176,351.9	210,090.5
Capital Stock (K)	USD Million, Constant 2005	121,276.0	175,017.9	268,431.1	471,584.5	570,627.8	632,040.9	728,154.5
Investment (I)	USD Million, Constant 2005	15,227.4	18,842.9	42,914.4	69,809.7	33,741.1	50,965.1	53,958.9
Labor (L)	Million Persons	23.23	28.09	32.48	32.06	34.82	37.88	39.40
Population (P)	Million Persons	47.38	52.04	56.58	59.26	62.69	65.86	66.69

Variables	*1980*	*1985*	*1990*	*1995*	*2000*	*2005*	*2010*
Output per labor head (Y/L) (USD per person, constant 2005)	1,797.6	1,938.1	2,737.3	4,193.2	3,948.8	4,654.8	5,331.6
Capital per labor head (K/L) (USD per person, constant 2005)	5,219.7	6,229.4	8,263.0	1,4705.9	16,385.9	16,682.9	18,479.0
Growth of labor (n) [10] (percent)	0.9	1.2	1.3	1.3	1.4	1.5	1.6
Growth of technology (g) [11] (percent)	1.0	1.0	1.2	1.3	1.1	1.3	1.5
Depreciation rate (δ) (percent)	4.1	3.9	4.0	4.1	3.9	3.9	3.9

Source: UNSTAD Stat, NESDB, various years, 1980-2010.

[8] The National Economic and Social Development Board of Thailand (NESDB)
[9] the National Statistical Office of Thailand (NSO)
[10] Estimated equation: LOG(LL_THA) = 16.9868 + 0.0153*@TREND, $R^2 = 0.9287$
[11] Estimated equation: LOG(GDPR_THA) = 2.3501 + 0.0110*@TREND + 0.5916*LOG(KK_THA) + (1-0.5916)*LOG(LL_THA), $R^2 = 0.9864$

Construction of the level of human capital (h^*)

To implement the model, we restricted our focus to human capital investment in the form of education, thus ignoring investment in health, training and among other things. We differentiated the level of human capital by the investment intensity on education which disaggregates into 3 levels from low, moderate and high education level. We obtained the Labor Force Survey of Thailand 1975-2015 and nominated human capital investment by the education investment intensity level from ISCED and LFS 14-17 levels into 3 levels of human capital investment intensity which consists of (1) low intensity, (2) moderate intensity and (3) high intensity. In addition, we also classified skilled-unskilled labor matched with 9 occupations into (1) skilled and (2) unskilled labor. (Table 3-8) (for classifications, see Appendix)

Table 3-8. Number of total labor and average wages by educations and occupations, 1975-2015

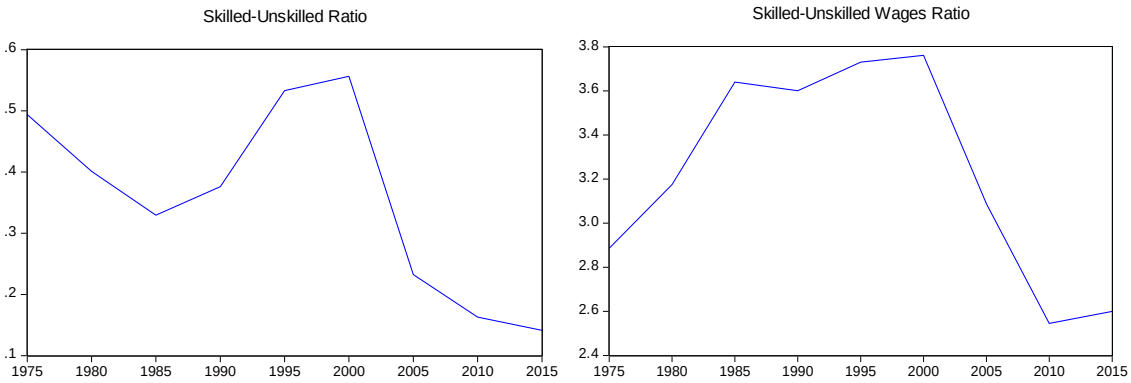
Human Capital (H)	*1975*	*1980*	*1985*	*1990*	*1995*	*2000*	*2005*	*2010*	*2015*
The number of labor by educations [12] (Thousand persons)									
Low (L)	20,395.3	21,747.2	24,537.8	28,216.0	28,587.9	27,093.5	27,308.4	26,994.2	24,218.6
Moderate (M)	560.1	813.7	1,369.7	2,031.9	2,603.3	3,414.0	5,549.2	7,180.4	8,052.7
High (H)	158.2	247.7	469.3	948.0	1,667.2	2,120.1	3,481.5	4,480.5	5,847.8
** Ratio (% of total) **									
Low (L)	96.6	95.5	93.0	90.4	86.9	83.0	75.1	69.8	63.5
Moderate (M)	2.7	3.6	5.2	6.5	8.0	10.5	15.3	18.6	21.1
High (H)	0.7	1.1	1.8	3.0	5.1	6.5	9.6	11.6	15.3

Wages	*1975*	*1980*	*1985*	*1990*	*1995*	*2000*	*2005*	*2010*	*2015*
All	1,078.1	1,480.5	2,010.5	3,041.0	5,142.0	5,996.6	8,551.1	14,263.0	16,241.3
*Mean of wages by occupations (Baht / month / person) * at current price*									
Skilled	1,838.4	2,706.2	3,894.2	5,636.1	9,254.6	10,150.9	17,284.8	25,847.7	29,753.1
Unskilled	636.9	852.2	1,069.7	1,565.2	2,480.8	2,698.4	5,596.3	10,155.4	11,443.9
S/U Ratio	2.88	3.17	3.64	3.60	3.73	3.76	3.08	2.54	2.59
*Mean of wages by educations (Baht / month / person) * at current price*									
Low (L)	589.2	788.5	912.8	1,228.6	1,763.3	1,771.3	4,823.9	9,216.4	9,411.6
Moderate (M)	1,916.9	2,702.5	3,538.9	4,927.7	7,813.5	8,499.4	8,757.8	12,805.8	14,210.7
High (H)	1,753.8	2,781.5	4,012.1	6,385.7	11,292.8	13,601.8	18,076.7	26,281.8	30,857.3

Source: ISCED and LFS, 3rd quarter, various years, NSO.

[12] See Classifications in Appendix.

Fig. 3-4. Human capital contribution in Thailand 1975-2015



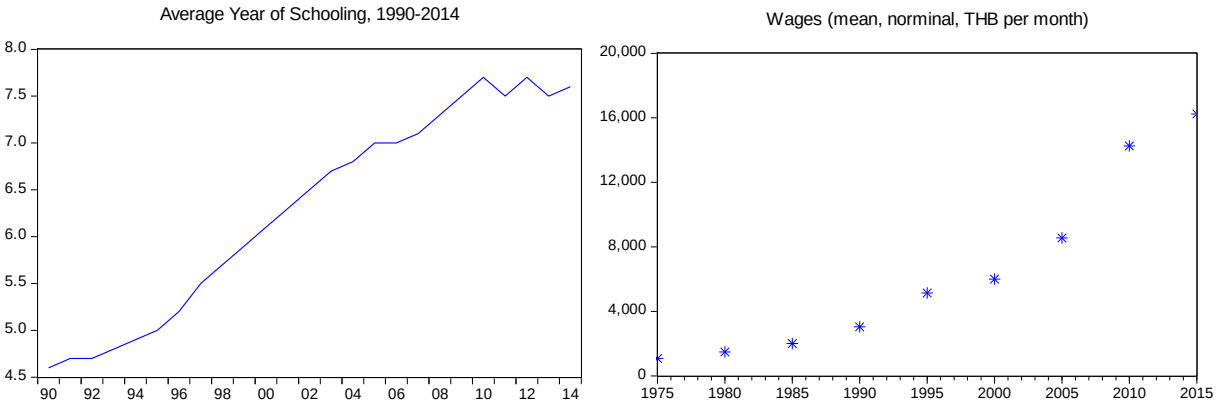
Source: Compiled data from Labor Force Survey, 3rd quarter, various years, NSO.

During the period 1985-2000, foreign capital relocated production to Thailand and initiated the best practices of human resources development systems, for example, Japanese manufacturing emphasizes highly on training and skill development to lower the cost and improve productivity. The proportion of skilled labor on unskilled labor had been improved in a better direction in the high growth period during the 1990s.

However, after the Asian Financial Crisis in 1997, the capital was scarcity and investment in upgrading production technology was delayed. Instead of replacing with automatic and efficient machinery, businesses were forced to hire unskilled Thai labor and also abundant neighbor's migrants[13]. During the post-crisis, the proportion of labor with low educational level had shown a decreasing trend, while the medium-high education labor likely to increase, it, unfortunately, turned down after the crisis. Although the ratio of the wage between skilled and unskilled labor has exposed in the closer gap, nonetheless it can be implied that wages were stagnant especially in skilled and high-educated workers.

[13] Migrants mostly are from Myanmar, Lao PDR and Cambodia.

Fig. 3-5. Schooling and wages of working-age population in Thailand, 1990-2015



Source: HDI indicators of UNDP and LFS of Thailand.

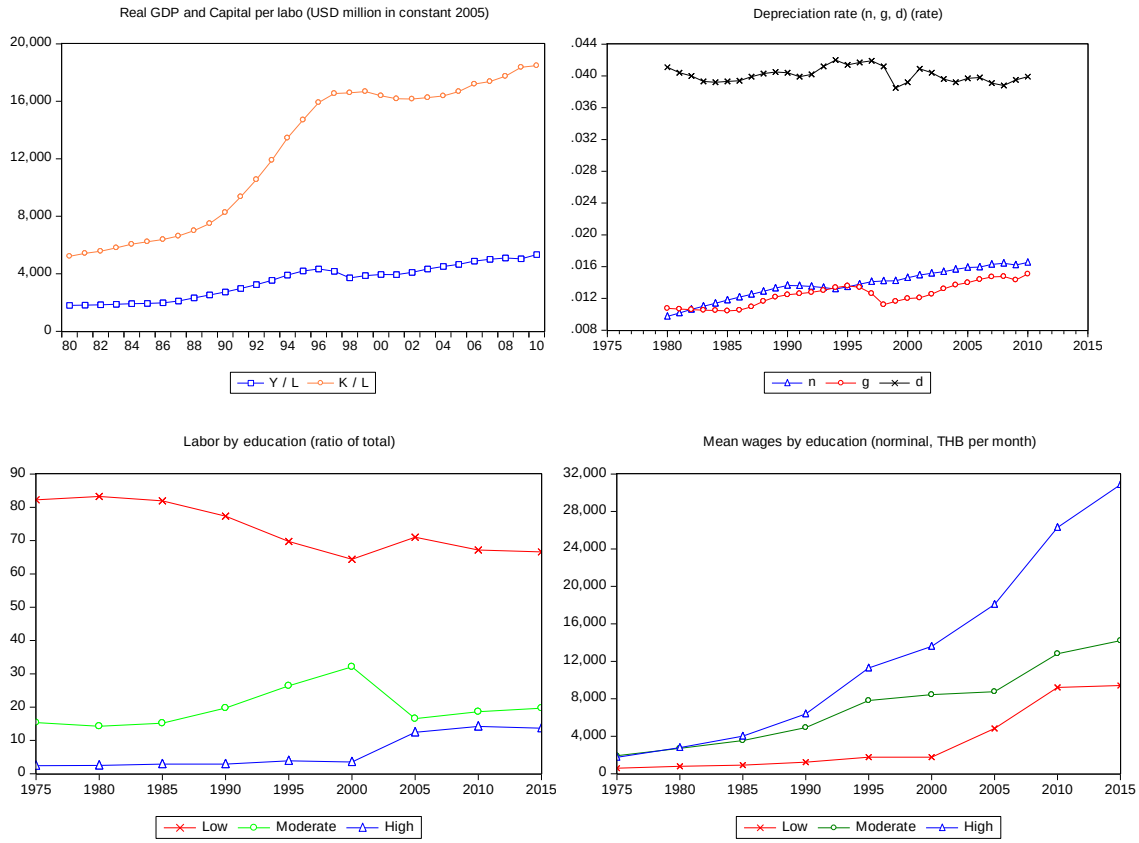
Table 3-9. Descriptive Statistics

Variables	*Variables Name*	*Period*	*Obs.*	*Mean*	*S.D.*	*Min.*	*Max.*
yol_tha	Output per labor head (Thousand Baht / person)	1980-2010	31	3,473.8	1,180.3	1,797.6	5,331.6
kol_tha	Capital per labor head (Thousand Baht / person)	1980-2010	31	12,353.2	4,950.8	5,219.7	18,479.0
ll_tha	Labor head (Million person)	1980-2010	31	32.73	4.54	23.23	39.40
$n+g+\delta$	Depreciation rate (percent)	1980-2010	31	6.6	0.3	6.0	7.1
l_edu_l_ratio_iv	The ratio of low education persons to total labor	1975-2015	41	73.65	6.82	64.37	83.24
l_edu_m_ratio_iv	The ratio of moderate education persons to total labor	1975-2015	41	19.83	5.08	14.24	32.10
l_edu_h_ratio_iv	The ratio of high education persons to total labor	1975-2015	41	6.22	4.71	2.39	14.22
w_edu_l_iv	Mean wages of low education labor (Baht / month / person)	1975-2015	41	3,171.94	3,140.31	589.21	9,411.62
w_edu_m_iv	Mean wages of moderate education labor (Baht / month / person)	1975-2015	41	7,115.97	3,801.89	1,916.99	14,210.74
w_edu_h_iv	Mean wages of high education labor (Baht / month / person)	1975-2015	41	12,338.48	9,169.74	1,753.81	30,857.38

Note. Subscript "_iv" is log-linear interpolated variables [14] from 5-year series values.

[14] Log-Linear Interpolated Variables formula is: $IV = EXP[(1-\lambda)\log(P_{i-1}) + \lambda(\log(P_{i+1})]$ where, P_{i-1} is the previous missing value, P_{i+1} is the next non-missing value, and λ is the relative position of the missing value divided by the total number of missing values in a row.

Fig. 3-6. Descriptive Statistics



Source: Author

Empirical Results

Table 3-10 presents regression of the log of income per capita on the log of (n+g+δ), the log of the capital per labor, and the log of the ratio of labor by education investment in Equation 2 or (eq.2), and the log of the ratio of labor by education investment weighted by wages. (eq. 3) The human capital measure enters significantly with the log of the ratio of labor by education investment weighted by wages. (eq.3) However, it is noted that the sign of log of the (n+g+δ) in Equation 2 was significant but contradicted with the theoretical framework. Moreover, the human capital model also greatly reduces the size of the coefficient on physical capital investment which explains about 45 percent in the non-human capital investment to about 36 percent in the human capital one. The human capital models also improve the fit of the regression compared with (eq.1) Our result strongly supports the augmented Solow growth model. The coefficient (β) of Equation (eq.3) was 0.14 which explained that the rate of return to the human capital investment was relatively small at 14 percent compared to 34 and lower than 50 percent of the rate of return to the capital and labor head input respectively.

Table 3-10. Estimation results

Dependent variable: log real GDP per labor, log (Y/L)						
	EQ(1)		*EQ(2)*		*EQ(3)*	
Observations:	31		31		31	
log (n+g+δ)	- 0.96	***	2.57		-2.27	***
	(0.12)		(0.27)		(0.27)	
log (K/L)	0.69	***	0.55	***	0.45	***
	(0.13)		(0.02)		(0.03)	
log (L+M+H)	-		2.14	***	-	
	-		(0.21)		-	
log (wL+wM+wH)	-		-		0.08	***
	-		-		(0.02)	
A.R.(1)	-		-		0.31	
					(0.47)	
R-square	0.99		0.99		0.99	
s.e.e.	0.03		0.02		0.02	
D.W.	1.62		1.08		1.33	
Implied α	0.46				0.34	
Implied β					**0.14**	

Source: Author's calculation
Note: Standard errors are in parentheses.
***, **, * denote significance at the 1, 5, 10 percent level
(*** p<0.01, ** p<0.05, * p<0.1)

Conclusion

The economic development of Thailand in the past relied much on physical capital investment and abundant cheap labor to support the labor-intensive industry. However, after the Asian Financial Crisis in 1997, the financial system and capital accumulation processes were collapsed. Thailand had lost the ability to build its capital-intensive industries. Although Thailand had to advance its production but then turned to delay the additional investment (as reviewed by Bowonthumrongchai, 2020) and ultimately replaced with cheap and abundant labor from neighboring migrants.

The investment on education seems to be improved since there was the rising of the average year of schoolings and the mean wages of labor. However, low academic achievement passed negative consequences for students' future labor-market and income prospects. Then, we hypothesized that education investment intensity and transitional of labor in term of quality improvement from low-education to higher education in Thailand was too slow to support advanced industries and produce higher growth.

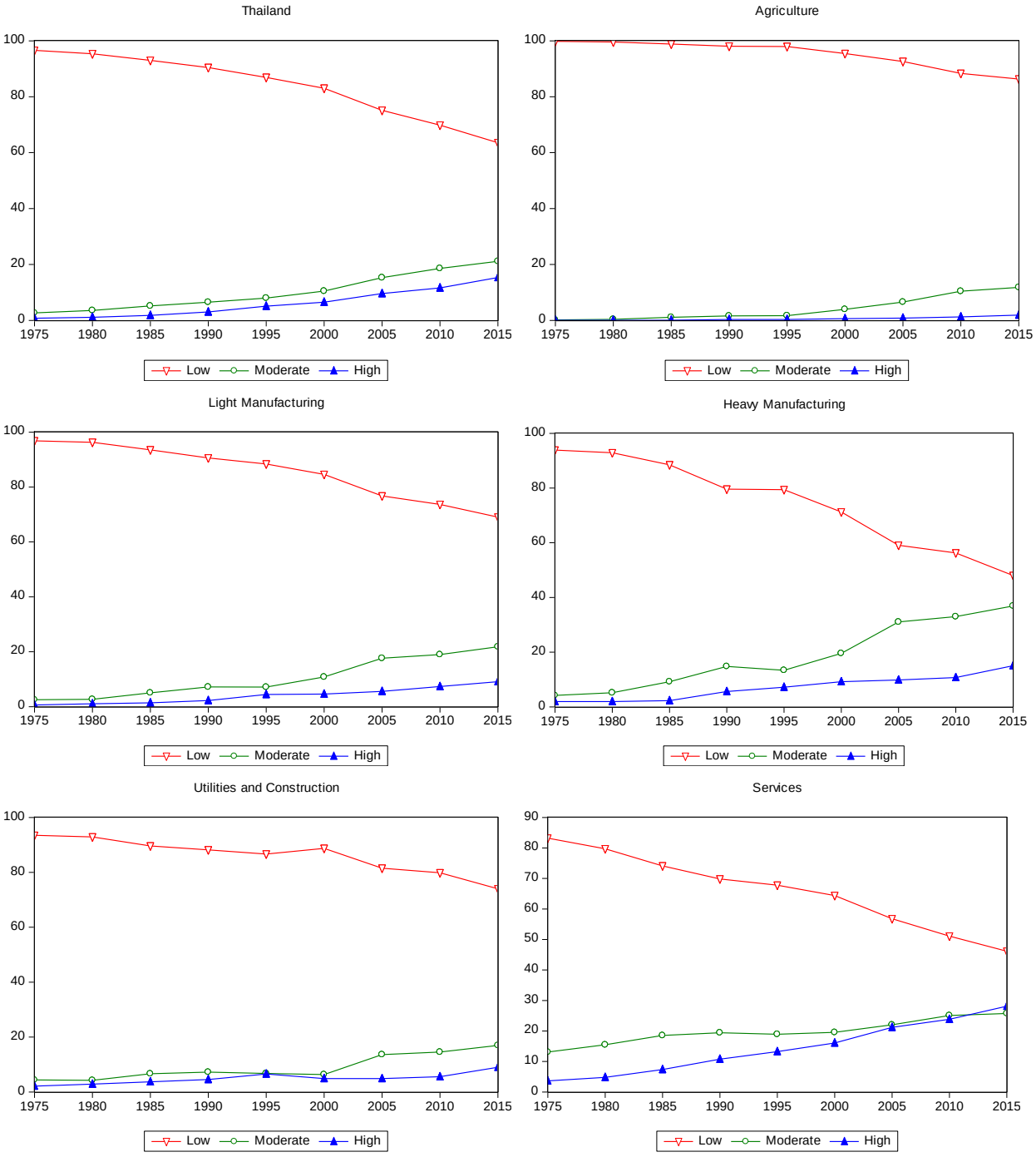
As we applied the human capital augmented Solow growth models to investigate the contribution of human capital in Thailand during 1980-2010. This study restricted our focus to human capital investment in the form of education, thus ignoring investment in health, training and among other factors. The Labor Force Survey of Thailand during 1975-2015 were obtained and nominated the human capital investment by the education investment intensity levels.

As a result, likewise various studied, we confirmed that human capital growth *positively and significantly* raised the income per capita and economic development in Thailand during 1980-2010. Nevertheless, the rate of return to the human capital investment was relatively small compared to the rate of return to labor and capital inputs. In addition, in the next part we have tried to apply another technique and deeply examined the sectoral analysis by disaggregate sectors into 5 key industries then continue to test under the similar hypothesis.

3.2.3 Nested Human Capital Model and Hypothesis Testing

Since the overall rate of return to the human capital investment in Thailand during 1980-2010 was relatively too small comparatively. We have additionally suspected that economic activities and transformation of human capital in each industry would not homogeneous and roles of human capital on each industrial development would have variance. Then, we continue to examine the sectoral analysis by disaggregate human capital investment intensity into 5 significant industries. Key industries of this section are classified into 5 sectors; (1) agricultures, (2) light manufacturing, (3) heavy manufacturing, (4) public utilities and construction and (5) trade and services. Human capital variable in this part is still proxied by the number of labors by education levels with fragmented key 5 industries. Later, we examine the sectoral contribution of human capital by estimate Cobb-Douglas sectoral production functions with nested human capital models.

Fig. 3-7. Transition of human capital in key industries, 1975-2015 (ratio, % of total)



Remark: 1) L, M, H are number of low, moderate, high educated employed labors, 1975-2015.

Sources: ISCED and LFS, 3rd quarter, various years, NSO, Thailand.

From Figure 3-7, it found that during the 1980s, most labor-intensive industries such as agriculture and light manufacturing sector made use of the abundant and over-supply of labor. Most of labors, around 79.7-99.6% of the total labors of these sectors had a low level of education. While only 1.0-15.5% of workers in most of the industries and service sectors had middle-high level of education.

After few decades passed, in 2010, the agriculture, light manufacturing and utilities and construction industries are still labor-intensive. Although, there were utilizing low-educated labors in a lower proportion, but still as high as 67.2-88.3% of total labor force. Despite the fact that most industrial sectors have gradually shifted to hiring middle-high educated workers which slightly increasing to 8.7-50.7% of the total workers. Especially, the rising star heavy industries and services sectors which have shown rapid growth in production and exports during the 1990s - 2000s such as the chemicals, electronics, automobiles sectors. They advanced to employ middle-high educated workers up to 50% of the total workers.

For an average wage of manufacturing in Thailand, wages increased most sharply after the 1980s and decreased since the time of the Asian financial crisis during 1997-2000. Surprisingly, in the overall during 1975-2015, the average wages of the low education group have a compound growth rate of approximately 1.9-5.3%, especially in the agricultural sector. While the average wages of labor with middle-to-high level education has an average growth rate of only (-)0.3-2.8%

Workers with high education investment intensity levels in the manufacturing sector such as chemicals, utilities and construction, and service sectors have the highest growth rate of average wages at 2.8%, 2.1% and 1.6%, respectively. For services, automobiles and electronics which utilized middle-class education, their growth rate of the average wages was at 0.8-1.2%.

Data for Empirical

We acquired data sets from the Labor Force Surveys of Thailand during 1975-2015 provided by the National Statistical Office (NSO). We constructed the '*Human Capital Level*' proxied by the summation of the number of moderate and high educated labors in each key industry.

Table 3-11. Number of labors in key industries by education investment intensity, 1975-2015

Unit: Thousand persons

Labors (L)		*1975*	*1980*	*1985*	*1990*	*1995*	*2000*	*2005*	*2010*	*2015*
1) Agricultures		15,755.1	16,188.6	18,234.0	20,199.9	17,175.7	16,264.1	15,489.9	15,727.3	13,108.3
	L	15,725.4	16,123.7	18,021.3	19,811.6	16,827.8	15,522.6	14,348.7	13,893.2	11,314.3
	M	26.2	62.6	197.2	327.0	293.7	639.4	1,018.1	1,637.0	1,548.5
	H	3.6	2.3	15.4	61.3	54.2	102.2	123.1	197.1	245.6
2) Manufacturing - Light		954.4	1,187.4	1,345.2	1,885.9	2,318.5	2,592.5	2,824.6	2,764.2	2,828.4
	L	924.4	1,143.3	1,258.6	1,708.4	2,049.6	2,193.2	2,167.8	2,036.6	1,953.0
	M	24.1	31.9	68.0	135.4	165.9	280.8	499.0	525.1	617.8
	H	5.9	12.2	18.6	42.1	103.0	118.5	157.8	202.4	257.7
3) Manufacturing - Heavy		377.6	628.1	747.7	1,267.8	2,089.8	2,115.1	2,546.4	2,432.4	3,420.6
	L	354.6	583.6	661.7	1,009.0	1,659.4	1,506.8	1,505.0	1,369.0	1,643.6
	M	15.8	32.4	69.0	187.8	279.8	414.0	791.1	802.9	1,262.4
	H	7.3	12.1	17.0	71.1	150.7	194.3	250.3	260.5	514.6
4) Utilities, Constructions		388.0	508.9	718.8	1,153.3	2,056.7	1,502.6	2,000.0	2,208.1	2,330.1
	L	362.6	472.7	644.0	1,017.3	1,782.7	1,333.6	1,630.2	1,763.5	1,724.7
	M	17.0	21.7	48.0	83.6	138.8	95.4	272.2	321.5	395.2
	H	8.4	14.5	26.8	52.5	135.2	73.6	97.6	123.1	210.1
5) Services		3,638.4	4,295.6	5,331.1	6,689.1	9,244.8	10,153.2	13,478.2	15,523.0	16,431.6
	L	3,028.3	3,424.0	3,952.1	4,669.8	6,268.4	6,537.3	7,656.9	7,931.9	7,582.9
	M	477.1	665.1	987.5	1,298.2	1,752.2	1,984.4	2,968.8	3,893.8	4,228.9
	H	133.0	206.5	391.4	721.1	1,224.2	1,631.4	2,852.6	3,697.3	4,619.9

Remark: 1) L, M, H are low, moderate, high education investment intensity

Sources: ISCED and LFS, 3rd quarter, various years, NSO, Thailand.

Additionally, gross capital stock of Thailand of which provided by the NESDB is available only one aggregated manufacturing sector. Cooperatively, Limskul and Bowonthumrongchai (2019)[15] have applied the 'Perpetual Inventory Method' following Berlemann and Wesselhoft (2014) to estimate initial and terminal capital stocks of these similar 5 sub-sectors. We credited and relied on their skillful estimations.

Table 3-12. Capital stocks in key industries of Thailand, 1980-2010

Unit: Billion Baht

Capital Stocks (K)	***1980***	***1985***	***1990***	***1995***	***2000***	***2005***	***2010***
(At constant price, 2000)							
1) Agricultures	488.8	575.9	675.2	1,004.9	1,276.4	1,498.4	1,870.4
2) Manufacturing – Light	19.8	44.8	47.2	71.6	82.0	80.5	87.7
3) Manufacturing – Heavy	17.7	39.5	58.0	118.1	147.6	183.6	247.4
4) Utilities, Constructions	26.6	58.8	88.5	157.3	237.9	293.0	351.8
5) Services	2,542.8	3,696.4	5,715.5	10,039.6	12,175.2	13,223.4	15,005.9
(At current price)							
1) Agricultures	194.2	290.8	476.9	770.4	1,276.4	1,840.0	2,670.8
2) Manufacturing – Light	6.5	18.8	27.2	54.6	83.7	100.0	131.9
3) Manufacturing – Heavy	5.6	16.5	33.5	86.6	145.9	226.9	337.8
4) Utilities, Constructions	11.2	30.4	60.2	126.8	237.9	368.5	569.9
5) Services	1,012.1	1,830.5	3,768.2	7,850.3	12,175.2	16,222.1	21,566.2

Source: Limskul and Bowonthumrongchai (2019).

National Accounts of Thailand, various years, NESDB, Thailand.

[15] Dr.Kitti Limskul is an author's advisor and Mr. Thongchart Bowonthumrongchai is author's doctoral classmate at the Faculty of Economics, Saitama University, in Japan during 2017-2020.

Table 3-13. Descriptive statistics of variables (at constant price 2000)

Variables	*Variables Descriptions*	*Period*	*Obs.*	*Mean*	*S.D.*
ZZir_agri	Real output of agriculture (Thousand Baht)	1975-2010	8	6.35 E+08	3.17 E+08
ZZir_light	_____light manufacturing (Thousand Baht)	1975-2010	8	1.52 E+09	7.98 E+08
ZZir_heavy	_____heavy manufacturing (Thousand Baht)	1975-2010	8	2.87 E+09	2.75 E+09
ZZir_util	_____utilities (Thousand Baht)	1975-2010	8	7.98 E+08	5.91 E+08
ZZir_ser	_____services (Thousand Baht)	1975-2010	8	3.31 E+09	2.36 E+09
ZJr_agri	Real intermediate input of agriculture (Thousand Baht)	1975-2010	8	2.18 E+08	1.35 E+08
ZJr_light	_____light manu. (Thousand Baht)	1975-2010	8	1.02 E+09	5.55 E+08
ZJr_heavy	_____heavy manu. (Thousand Baht)	1975-2010	8	2.16 E+09	2.16 E+09
ZJr_util	_____utilities (Thousand Baht)	1975-2010	8	5.14 E+08	4.09 E+08
ZJr_ser	_____services (Thousand Baht)	1975-2010	8	1.16 E+09	9.25 E+08
l_edu_l_agri	Low educated labors in agriculture (Person)	1975-2015	9	1.57 E+07	2.45 E+06
l_edu_l_light	_____light manu. (Person)	1975-2015	9	1.71 E+06	4.82 E+05
l_edu_l_heavy	_____heavy manu. (Person)	1975-2015	9	1.14 E+06	5.01 E+05
l_edu_l_util	_____utilities (Person)	1975-2015	9	1.19 E+06	5.81 E+05
l_edu_l_ser	_____services (Person)	1975-2015	9	5.67 E+06	1.93 E+06
l_edu_m_agri	Moderate educated labors in agriculture (Person)	1975-2015	9	6.38 E+05	6.21 E+05
l_edu_m_light	_____light manu. (Person)	1975-2015	9	2.60 E+05	2.30 E+05
l_edu_m_heav	_____heavy manu. (Person)	1975-2015	9	4.28 E+05	4.33 E+05
l_edu_m_util	_____utilities (Person)	1975-2015	9	1.54 E+05	1.39 E+05
l_edu_m_ser	_____services (Person)	1975-2015	9	2.02 E+06	1.37 E+06
l_edu_h_agri	High educated labors in agriculture (Person)	1975-2015	9	8.94 E+04	8.64 E+04
l_edu_h_light	_____light manu. (Person)	1975-2015	9	1.02 E+05	9.05 E+04
l_edu_h_heav	_____heavy manu. (Person)	1975-2015	9	1.64 E+05	1.65 E+05
l_edu_h_util	_____utilities (Person)	1975-2015	9	8.24 E+04	6.62 E+04
l_edu_h_ser	_____services (Person)	1975-2015	9	1.71 E+06	1.63 E+06

Source: Author

Empirical Result

Table 3-14. Estimated sectoral production functions and nested labor by education, 1975-2010

Dependent variable: log Real Output per Labor, log (ZZIr/L)										
	(Agri)		***(Light)***		***(Heavy)***		***(Utility)***		***(Services)***	
Observations:	6		6		6		7		6	
Constant	1.50	***	0.27		1.02	***	1.46	**	1.61	***
	(0.05)		(0.57)		(0.06)		(0.30)		(0.18)	
log (Kr/L)	0.003		0.07	***	-0.02		0.02		0.16	***
	(0.02)		(0.01)		(0.02)		(0.04)		(0.04)	
log (ZJr/L)	0.82	***	1.04	***	0.91	***	0.81	***	0.65	***
	(0.02)		(0.03)		(0.01)		(0.05)		(0.03)	
A.R.(2)	0.02		0.30		0.27		-		0.59	
	(0.02)		(0.57)		(0.23)				(0.10)	
Adjusted R^2	0.99		0.99		0.99		0.95		0.98	
s.e.e.	0.01		0.01		0.01		0.06		0.02	
D.W.	2.09		2.18		2.19		1.52		2.09	
Dependent variable: log Labor, log (L)										
Observations:	8		7		9		9		9	
Constant	1.56	**	3.07	***	3.38	***	1.19	***	3.59	**
	(0.52)		(0.23)		(0.84)		(0.16)		(1.23)	
log (edu_L)	0.86	***	0.62	***	0.48	***	0.76	***	0.36	**
	(0.03)		(0.01)		(0.08)		(0.02)		(0.12)	
Log (edu_M + H)	**0.05**	***	**0.19**	***	**0.32**	***	**0.18**	***	**0.44**	***
	(0.00)		(0.00)		(0.03)		(0.01)		(0.04)	
A.R.(1)	0.64	***	0.16		-		-		-	
	(0.13)		(0.12)							
Adjusted R^2	0.98		0.99		0.99		0.99		0.99	
s.e.e.	0.01		0.01		0.05		0.01		0.03	
D.W.	2.16		1.87		2.02		1.85		0.95	

Source: Author's estimation.
Note: Standard errors are in parentheses.
***, **, * denote significance level at the 1, 5, 10 percent respectively
(*** p<0.01, ** p<0.05, * p<0.1)

Table 3-15. Contribution of human capital growth in key industries of Thailand, 1975-2010

Key Industries	***Contribution of Human Capital Growth***
1) Agricultures	0.05 ***
2) Manufacturing - Light	0.19 ***
3) Manufacturing - Heavy	0.32 ***
4) Utilities, Constructions	0.18 ***
5) Services	0.44 ***

Source: Author

Note: Standard errors are in parentheses.
***, **, * denote significance level at the 1, 5, 10 percent respectively
(*** p<0.01, ** p<0.05, * p<0.1)

Presumably, we have previously doubted that economic activities and transformation of human capital and roles of human capital on each industrial development have significant impacts. *This study significantly insisted that contribution of human capital growth on key industries were divergence*.

Besides, during 1980-2010, agriculture sector in Thailand deployed abundant of low educated labor and its human capital growth generated lowermost at 5 percent contributions to its real output growth. Light manufacturing and utilities sectors gradually improved and employed more middle-educated labor which their human capital growth supported moderate advancement at 19 and 18 percent to their real output growth, respectively. Therewith, human capital growth in heavy manufacturing and service industries in Thailand preceded the high endowment to their sectoral growth at 32 and 44 percent in orderly. Incidentally, *this study ensured that the more education and competence labor has, the more efficiency and growth industry obtains.*

3.3 Counterfactual Scenarios of Human Capital Growth and Economic Development in Thailand during 1990-2015

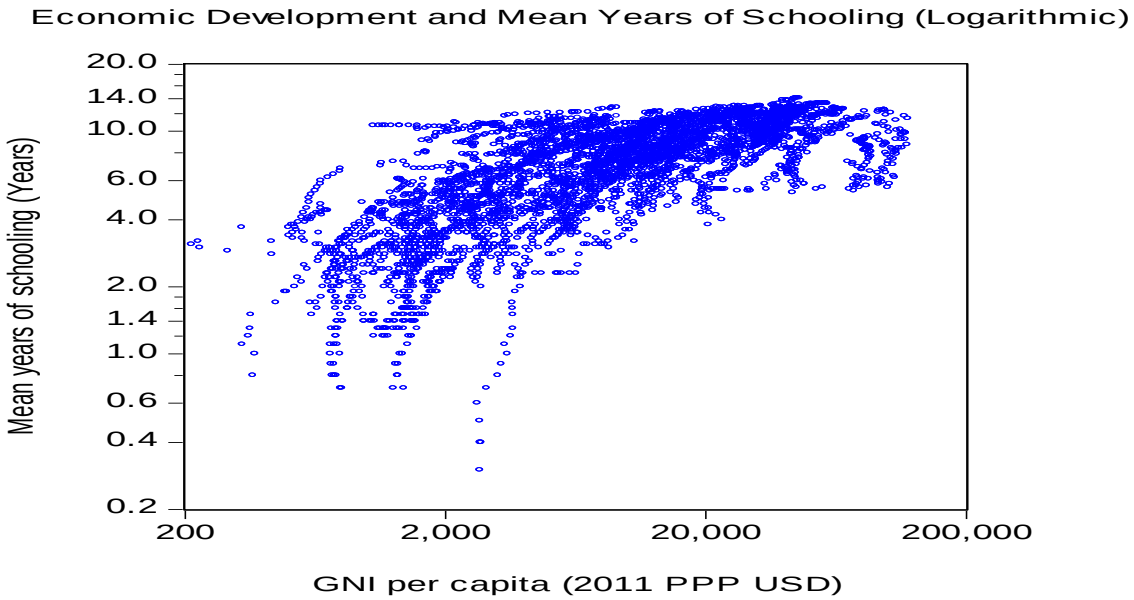
3.3.1 Determination of the Years of Schooling: Applying Panel Econometric Model

Last section was proof that number of higher educated labor is one of the significant factors contributed to higher efficiency of the production in developing country like Thailand. Because educated labor is capable to handle more difficult tasks and complicated machines. With capital, company can easily purchase new machines or updated software to improve their efficiency within short periods, however, labor need not only capital but also time to accumulate years of schooling and experiences before employer can utilize them at work. Figure 3-8. And Table 3-16. have shown that labor in high income countries tend to obtain higher years of schooling in term of number of years and speed of increasement. However, supply of educated labor cannot be increased within a day or a month, it should be prepared since earlier decades through population growth and educational plan. Jesperson E. of UNDP (2011) stated that most developed countries have good education facilities and provide better services to their citizen. However, majority of the developing countries have many constraints and focuses less spending on education facilities, consequently limit the poor to have access of their children's education. Commonly, the developing countries are busy in many aspects, they mostly put emphasis on increasing economic growth while the development of socio economy holds less priority to the country's development strategy.

Hence this section we try to benchmark the improvement of education and human development in Thailand with developed countries. We benchmark the development of Thailand with forerunner countries such as OECD countries, and more developed countries in East Asia such as Korea, Taiwan, Hong Kong and Singapore. Panel data cross-countries analysis with pooled regression will be appropriated to investigate the relationship between education, human development and epoch of economic advancement. Later, counterfactual approach will be applied to find the suboptimal level of education which represented by the "mean years of schooling[16]" which should have obtained during the high growth period given that Thailand would growth similar to the forerunner country, for example, Taiwan economy.

[16] Average number of years of education received by people ages 25 and older, converted from education attainment levels using official durations of each level, UNDP 2018.

Fig. 3-8. Epoch of economic development and education of the World, 1990-2017



Source: 189 countries, Human Development Index (HDI) 2018, UNDP (accessed November 2019)

Table 3-16. Epoch of growth and education of Thailand and forerunner countries, 1990-2015

Year	*GNI per Capita (2011 PPP USD)*				*Mean years of schooling (years)*			
	Thailand	**S/E Asian**	**World**	**OECD**	**Thailand**	**S/E Asian**	**World**	**OECD**
1990	*6,560*	14,892	12,423	24,915	*4.6*	4.6	5.9	9.0
1995	*9,177*	17,096	12,836	25,888	*5.0*	5.3	6.6	9.7
2000	*9,003*	17,611	14,482	30,390	*6.1*	6.2	7.0	10.2
2005	*11,006*	19,265	15,796	33,855	*7.0*	6.7	7.5	11.0
2010	*12,918*	21,474	16,495	34,540	*7.7*	7.4	8.0	11.5
2015	*14,455*	23,340	17,654	36,948	*7.6*	7.8	8.5	11.9

Remark: South East Asian, World and OECD group consists of 10, 189 and 36 member countries respectively.

Source: Compiled from the Human Development Index (HDI) 2018, UNDP (accessed November 2019)

Data for the empirical

Table 3-17. Descriptive statistics of variables

Variables	***Variables Descriptions***	***Period***	***Obs.***	***Mean***	***S.D.***
HDI	Human development index (0 – 1)	1990-2017	5,292	0.6513	0.0367
GNI_CAP	Gross national income per capita (2011 PPP USD)	1990-2017	5,292	15,112.54	1,949.99
SCH	Mean years of schooling (Years)	1990-2017	5,292	7.35	0.79
LIFE_EXP	Life expectancy (Years)	1990-2017	5,292	68.09	2.43

Source: 189 countries, Human Development Index (HDI) 2018, UNDP (accessed November 2019)

Fig. 3-9. Human development index (HDI) and indicators, 1990-2017. (Average 189 countries)

Source: 189 countries, Human Development Index (HDI) 2018, UNDP (accessed November 2019)

Empirical results

Table 3-18. Panel analysis with pooled estimation of World's HDI and education, 1990-2017

Dependent variable:	**Human Development Index (HDI)**							
	(OECD)		***(Non-OECD)***		***(ASEAN)***		***(Thailand)***	
Countries:	35		151		10		1	
Pool Observations:	943		3568		270		27	
Constant	0.15 (0.04)	***	0.18 (0.02)	***	-0.009 (0.11)		0.48 (0.05)	
GNI_CAP	1.18 e-06 (7.59 e-08)	***	1.23 e-06 (5.68 e-08)	***	8.81 e-07 (1.43 e-07)	***	3.81 e-06 (1.22 e-06)	***
SCH	**0.009** (0.0005)	****	**0.011** (0.0005)	****	**0.010** (0.001)	****	**0.011** (0.003)	****
LIFE_EXP	0.007 (0.0006)	***	0.006 (0.0002)	***	0.009 (0.001)	***	0.002 (0.005)	
AR(1)	0.96 (0.02)	***	0.95 (0.03)	***	0.96 (0.02)	***	0.96 (0.03)	***
Adjusted R^2	0.99		0.99		0.99		0.99	
s.e.e.	0.003		0.004		0.002		0.002	
D.W.	1.60		1.71		1.96		1.55	

Source: Author's calculation
Note: Standard errors are in parentheses.
***, **, * denote significance at the 1, 5, 10 percent level respectively
(*** p<0.01, ** p<0.05, * p<0.1)

Table 3-19. Estimated function of the mean years of schooling (SCH)

Dependent variable:	**log Years of Schooling, log (SCH)**	
Observations:	4,612	
Constant	2.733 (0.068)	***
log (GNI_CAP)	**0.012** **(0.004)**	****
AR(1)	0.981 (0.00)	***
Adjusted R^2	0.99	
s.e.e.	0.02	
D.W.	1.59	

Note: Standard errors are in parentheses.
***, **, * denote significance at the 1, 5, 10 percent level respectively
(*** p<0.01, ** p<0.05, * p<0.1)

Remark: Assumed at the equilibrium, the representation equations is

LOG(SCH) = 2.7332 + 0.0123*LOG(GNI_CAP) + [AR(1)=0.9819]

Source: Author's calculation

3.3.2 Counterfactual scenario of human capital growth

Since we have tried to benchmark the epoch of economic development of Thailand with forerunner countries in East Asia such as South Korea, Hong Kong, Singapore and Taiwan. It was clearly observed that an economic development of South Korea has been driven by domestic industrial development and strong performance was fueled by export of heavy industrial goods and information communication technology (ICT) related products. South Korea has achieved remarkable success in combining rapid economic growth with significant innovation and technology development. Since Hong Kong and Singapore are scarce of land and natural resources, their backbone industry mainly are trade and services industry which significantly different with the background of economic development in Thailand. Hence, the most similar to Thai economic development seems to be Taiwan economy. After the colonization periods under the Dutch, Chinese and Japanese's rule, Taiwan economy has been rapidly developed from agricultural economy to industrialization which began in the late-1950s. Taiwan became known for its cheap manufactured exports produced by small and medium enterprises linked by flexible sub-contracting production networks with technology transfer from EU and Japanese. Growth policy during 1960s-1970s such as import substitution regime, domestic manufacturer protection and export processing zone with tariff benefits primarily effected the effective Taiwan's industrialization period. Thus, we have emphasized the epoch of Taiwan's sources of growth that productivity grew substantially in exported manufacturing industry which most similar to the economic development in Thailand during 1980-2010. Therefore, counterfactual approach in this section will be applied to find the suboptimal level of education which represented by the "mean years of schooling" which should have obtained during the high growth period given that Thailand would growth similar to the forerunner country like Taiwan economy during 1960s-1990s.

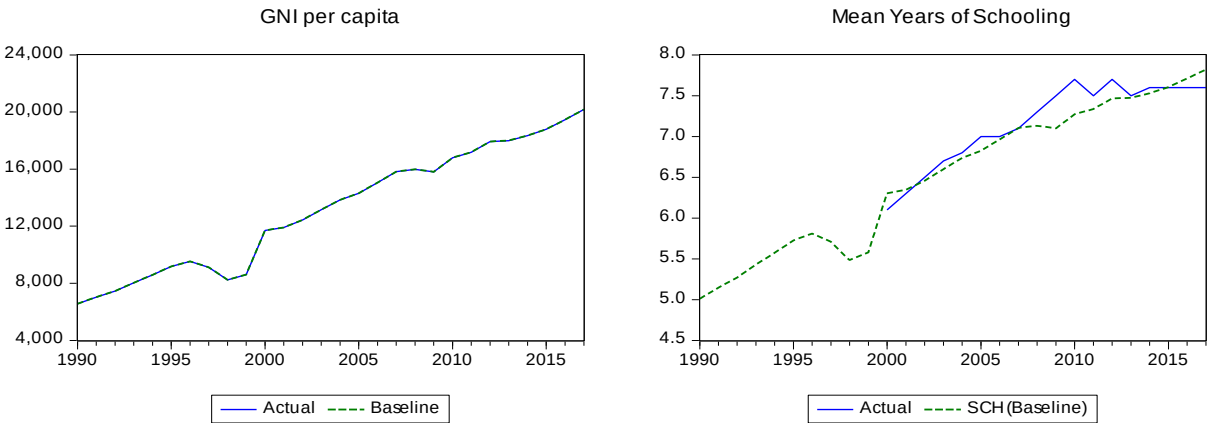
Table 3-20. Benchmarking the epoch of economic development with Asian NICs, 1990-2015

	GNI per Capita (2001 PPP USD)				
Year	***Thailand***	***Taiwan****	***Korea***	***Hong Kong***	***Singapore***
1990	6,560	8,420	11,614	26,175	33,996
1995	9,177	13,315	16,482	32,678	45,228
2000	9,003	15,105	20,601	34,330	51,367
2005	11,006	16,846	25,315	41,166	57,709
2010	12,918	19,765	30,387	49,139	71,681
2015	14,455	23,367	34,276	54,608	78,742

Remark: * Taiwan data is at constant price of 2008

Source: HDI 2018, UNDP and National Statistics of Republic of China (Taiwan) (accessed on November 2019)

Fig. 3-10. Baseline model simulation compared with actual, 1990-2015



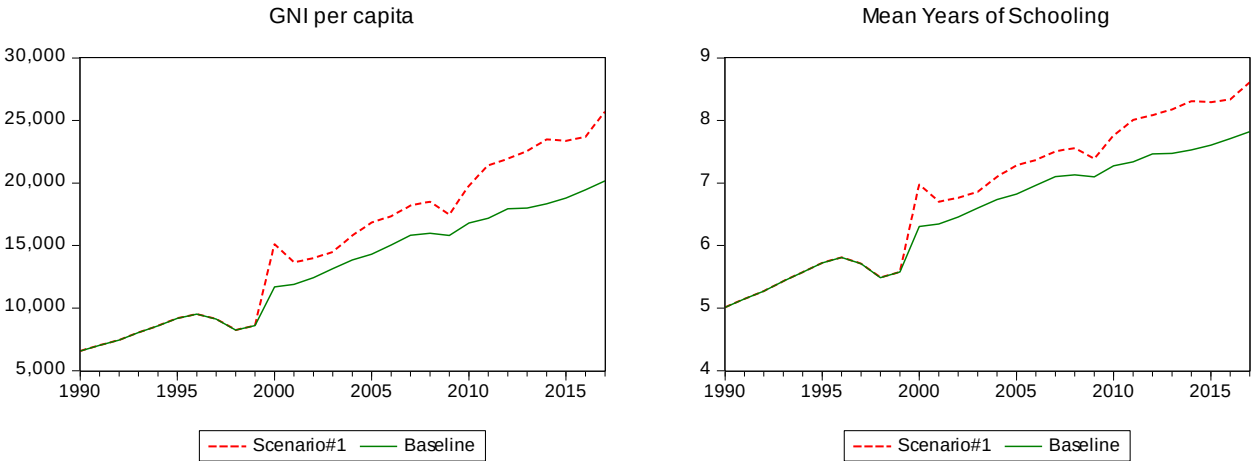
Source: Author

Table 3-21. Estimated scenarios of human capital growth, 1990-2015

Year	***Mean Years of Schooling (years)***		
	Actual	***Baseline***	***Scenario#1 ****
1990	5.0	5.0	5.0
1995	5.6	5.6	5.7
2000	6.1	6.3	6.9
2005	7.0	6.9	7.2
2010	7.7	7.2	7.7
2015	7.6	7.6	8.3

Remark: If growth scenario of Thailand during 2000-2015 equaled to Taiwan economy.
Source: Author

Fig. 3-11. Scenario#1 simulation against baseline, 2000-2015



Remark: If growth scenario of Thailand during 2000-2015 equaled to Taiwan economy.
Source: Author

Conclusion

This chapter applied the human capital augmented Solow growth models to investigate the contribution of human capital in Thailand during 1980-2015 and confirmed that human capital growth *positively and significantly* raised the income per capita and economic development in Thailand during 1980-2015. Roles of human capital on the advancement of each industries would have variance and contribution of human capital growth on key industries were *significantly divergence*. Besides, the sectoral analysis ensured that *the more education and competence labor has, the more efficiency and sectoral growth industry obtains*.

Furthermore, we benchmarked the development of Thailand with forerunner countries such as OECD and more developed countries in East Asia. We applied the panel data cross-countries analysis with pooled regression methodology to investigate the relationship between education which represents by the mean years of schooling and the epoch of economic advancement. This study confirmed in case of Thailand that, assumed at the equilibrium, growth of income per capita is *significantly positive* with the growth of mean years of schooling. Then, the counterfactual estimation on the condition that Thailand during the high growth period 2000-2015 would growth similar to the forerunner country like Taiwan, the suboptimal level of the mean years of schooling of Thailand should be 6.9 year at the year 2000 and gradually increased to 8.3 years after the year 2015. It can be implied that during the year 2000-2015, supposing that Thai economy and income per capita would growth similar to the Taiwanese economy, given the capital growth and the other endowments are being constant, the employed labor in Thailand should graduate the level of education at least at the *junior high school level*.

Chapter 4

An Equilibrium of Demand-Supply of Human Capital: A Macroeconomic and the Input-Output Approach

The main objective of this chapter aims to integrate demand-supply of human capital and economic growth by using macroeconomic and the input-output framework to estimate impacts of human capital in the manufacturing sectors of Thailand. Firstly, we review the industrial development in Thailand during 1980-2010 by using the input-output analysis. We apply the 'Inter-Industry' relationships under the Input-Output Tables' framework to estimate the demand for labor and human capital of Thailand 1980-2010. We will counterfactually analyze the equilibrium of demand and supply of human capital during the historical path of Thailand.

4.1. Manufacturing Growth and Employment in Thailand 1980-2010

Firstly, we review the industrial development in Thailand during 1980-2010 by investigating the equilibrium in product market using the Input-Output Framework. Accordingly, we will also explore the employment simultaneously determined in the labor market of Thailand. Equilibrium in the product market, is determined by the Interindustry Analysis to obtain the equilibrium output and its Forward-Backward Linkage Analysis[1]. Equilibrium in the labor market is assumed to determine employment level simultaneously. The first part is the description of industrial structure and growth during 1980-2010. We have estimated also the labor demand and employment generation from the demand side (I-O). It will be later matched with labor supply which we have analyzed in previous chapters.

The gross output growth during high growth period 1980-1995, the proportion of agricultural and mining output fell sharply, while services and industrial sectors has grown significantly. Especially after the Plaza Accords from 1985, private direct investment from abroad especially investment in the automotive and electrical industries were noticeable. The gross output proportion of all manufacturing sector expanded from 51.4 to 56.3 percent in 1990 and then stable

[1] See Miller and Blair (1985) applied Leontief Inverse Matrix, $(I - A)^{-1}$to measure the intersectoral linkages. The Backward Linkage (direct plus indirect):$B(d+i)_j = \sum_{i=1}^{n} \alpha_{ij}$ The Forward Linkage (direct plus indirect): $F(d+i)_i = \sum_{j=1}^{n} \alpha_{ij}$ If the backward linkage of sector I is larger than that of sector j, one might conclude that a dollar's worth of expansion of sector I output would be more beneficial to the economy than would an equal expansion in sector j's output, in terms of the productive activity throughout the economy that would be generated by it. Similarly, if the forward linkage of sector r is larger than that of sector s, it could be said that a dollar's worth of expansion of the output of sector r is essential to the economy than a similar expansion in the output of sector s, from the point of view of the overall productive activity that it would support.

with a slightly decreased to 55.5 percent in 1995. The output proportion of motor vehicle manufacturing and repairing industry expanded from 2.5 to 3.2 percent. Electrical machinery and apparatus manufacture greatly expanded from 0.8 to 1.4 and 0.9 percent. For rubber and plastic products, and chemical industries slightly increased from 1.4 to 2.1 percent and 1.3 to 1.6 percent respectively. Therefore, during 10 miracle years (1985-1995), Thailand's real export growth reached 27 percent in 1987/88 and 20 percent in average, and final demand growth reached 16 percent in 1989/90 and 12 percent in average, then positively resulted in overall economic expansion with real GDP growth touched 13.3 percent in 1987/88 and 10 percent in average.

After the Asian Financial Crisis in 1997, the output proportion of manufacturing production fell from 54.1 percent in 2000 to 49.0 percent in 2005, while agriculture and services inversely expanded. The production of all manufacturing was reduced, particularly in the manufacturing of electrical machinery and apparatus declined sharply from 6.2 to 2.0 percent. However, after 2005, since private investment and foreign direct investment of EU, USA, ASEAN, and Japan had returned and gradually expanded. Later, in 2010, the overall output proportion expanded to 57.2 percent, the highest level since ever. All focused manufacturing sectors grew, especially in the electronics industry output increased the most to 12.3 percent or almost a quarter of the total manufacturing production.

Table 4-1. Structure of gross output ($\bar{X}$) by industry of Thailand, 1980-2010 (ratio, % of total)

Key Industries	*1980*	*1985*	*1990*	*1995*	*2000*	*2005*	*2010*
Agricultures	**16.3**	**13.0**	**8.7**	**14.1**	**15.1**	**16.4**	**9.2**
Manufacturing - Light	**23.3**	**23.7**	**20.0**	**16.8**	**16.9**	**20.0**	**13.6**
Food Manufacturing	13.0	13.3	9.5	9.0	9.7	12.6	7.5
Rubber and Plastic Products	1.7	1.4	1.4	2.1	2.2	1.7	2.5
Others	8.6	9.0	9.1	5.7	5.0	5.7	3.6
Manufacturing - Heavy	**18.6**	**17.9**	**25.0**	**29.2**	**31.0**	**19.8**	**36.0**
Electrical Machinery and Apparatus	1.4	1.6	3.8	3.9	6.2	2.0	12.3
Motor Vehicles and Repairing	2.8	2.5	4.7	3.2	2.7	2.5	4.6
Chemical Industries	1.8	1.3	1.5	1.6	2.9	2.3	3.4
Industrial Machinery	0.6	0.8	1.4	0.9	0.8	0.9	1.6
Others	12.0	11.7	13.6	19.6	18.4	12.1	14.1
Utilities, Constructions	**8.2**	**9.8**	**11.2**	**9.6**	**6.2**	**9.1**	**7.6**
Trade and Services	**33.6**	**35.6**	**35.0**	**30.3**	**30.8**	**34.6**	**33.6**
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**

Note: Measured by gross output proportion (%), at constant price.
Source: Author's calculation

Table 4-2. Employment structure by key industries, 1975-2015

Unit: Thousand persons, and % of total

	1975	*1980*	*1985*	*1990*	*1995*	*2000*	*2005*	*2010*	*2015*
Agricultures	15,755.1 (74.6)	16,188.6 (71.0)	18,234.0 (69.1)	20,199.9 (64.8)	17,175.7 (52.2)	16,264.1 (49.8)	15,489.9 (42.6)	15,727.3 (40.7)	13,108.3 (34.4)
Manufacturing - Light	954.4 (4.25)	1,187.4 (5.2)	1,345.2 (5.1)	1,885.9 (6.0)	2,318.5 (7.1)	2,592.5 (7.9)	2,824.6 (7.8)	2,764.2 (7.2)	2,828.4 (7.4)
Manufacturing - Heavy	377.6 (1.8)	628.1 (2.8)	747.7 (2.8)	1,267.8 (4.1)	2,089.8 (6.4)	2,115.1 (6.5)	2,546.4 (7.0)	2,432.4 (6.3)	3,420.6 (9.0)
Utilities, Constructions	388.0 (1.8)	508.9 (2.2)	718.8 (2.7)	1,153.3 (3.7)	2,056.7 (6.3)	1,502.6 (4.6)	2,000.0 (5.5)	2,208.1 (5.7)	2,330.1 (6.1)
Trade and Services	3,638.4 (17.2)	4,295.6 (18.8)	5,331.1 (20.2)	6,689.1 (21.4)	9,244.8 (28.1)	10,153.2 (31.1)	13,478.2 (37.1)	15,523.0 (40.2)	16,431.6 (43.1)
Thailand	21,113.6 (100)	22,808.6 (100)	26,376.7 (100)	31,196.0 (100)	32,885.4 (100)	32,627.5 (100)	36,339.1 (100)	38,655.1 (100)	38,119.1 (100)

Remark: Number in parentheses ( ) is ratio (% of total).

Sources: Compiled from LFS, 3rd quarter, various years, NSO, Thailand.

Ketsawa (2019) has found that since 1990, Thai manufacturing had shown improvement of the backward and forward-linkages domestically. It may be a result of Thai industries' deepening policy and promotion of local contents usage were continued and expanded. Establishment of ties between local suppliers and multi-national firms were ~~an~~ important channel of technology transfer from multinational firms to local suppliers. Industrial linkages could upgrade and diversify the industrial structure by stimulating the development of upstream industries and component suppliers. We are selecting some sub-sectors to highlight the manufacturing growth in Thailand as follow:

1) Light Manufacturing

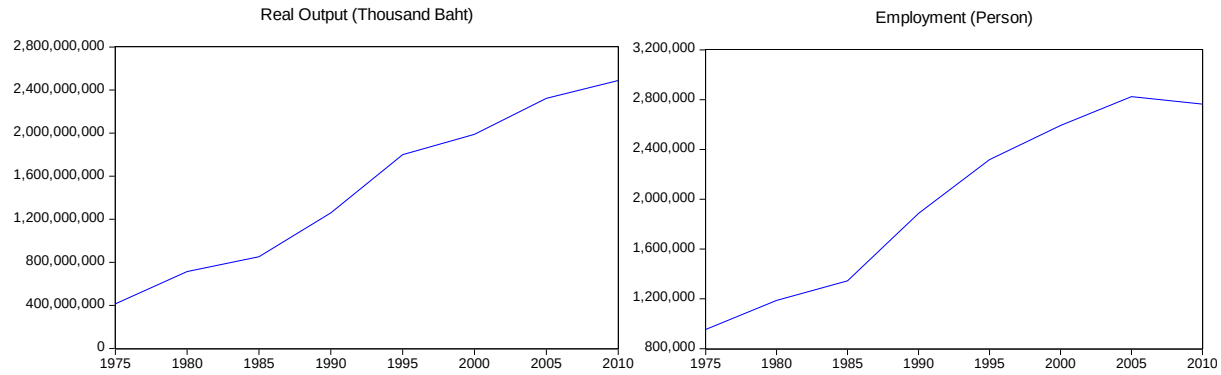
Case 1.1) Rubber and Plastic Industry

From Figure. 4-1, rubber and plastic sectors had extremely high backward linkage with highest input multipliers at 2.39, 2.41, 2.35 in 1995, 2005, 2010, respectively. Rubber industry requires huge local agricultural inputs, labor intensive, logistic and trading services. This industry is one of the most important industries of Thailand in term of employment and export volume. There are more than 200,000 workers are involved with 6 million rubber planters in Thailand. Thailand is the biggest producer of natural rubber and processing rubber with around one-third of the total world production. Ministry of Industry revealed that total annual output was 3.57 million tons in 2010/11 which 83% export in form of primary processing rubber, and the remaining 17% was used as raw material in the rubber industry, such as tires for automobile industry, rubber shoes,

rubber gloves and industrial rubber, etc. Primary processing rubber and rubber products are the highest export value of Thailand with around 21.5 billion US$ annual.

For plastic industry, it is one of the major supporting industry of Thailand which added value to the petroleum and petrochemical industries, for example, plastic beads are made from petroleum resources such as natural gas. The plastic industry will be utilized raw materials from the petrochemical industry to produces various plastic products such as car bumpers for the automobile industry, cans, pipes, plastic bottles and others. According to the survey of Ministry of Industry 2010/11, there were 3,000 plastic and related entrepreneurs, and 80 percent (2,350) were manufacturers of plastic products with the combined annual production capacity of 3.2 million metric tons and employed 300,000 workers. Mostly they were small and medium sized factory located in Bangkok and vicinities. Therefore, rubber and plastic industry plays important roles as upstream industry produced intermediate inputs for many leading industries especially automobile industry.

Fig. 4-1. Real output and employment, light manufacturing, 1975-2010



Source: Author

2) Heavy Manufacturing

Case 2.1) Electrical Machinery and Apparatus Industry

Globalization rapidly changes consumer behaviors and needs, the electronics and electrical industries have to develop based on other major consumer products, such as telecommunications equipment especially smartphones, smart electrical appliances products, electronics in the automotive industry, and personal computers and tablet. Major players in determining the direction of technology development are the United States, Europe, Japan and South Korea. Thailand has outstanding potential in the field of hard disk drive, semiconductor, and electrical appliances, especially air conditioning and compressor, washing machine, and refrigerator. The electrical industry is a medium level-technology industry, while the electronics

industry is a high technology-based industry, therefore, most of the manufacturer needs joint venture with foreign entrepreneurs especially Japanese makers.

Since the 1990s, due to rising wages in industrialized countries and Japan, foreign companies relocated production base to Thailand. At that time, major electronic component companies are Thai CRT, producing television tube, a joint venture between the Siam Cement Group of Thailand and Mitsubishi from Japan. Tube production was using local parts about 80 percent of all parts. Accordingly, Thailand has been playing a significant role in this industry as a production-based country, which strength is the capability to produce small and high precision products.

As the result, there is exposed by this study that electrical machinery and electronic industry had significantly improved in both of backward and forward linkages. This industry requires main input from its own industry and trading procedures. Input multipliers of electrical and electronic industry improved sharply from 1.77 in 1995 to 2.49 in 2010, which was highest in this group, and output multipliers also remarkably increased from 1.33 in 1995 to 2.06 in 2010. After the year 2000, this industry became one of the most leading performance industries of Thailand, both in terms of production output, exports, and employment, which has been the highest income generated industry for many consecutive years. Significantly, export value accounts for over 30% of the total export value of Thailand and employed over 500,000 workers each year. As the industry has been developing for a long time, Thailand is currently the No. 1 production base of home appliances in ASEAN. (Thailand Electrical and Electronics Institute, 2012)

Case 2.2) Motor Vehicles and Repairing Industry

Recently, Thailand is the important location of the automobile assembly plants of almost all top manufacturers in the world. There are 12 automobile manufacturers, 6 motorcycle manufacturers, and more than 2,300 vehicle parts manufacturers. Within Tier 1 (from total 3 tiers) category-manufacturers, leading automotive parts manufacturers are from Japan, EU, and USA. (Japanese manufacturers such as Denso, Aisin Seiki, Toyota Boshoku, Yazaki, Sumitomo, Hitachi, Calsonic Kansei, JTEKT and so on, and European and USA manufacturers such as Robert Bosch, Continental, Johnson Control, Delphi, ZF, TRW, Valeo, BASF, Autoliv, Michelin, 3M, etc.) In 2012, Thailand's automotive industry has a capacity of 2,675,000 vehicles per year, which highest since ever. It is divided into 1,355,000 passenger cars, 1,280,000 pickup trucks, and 40,000 other commercial vehicles per year. Total employment accounted for about 525,000 industrial workers per annual (Thailand Automotive Institute, 2012). Automotive industry which consists of first-tier, second-tier, and third-tier manufacturer requires massive raw materials from upstream

industries such as steel, petrochemical, plastic, tire and rubber, electrical and electronics, and also from supporting industries such as mold and dies, compounds. As the result, since 1990, backward linkage of automobile industry increased from 1.75 to 2.26 in 2010, afterward automobile industry became one of the key industries in Thailand. However, forward linkage had not increased much since exports ratio were high.

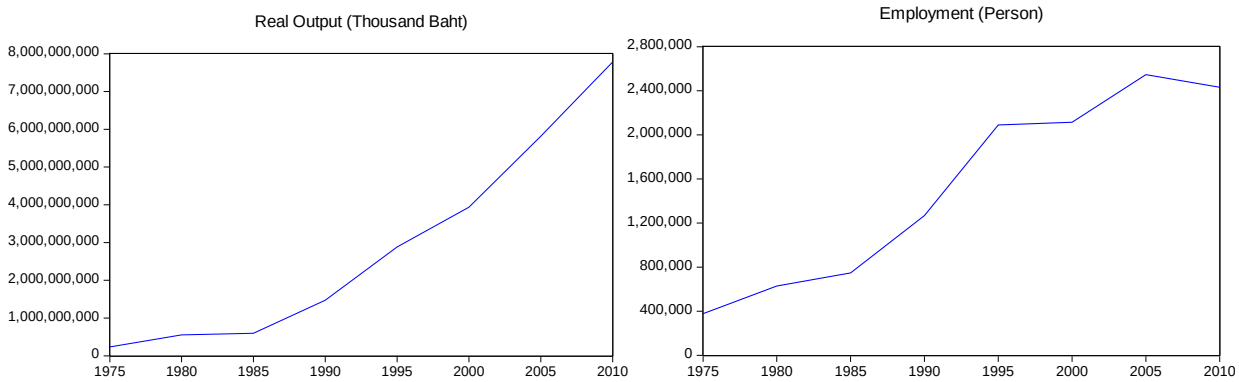
Case 2.3) Chemical Industry

For chemical industry shown moderate backward linkage but significantly high forward linkage. Output multiplier improved from 1.36 in 1985 to 2.25 in 2010 which was highest within this group. Since the chemical industry is a large upstream industry for most of the industries. This industry consists of 3 major layers; (1) upstream chemical industry such as inorganic and organic chemicals; acid, salt, alkali, ethyl-alcohol, (2) intermediate chemical industry as based chemical for other industries; vinyl-chloride, benzene, (3) downstream chemical industry such as fertilizer and pesticides, paints and lacquers, medicines, washing and cleaning products, and cosmetics industry. The chemical industry is mainly import substitution industry which 75% are downstream chemical entrepreneurs and 25 percent are upstream and intermediate manufacturers. The upstream chemical industry structure uses relatively high raw materials and energy about 45 percent and 50 percent, but very low labor inputs only 5 percent. Furthermore, downstream chemical industry uses high raw materials about 70-90 percent which mostly imports upstream chemicals from abroad.

Case 2.4) Machinery Industry

The machinery industry is engaged in the assembly and manufacture of machinery and components as core activities and supporting activities for upstream industry and service industry. Machinery industry consists of industrial machinery, machine tools, and agricultural machinery and livestock machine. Most mechanical manufacturers will work as designers and machine assembly that required tools, equipment, and computer programs that are costly and capital intensive which the limited number of enterprises can provide both of hardware and software. Small or medium sized enterprises cannot purchase and upgrade equipment, tools and computer programs to raise capacity to meet optimum level. Moreover, this industry is risky business, even though large manufacturer, if the volume of sales drops, the cost per unit of machinery production of the manufacturer will higher that cause lower competitiveness. As the result, machinery industry was observed moderate backward and forward linkages.

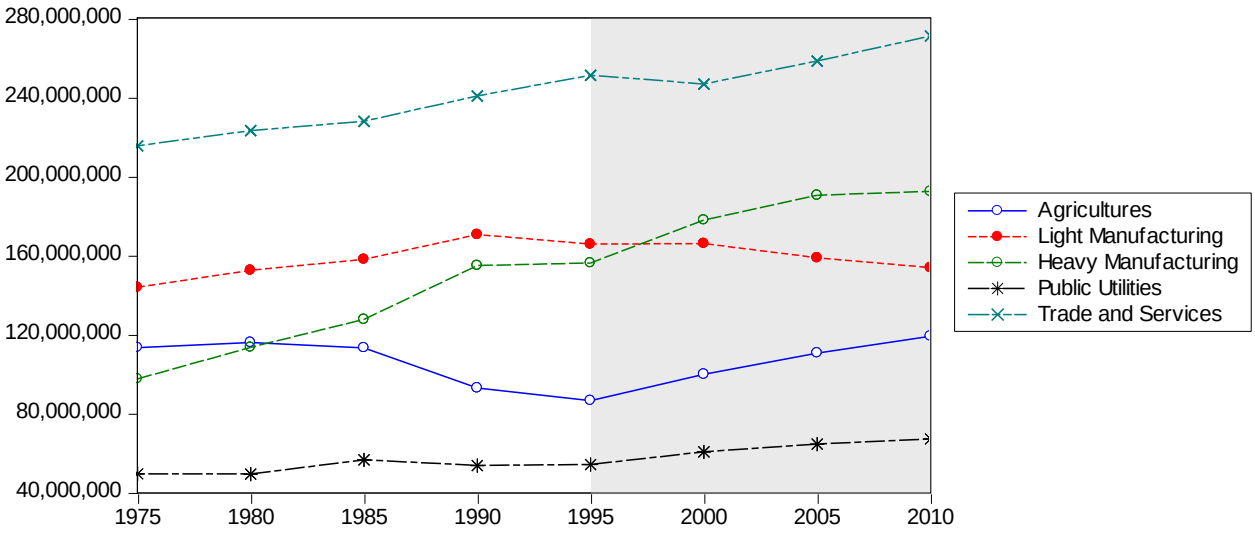
Fig. 4-2. Real output and employment, heavy manufacturing, 1975-2010



Source: Author

It can be concluded that after the Asian Financial Crisis in 1997, even though the gross output was diminishing, Thai manufacturing had progressively improved in both of backward & forward linkages within domestic upstream - downstream supply chains which significantly advanced in the electrical and electronics industry. The automotive industry had high improvement in backward linkages with domestic suppliers, however, moderate in forward linkages since export proportion was high. The chemical industry had been developed in forward linkages with downstream industries. In addition, it was observed that these industries became higher dependence on inter-industry supply and demand domestically. Furthermore, it can be also implied that these industries' deepening policy and usage of local contents were continued and expanded. Establishment of ties between local suppliers and multinational firms were an important channel of technology transfer from multinational firms to local suppliers. Industrial linkages could upgrade and diversify the industrial structure by stimulating the development of upstream industries and component suppliers. If there was without the desirable performance of Japanese, manufacturing and overall Thai economy would not have promptly recovered from the severe crisis and sustained economic growth.

Fig. 4-3. Gross output of key industries ($\bar{X}$), 1975-2010 (at current price, Thousand Baht)

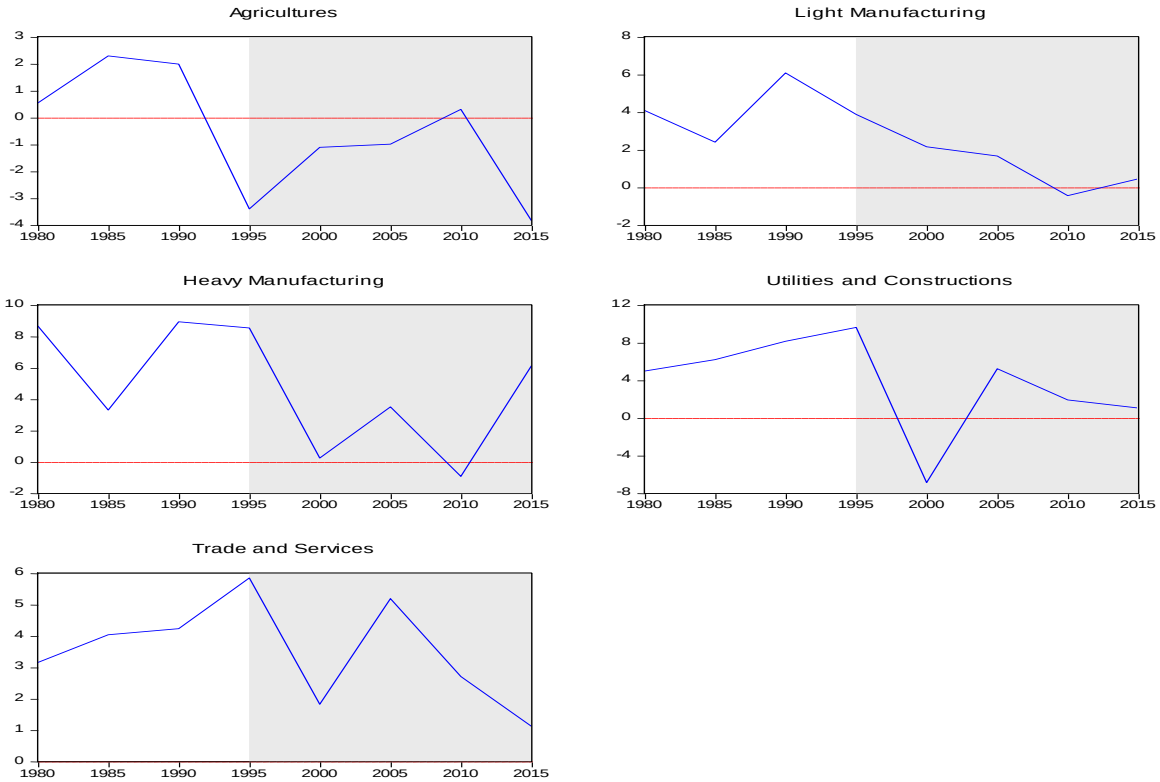


Remark: $\bar{X}$ denotes gross output level required to meet the final demands, $\bar{X} = [I\text{-}A]^{-1} * FDi$

FDI is final demand and $[I\text{-}A]^{-1}$ represents the Leontief Inverse Matrix.

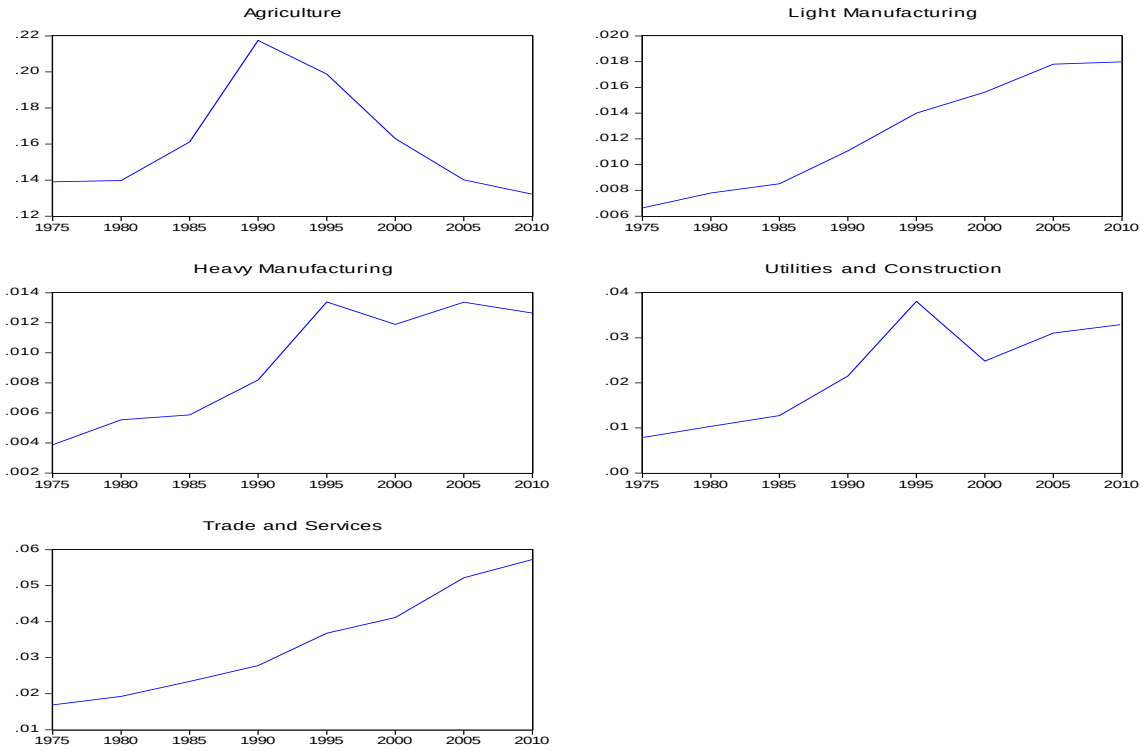
Source: Author.

Fig. 4-4. Growth of employment in key industries, 1975-2015 (%)



Sources: Compiled from LFS, 3rd quarter, various years, NSO, Thailand.

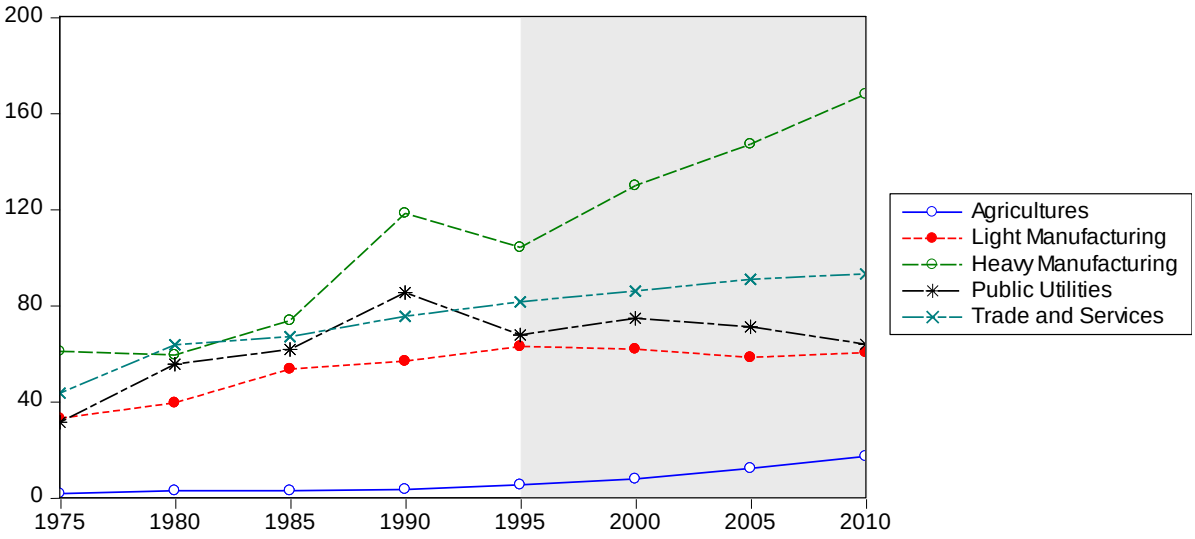
Fig. 4-5. Employment-Output ratio (delta, δ), 1975-2010



Remark: Employment-Output ratio (δ) is captured from employment (L^d) /over gross output ($\hat{X}$) ratio. Employment-Output ratio or Elasticity of Employment with respect to output, for instance, how much employment growth is associated with 1 percent point of sectoral growth.

Source: Author.

Fig. 4-6. Average real wage, 1975-2010 (Thousand Baht / Person / Year)



Source: Author.

Table 4-3. Employment of high human capital in key industries, 1975-2015,

Unit: Thousand persons, and % of total

Key Industries	*1975*	*1980*	*1985*	*1990*	*1995*	*2000*	*2005*	*2010*	*2015*
1) Agricultures	5.2	3.0	15.7	64.9	57.4	105.6	161.3	214.3	256.9
	(1.0)	(0.4)	(1.4)	(3.7)	(2.1)	(3.2)	(3.5)	(3.9)	(3.7)
2) Manufacturing - Light	16.4	27.6	49.9	105.8	194.0	251.9	257.8	271.8	333.6
	(3.4)	(3.9)	(4.5)	(6.1)	(7.1)	(7.7)	(5.6)	(5.5)	(4.8)
3) Manufacturing - Heavy	15.2	30.5	60.8	177.9	287.2	438.1	420.5	406.8	704.9
	(3.1)	(4.3)	(5.5)	(10.2)	(10.6)	(13.3)	(9.1)	(7.5)	(10.2)
4) Utilities, Constructions	17.3	25.1	53.0	104.0	216.2	123.7	181.5	194.5	324.7
	(3.6)	(3.5)	(4.8)	(6.0)	(7.9)	(3.8)	(3.9)	(3.6)	(4.7)
5) Services	431.0	630.1	925.4	1,286.3	1,966.4	2,363.0	3,582.4	4,347.9	5,298.4
	(88.9)	(88.0)	(83.8)	(74.0)	(72.3)	(72.0)	(77.8)	(80.0)	(76.6)
Thailand	485.0	716.2	1,104.8	1,738.9	2,721.1	3,282.3	4,603.4	5,435.3	6,918.5
	(100)	(100)	(100)	(100)	(100)	(100)	(100)	(100)	(100)

Remarks: 1) Skilled-unskilled labor are disaggregated employed labor in each education by occupations
(See appendix - labor matching criteria by education and occupations)
2) Human capital (high level) is proxied by summation of the number of employed labors by
Skilled High Edu + Skilled Moderate Edu + Unskilled High Edu.
3) Number in parentheses ( ) are ratio (% of total)

Sources: Compiled from ISCED and LFS, 3rd quarter, various years, NSO, Thailand.

Table 4-4. Average real wages, 1975-2010 (at constant price 2000)

Unit: Thousand Baht / person / year

Real Wages (Wr)	**1975**	**1980**	**1985**	**1990**	**1995**	**2000**	**2005**	**2010**
1) Agricultures	1.48	2.66	2.68	3.19	5.13	7.63	12.00	16.95
2) Manufacturing – Light	32.78	39.28	53.36	56.65	62.71	61.62	58.17	60.16
3) Manufacturing – Heavy	60.70	59.15	73.53	118.20	103.93	129.74	146.93	167.81
4) Utilities, Constructions	31.15	55.35	61.48	85.19	67.48	74.45	70.89	63.64
5) Services	43.38	63.49	66.82	75.24	81.30	85.76	90.69	92.91

Note: Real average wage (wr) is nominal wage (w) deflated by the consumption expenditure deflator (p_pce)

Source: Compiled from Input-Output Tables of Thailand, NESDB.

4.2 Transition of Thai Manufacturing Industry

At the beginning of Thailand's industrial development, during the 1st – 3rd of the National Economic and Social Development Plan (1961-1971), Thai government promoted labor-intensive and light manufacturing such as processed agriculture products, food, textile and wooden furniture industry. Value-added share had been shifted from agricultures to manufacturing industry. The share of manufacture value-added had increased. During 1970s – 1980s, domestic production was dominated by the light manufacturing but shown the declining growth trend. (see Table 4-5) Huge investment projects both from domestic and foreign investors took place in the manufacturing sectors as production for import substitution to serve and boost domestic demand. At that time, the rising of domestic demand of manufacturing products supported growth of Thai economy.

After serious trade deficit circumstances during 1980s, from the 4th NESDP, the government shifted its economic development strategy toward an outward-looking and export-oriented policy. By this point in time, Thailand already possessed reliable basic infrastructure, and together with tax incentives and other subsidies, while government aimed to attract further foreign investment, as well as fostering domestic investment. After 1985, there was big waves of the relocation of foreign heavy manufacturing to Thailand such as automotive parts and assembling, electronics and electrical appliances, machinery, chemical, and petroleum refinery. Domestic production and import substitution of heavy manufacturing were the main sources of industrial growth.

As the results from export promotion strategy during the 5th – 7th NESDP (1982-1996), industrial goods' production had expanded at highest rate more than 10 percent on average over the past four decades. The income from export of manufacturing sector became the main national revenue instead of the agricultural-based sector. Especially during 1990s and the 7th NESDP, advance and complicated products were produced, such as in the food processing and automotive assembling. There were various types of complicated food processing products, for example, canned food, sweetened and condensed milk, instant noodles. In the automotive and electronic industry, Thai manufacturer especially who linked with the global value chain was able to produce higher technology and various type of products such as automobile parts, electrical parts, semiconductor, and transportation equipment. However, after the AFC in 1997, both of light and heavy manufacturing had been affected seriously, Manufacturing growth was sensitive to the financial crisis. Agricultures and services sectors have absorbed unemployment from the industrial in urban area. Since 2000, Thai economy was replaced by the contribution from the trade and services sectors when measured in term of value-added.

Table 4-5. Contribution of domestic production, imports and value added, 1975-2010

(at current price)

Key industries	*1975*			*1980*		
	Contributions (in %) of total sector			Contributions (in %) of total sector		
	Domestic production	Imports	Sectoral value added	Domestic production	Imports	Sectoral value added
1) Agricultures	8.58	19.21	25.68	7.84	20.11	22.27
2) Manufacturing - Light	36.02	9.89	13.25	31.73	9.06	13.19
3) Manufacturing - Heavy	23.52	66.72	9.45	28.34	62.69	12.25
4) Utilities and Constructions	11.31	0.01	5.35	11.68	0.01	5.51
5) Services	20.57	4.17	46.27	20.41	8.14	46.78
	1985			*1990*		
1) Agricultures	8.30	15.24	16.33	5.24	7.25	11.79
2) Manufacturing - Light	30.36	9.63	15.72	25.11	9.97	12.36
3) Manufacturing - Heavy	24.42	66.92	12.07	33.07	78.42	16.94
4) Utilities and Constructions	12.28	0.25	7.34	13.79	0.10	9.81
5) Services	24.64	7.96	48.55	22.79	4.25	49.10
	1995			*2000*		
1) Agricultures	4.46	5.85	9.98	4.52	11.14	9.81
2) Manufacturing - Light	22.00	9.12	11.47	21.23	9.89	11.79
3) Manufacturing - Heavy	38.02	78.39	18.36	44.56	72.45	20.14
4) Utilities and Constructions	13.24	0.04	10.32	7.66	0.37	6.55
5) Services	22.28	6.60	49.86	22.03	6.15	51.71
	2005			*2010*		
1) Agricultures	4.96	16.29	11.34	5.18	16.50	12.74
2) Manufacturing - Light	16.44	7.64	9.87	14.76	7.89	8.88
3) Manufacturing - Heavy	48.22	69.46	21.05	49.47	67.78	20.77
4) Utilities and Constructions	8.91	0.01	6.16	8.93	0.15	5.55
5) Services	21.47	6.60	51.59	21.67	7.68	52.06

Notes: The share are calculated with respect to the total of all included sectors

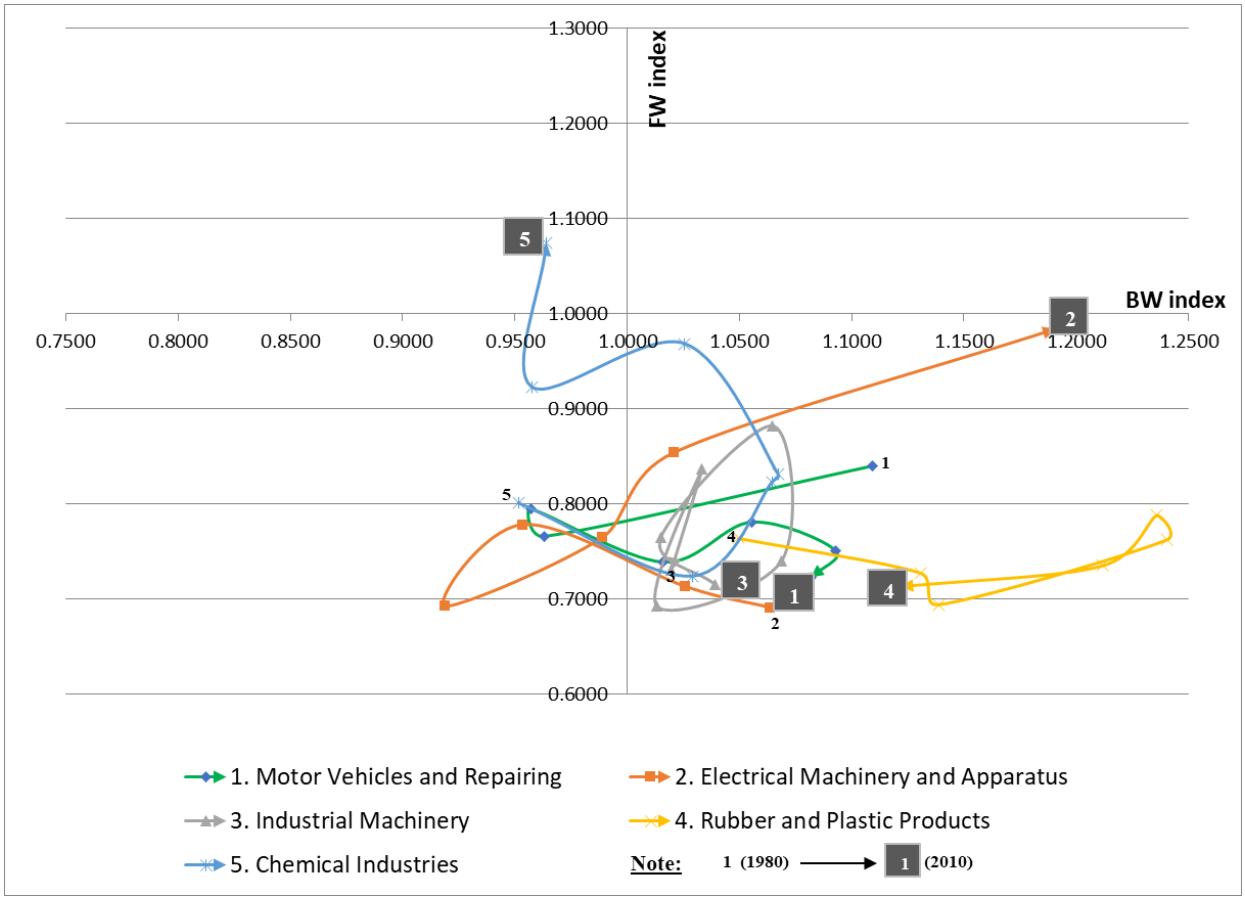
Source: Input-Output Table of Thailand, 1975-2010, NESDB, Thailand

In addition (see Table 4-6 and Figure 4-7), Ketsawa (2019) clearly shown that sources of industrial growth from the demand side of Thailand during 1980-1995, or before the Asian Financial Crisis in 1997 (AFC), were mainly determined by the *'domestic demand expansion'* rather than export expansion and import substitution. The electronic and electrical machinery, transport equipment, rubber and plastic, and textile mainly contributed manufacturing growth in Thailand. The growth of gross output of these capital deepening industries was 17.4, 13, 9.4 and 8.6 percent, respectively. These industries had shown significant backward linkage benefited from the rising of their comparative advantage. The *'export expansion'* became the main sources of industrial growth which contributed almost 60 percent of the aggregate gross output of Thai

economy. The sources of growth and causes of structural change have significantly shown a declining competitiveness in labor intensive sectors but strong in the new technological oriented sectors. The output growth of almost industries was deteriorated. The aggregate gross output growth of all industries was declined from 8.2 to 4.7 percent after the AFC crisis.

During the structural change period of Thai economy, the overall employment growth in Thai industry has been increasing to 3 percent in 1990 but has diminished to under 0 percent after the AFC in the year 2000. On the other hand, employment in agriculture has been rising after the AFC since agriculture sector has absorbed the reversing unemployed labor from industry sector in urban to rural area. Limskul (2020) mentioned that services and heavy manufacturing sector have also been a shock absorber of the Thai economy after the crisis. The light manufacturing is suffering from the competitiveness and could not absorb employment which showing a declining trend since 1990.

Fig. 4-7. Transition of key manufacturing in Thailand, 1980-2010 (at current price)



Remark: Indices are calculated at the current price.
Source: Ketsawa (2019)

Table 4-6. Sources of growth and deviations from proportional growth, 1980-2010 (%, at current price) (Ketsawa, 2019)

1980-1995

	Sectors	Aggregate gross output growth/1	Sources of growth (%) (1) Domestic demand expansion	(2) Export expansion	(3) Import substitution	Change in input-output coefficients (4)
S1	Agriculture, Forestry, Fishery	*2.3%*	73.4	45.6	-19.4	0.4
S2	Mining and Quarrying	*5.6%*	77.8	29.6	-18.8	11.4
S3	Food Manufacturing	*5.0%*	77.1	42.2	-21.4	2.2
S4	Textile Industries	***8.6%***	77.6	46.8	-26.8	2.4
S5	Paper Industries and Printing	*5.4%*	80.4	35.7	-20.6	4.6
S6	Chemical Industries	*7.9%*	75.7	44.7	-26.9	6.5
S7	Petroleum Refineries	*3.9%*	77.2	29.9	-19.2	12.1
S8	Rubber and Plastic Products	***9.4%***	66.7	50.6	-19.6	2.3
S9	Non-Metallic Products	*11.4%*	91.1	24.3	-16.8	1.3
S10	Basic Metal	*3.4%*	78.0	34.9	-15.4	2.5
S11	Fabricated Metal Products	*11.5%*	78.6	40.4	-25.4	6.3
S12	Industrial Machinery	*11.8%*	73.7	31.4	-14.7	9.6
S13	Electrical Machinery and Apparatus	***17.4%***	60.8	99.6	-46.8	-13.7
S14	Motor Vehicles and Repairing	*11.0%*	75.9	24.5	-7.9	7.5
S15	Other Transportation Equipment	***13.0%***	**141.5**	**128.2**	-137.2	-32.5
S16	Other Manufacturing	***14.3%***	78.6	46.4	-25.8	0.8
S17	Electricity and Water Works	*12.0%*	82.7	31.4	-17.8	3.7
S18	Construction	*10.3%*	95.1	8.2	-5.1	1.8
S19	Trade	*7.3%*	82.0	29.9	-15.3	3.4
S20	Services (Restaurants and Hotels)	*7.8%*	80.9	30.7	-17.0	5.4
S21	Transportation and Communication	*8.0%*	82.5	28.8	-17.7	6.5
S22	Services (Bank, Insur, Real, others)	*9.7%*	90.3	26.8	-17.1	0.0
S23	Unclassified	*14.8%*	75.3	38.9	-21.6	7.5
	Thai Industry	***8.2%***	***78.9***	***34.4***	***-19.4***	**6.1**

1995-2010

	Sectors	Aggregate gross output growth/1	Sources of growth (%) (1) Domestic demand expansion	(2) Export expansion	(3) Import substitution	Change in input-output coefficients (4)
S1	Agriculture, Forestry, Fishery	*5.1%*	65.9	48.7	-6.5	-8.1
S2	Mining and Quarrying	***8.9%***	16.6	56.8	-10.9	37.5
S3	Food Manufacturing	*4.6%*	63.9	47.8	-3.2	-8.5
S4	Textile Industries	*-1.6%*	129.2	291.6	-172.5	-148.4
S5	Paper Industries and Printing	*3.1%*	69.0	65.7	-12.5	-22.2
S6	Chemical Industries	***9.3%***	36.9	66.5	-12.4	9.0
S7	Petroleum Refineries	***10.7%***	41.2	47.7	-8.7	19.7
S8	Rubber and Plastic Products	*6.6%*	38.8	60.4	-6.1	7.0
S9	Non-Metallic Products	*2.7%*	29.7	98.2	-25.8	-2.2
S10	Basic Metal	*4.1%*	-43.7	108.5	-27.7	63.0
S11	Fabricated Metal Products	*6.2%*	37.6	70.0	-14.3	6.7
S12	Industrial Machinery	*6.9%*	37.5	81.9	-21.9	2.5
S13	Electrical Machinery and Apparatus	***9.3%***	33.8	65.3	6.6	-5.6
S14	Motor Vehicles and Repairing	*5.2%*	56.9	72.4	-24.1	-5.3
S15	Other Transportation Equipment	*5.2%*	66.8	50.4	7.5	-24.7
S16	Other Manufacturing	*2.3%*	50.4	72.7	-17.1	-6.0
S17	Electricity and Water Works	***8.9%***	40.3	38.5	-7.9	29.1
S18	Construction	*-2.4%*	122.8	-50.7	9.9	18.0
S19	Trade	*4.4%*	46.7	48.5	-10.3	15.2
S20	Services (Restaurants and Hotels)	*4.8%*	42.8	49.6	-9.9	17.5
S21	Transportation and Communication	*2.2%*	56.7	53.0	-13.2	3.6
S22	Services (Bank, Insur, Real, others)	*4.7%*	68.4	53.5	-10.3	-11.5
S23	Unclassified	*6.4%*	54.7	37.7	-4.1	11.7
	Thai Industry	***4.7%***	***44.2***	***59.6***	***-11.3***	**7.5**

	Sectors	Output deviations (%)	Sources (% change in aggregate gross output) Domestic demand expansion	Export expansion	Import substitution	Change in input-output coefficients
S4	Textile Industries	*2.0%*	1.6	2.3	-2.0	0.1
S6	Chemical Industries	*0.1%*	0.1	0.1	-0.1	0.0
S8	Rubber and Plastic Products	*3.6%*	2.4	4.9	-3.5	-0.1
S13	Electrical Machinery and Apparatus	*15.8%*	8.1	26.5	-14.2	-4.6
S15	Transportation Equipment	*10.0%*	26.6	59.9	-61.2	-15.3

	Sectors	Output deviations (%)	Sources (% change in aggregate gross output) Domestic demand expansion	Export expansion	Import substitution	Change in input-output coefficients
S4	Textile Industries	*-10.2%*	-5.5	-0.3	-2.3	-2.0
S6	Chemical Industries	*8.1%*	-0.1	8.8	-2.3	1.7
S8	Rubber and Plastic Products	*4.9%*	0.6	4.1	-0.6	0.7
S13	Electrical Machinery and Apparatus	*8.1%*	2.0	5.9	0.9	-0.8
S15	Other Transportation Equipment	*3.0%*	3.4	1.8	0.9	-3.1

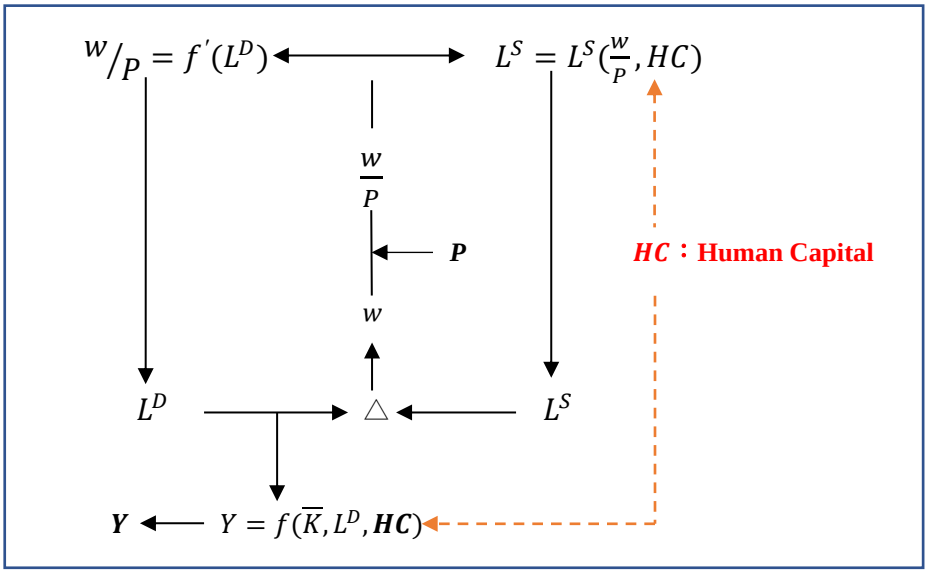
Notes: 1) Sources of sectoral growth contributions are expressed as percentages of the percent change in aggregate gross output (%)
2) For each sub-component column, a sum of (1) domestic demand, (2) export expansion, (3) import expansion and (4) change in coefficients are equal to 100.

4.3. Conceptual Framework and Model

4.3.1) Conceptual Framework

Industries maximize profit by choosing the optimal combination of labor and capital to produce a given number of output (as the Production Function) Relying only on capital or solely on labor is more costly and inefficient than utilizing some combination of the two factors. Firms or industries can growth due to the accumulation of capital and labor in term of quantity and quality. In the long run, labor supply is determined by the population size and growth and the labor force participation rate in each economy, but in the short run it depends on variables such as worker preferences, the skills and training a job requires, and wages available in the alternative occupations. Human capital and skills can be both accumulated since they were student before participate into the labor market and during their working period in the labor market through the training to obtain new or more advance skills, maintain their good health and learning by doing.

Fig. 4-8. Neoclassical model of labor market (Human Capital augmented)



Source: Nagashima M. and Author.

Theoretically, the labor market differs from the products and services market because labor demand is not desired for its own but rather because it aids in producing output. Firms and industries are seeking to produce the optimum level of output and the lowest possible cost; therefore, industries determine their demand for labor through the profit maximization. Firms can increase profit by hiring more labor if the marginal revenue product of labor (MRP_L) is greater than the marginal cost of that additional unit of labor or the wage rate. Thus, firms will stop hiring as soon as the mentioned two values are equal. The labor market equilibrium occurs when the MRP_L equals the prevailing wage rate. In addition, firms with higher level of human capital would obtain higher optimum level of output and lowest labor cost.

Thus, from Figure 4-8, this chapter we have an explicit labor demand by Input-Output sectors and by IO demand-supply equilibrium with fixed coefficient. At the equilibrium, we can get the labor demand (L^D*) from the gross output (X*). Gross output is determined from final demand; $\bar{X}$ = [I-A]$^{-1}$ * F, where, $\bar{X}$ is gross output levels required to meet the final demands, F is final demand and [I-A]$^{-1}$ is the Leontief Inverse Matrix. Then, we can further estimate the inverse demand function derivation for Real Wage rate ($^{Wage\ *}/_{Price}$) equals to the function of Output and L^D by Human Capital from IO solution. Hence, one common source of differences in wage rates is human capital. More skilled workers tend to obtain higher wages because their marginal product of labor tends to be higher. Then, the matching between Labor Supply with Labor Demand by sector is obtained by aggregate L* by sector (summation of L* by sector) to get Labor Demand (L^D*) overall. Assuming the $L^D* = L^S*$ overall, then we can estimate the Labor Supply (L^S) by Human Capital (HC) after the equilibrium condition met in Labor market equilibrium.

4.3.2) Labor Market Equilibrium

An equilibrium in the labor market is labor demand equal to labor supply, and in goods market is desired saving equal to desired investment. Supply is determined by the interaction between the labor market and the production function. Equilibrium in the labor market determines the equilibrium real wage ($^{Wage}/_{Price}$)* and the level of employment $L^{D*} = L^{S*}$. Given the equilibrium level of employment the production function gives full employment output Y*. Exogenous factors such as *Human Capital* that shift either the production function, labor demand or labor supply change the equilibrium level of X*. When the supply of labor increases the equilibrium price falls, and when the

demand for labor increases the equilibrium price rises. The classical assumption is that when the economy is out of general equilibrium, the aggregate price level, *P*, adjusts so that the economy can move back to general equilibrium. Notice that when *P* changes the labor demand-supply shifts. Thus, the classical assumption is that the labor demand-supply shifts in reaction to any shock that moves the economy away from the equilibrium. Equilibrium condition on the labor market is determined as following;

[Equilibrium] $L^D = L^S$

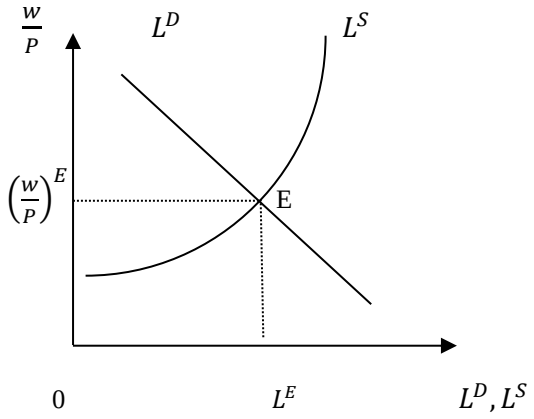
[Demand Function of Labor] $\frac{w}{P} = \frac{df}{dL^D}$

[Supply Function of Labor] $L^S = L^S\left(\frac{w}{P}, HC\right),\ \frac{\partial L^S}{\partial\left(\frac{w}{P}\right)} > 0,\ \frac{\partial L^S}{\partial HC} > 0$

[Production Function] $Y = f(L^D, K),\ \frac{\partial f}{\partial L^D} > 0,\ \frac{\partial^2 f}{\partial L^{D2}} < 0$

[Price Level] $P = \bar{P}$

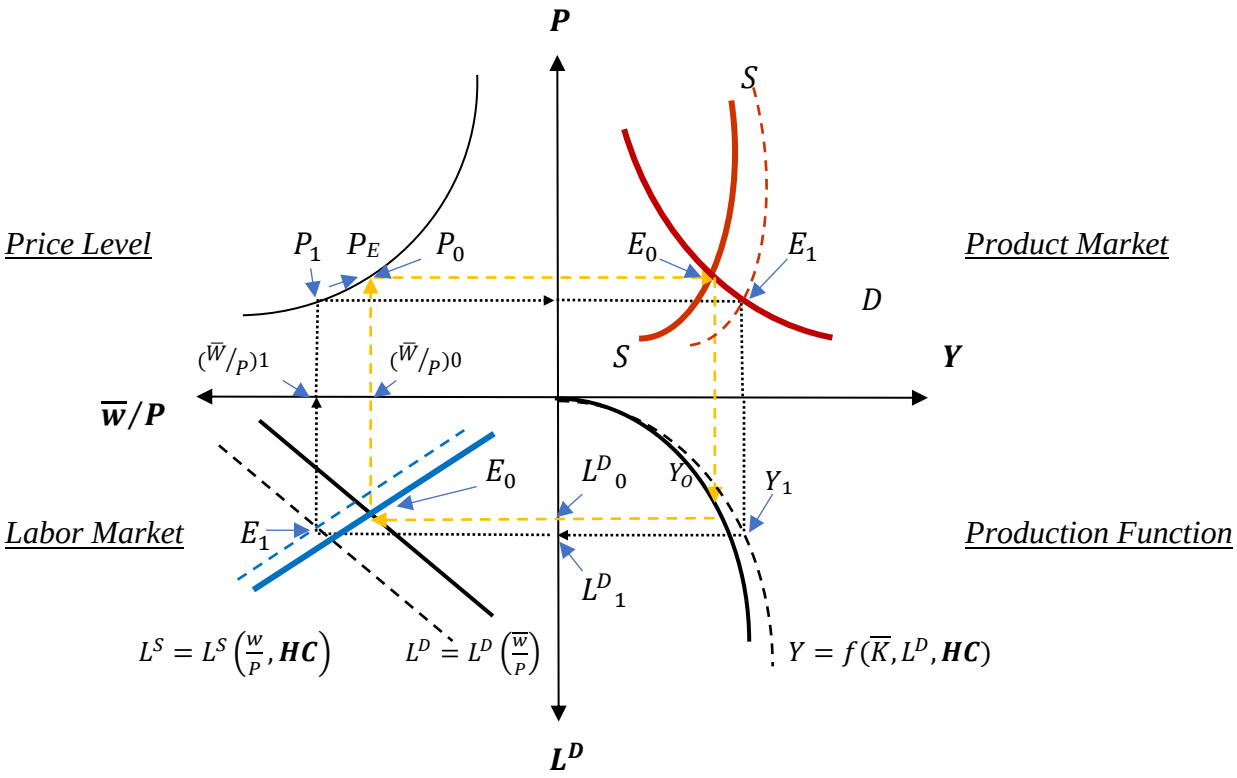
Fig. 4-9. Equilibrium in neoclassical labor market

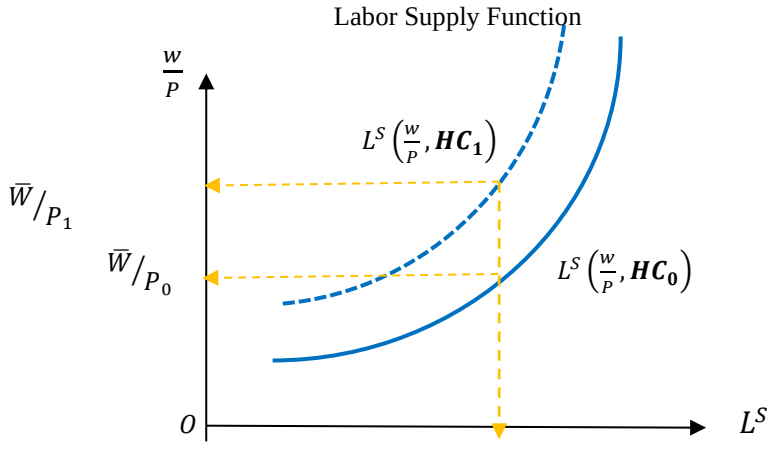


Source: Nagashima M. (2020)

4.3.3) Simultaneous Solution

Fig. 4-10. Simultaneous solution of labor and product market equilibrium (4-quadrant diagram)





Source: Nagashima M. and Author.

From Figure 4-8, 4-9, 4-10, the 4-quadrant diagram represents precisely the equilibrium in the labor market and product market. The diagram manages to explicitly explain the equilibrium value of the variables. Consider an economy using three factors, capital stock (*K*), quantity of labor input (*L*) and quality of labor input or augmented human capital (*HC*). The aggregate production function exhibits the standard properties including constant returns to scale and diminishing returns to each factor. In the neoclassical model, equilibrium level of output is determined by the employment of labor. The level of output and the level of employment is established in the labor market by the demand for and supply of labor. Assuming a profit-maximizing economy, labor will be demanded up to the point where the revenue earned from selling the total product produced by the marginal unit of labor is equal to the marginal cost of labor (*MC*) which is equal to the money wage (*W*) divided by the marginal product of labor (MP_L).

At equilibrium condition of the labor market (E_0), equilibrium real wage rate ($\bar{W}/_P$) and the equilibrium level of employment are determined at the point where the negative sloping labor demand curve (L^D) cuts the positive sloping labor supply curve (L^S), then the equilibrium level of employment ($L^D{}_0$), output (Y_0) can be determined. The equilibrium of neoclassical labor market is one where every worker willing to work at the real wage ($\bar{W}/_{P_0}$) is able to find work or this is the full employment point. The equilibrium output level (Y_0) is also called full employment output level. The full employment is occurred due to wage-price adjustment. For example, the excess supply of labor will reduce the real wage rate until labor supply is equal to the labor demand.

If we improved human capital accumulation by increasing level of education investment intensity in labor, the labor supply function (lower diagram in Figure 4-11) would be theoretically shifted up from $L^S\left(\frac{w}{P}, HC_0\right)$ to $L^S\left(\frac{w}{P}, HC_1\right)$. In the 4-quadrant diagram, the labor supply curve would be shifted up to the left-hand side which yields the higher real wage ($\bar{W}/_{P_1}$). At the same time, augmented human capital would be shifted up the production function through increasing in the total factor productivity that yields higher production level and output from Y_0 to Y_1. The aggregate supply would be increasingly responded and general price level adjustment would be decreased the price level from P_0 to P_1. Labor demand or employment will be increased from $L^D{}_0$ and newly determined at $L^D{}_1$ to meet the labor demand requirements for the higher level of production. The new equilibrium condition of the labor market and product market will be determined at E_1. *As the result, economy in the long-run would obtain higher real wage, total employment and aggregate output.*

4.3.4) Determination and Equations

1) Determination of equilibrium gross output, labor demand and employment

Gross output is determined from final demand;

$$\bar{X} = [\text{I-A}]^{-1} * \text{FDi} \quad \text{---------- (1)}$$

Where, $\bar{X}$ denotes gross output level required to meet the final demands, FDi is final demand and $[\text{I-A}]^{-1}$ represents the Leontief Inverse Matrix.

Determination of labor demand and employment

The analysis is based on the input-output demand-supply equilibrium with the fixed coefficients. At the equilibrium, a simple model of a profit-maximizing firm with a Cobb-Douglas production function where the derived demand for labor is obtained as

$$\ln L^D = c_1 - c_2 \ln (\frac{W}{P}) + c_3 \ln \overline{Yr} + \varepsilon_2 \quad \text{---------- (2)}$$

Then, we can further estimate the inverse demand function derivation for Real Wage Rate ($^{Wage}/_{Price}$) equals to the function of Output and L^D from IO solution:

$$\ln (\frac{W}{P}) = c_1 + c_2 \ln \overline{Yr} - c_3 \ln L^D + \varepsilon_3 \quad \text{---------- (3)}$$

where; L^D denotes labor demand or the level of employment, *w* is wage rate, *p* is aggregate price level, *Wr* represents real wage rate ($\frac{W}{P}$) and $\overline{Yr}$ is real output.

Determination of labor supply by human capital

In the long run, labor supply (L^S) is determined by income, wage rate (*w*), population size (*n*) and growth (*g*), depreciation rate (δ), and prices of related goods and services. In the short run, it depends on variables such as work-leisure preferences, the skills and training a job requires, and wages available in the alternative occupations. Theoretically, there are two factors that influence a worker supply of labor; substitution effect and income effect. Higher wages usually will encourage a worker to supply more labor because work is more attractive compared to leisure (substitution effect is dominated). However, when income effect outweighs the substitution effect, labor work fewer hours

because they can get their target income from a lower number of hours. Therefore, the supply curve for labor tends to be upward sloping and kinked back.

For human capital and economic growth aspects as mentioned in Chapter 3, since we limited human capital as the number of labors by education levels. Theories explicitly connected investment in human capital development to education, and the role of human capital in economic development, productivity growth, and output. In this study, labor supply can be proxied and disaggregated by education levels: L^S (*edu*). From IO solution, we can get;

$$\ln\ (\frac{ZZI_r}{L^D}) = c_1 + c_2 \ln (\frac{Kr}{L^D}) + c_3 \ln (\frac{ZJ_r}{L^D}) + \varepsilon_4 \quad \text{---------- (4)}$$

and, $$\ln L^S = c_4 + c_5 \ln HC_L + c_6 \ln HC_H + \varepsilon_5 \quad \text{---------- (5)}$$

where; ZZI_r denotes real output or real aggregate demand, at constant price of 2000, ZJ_r is real total intermediate input, at constant price of 2000, Kr is real capital stock, at constant price of 2000, HC_L represents labor supply by human capital (low level of education) and HC_H represents labor supply by human capital (high level of education).

2) Equilibrium determination in labor and product market

From (1)-(5), at equilibrium conditions $L^{S*} \equiv L^{D*} \equiv L^*$, the solution is;

[Wage Function] $Wr^* = f\ (L^{S*} \equiv L^{D*} \equiv L^*,\ ZZIr^*)$ ---------- (6)

[Aggregate D&S] $Pr^* = f\ (PCEr^*, GFCFr^*, GCEr^*, EXr^*, IMr^*, VSTKr^*, ZZIr^*)$ ----------(7)

[Production Function] $ZZIr^* = f(Kr^*, L^*\ by\ HC)$ ---------- (8)

where; *PCEr* denotes real private consumption expenditure, at constant price 2000, thousand Baht, *GFCFr* is real gross fixed capital formation, at constant price 2000, thousand Baht, *GCEr* is real government expenditure, at constant price 2000, thousand Baht, *EXr* is real export, at constant price 2000, thousand Baht, *IMr* is real imports, at constant price 2000, thousand Baht and *VSTKr* is real changes in inventories, at constant price 2000, thousand Baht.

4.3.5) Description and Notations of Variables

K	Capital stock, at market price, thousand Baht
Kr	Real capital stock, at constant price 2000, thousand Baht
L	Labor head, persons
HC_L	Low level of human capital, labor nested by educations and occupations, persons
HC_H	High level of human capital, labor nested by educations and occupations, persons
W	Average wage, at market price, thousand Baht / person / year
Wr	Real average wage, at constant price 2000, thousand Baht / person / year
ZZi	Aggregate demand, at market price, thousand Baht
ZZir	Real aggregate demand, at constant price 2000, thousand Baht
GDP	Gross domestic product, at market price, thousand Baht
GDPr	Gross domestic product, at constant price 2000, thousand Baht
PCE	Private consumption expenditure, at market price, thousand Baht
PCEr	Real private consumption expenditure, at constant price 2000, thousand Baht
GFCF	Gross fixed capital formation, at market price, thousand Baht
GFCFr	Real gross fixed capital formation, at constant price 2000, thousand Baht
GCE	Government expenditure, at market price, thousand Baht
GCEr	Real government expenditure, at constant price 2000, thousand Baht
EX	Exports, at market price, thousand Baht
EXr	Real export, at constant price 2000, thousand Baht
IM	Imports, at market price, thousand Baht
IMr	Real imports, at constant price 2000, thousand Baht
VSTK	Changes in inventories, at market price, thousand Baht
VSTKr	Real changes in inventories, at constant price 2000, thousand Baht
CPI	Consumer price index, at constant price 2000
P_pce	Price level of consumption expenditure, at constant price 2000
P_gfcf	Price level of gross fixed capital formation, at constant price 2000
P_gce	Price level of government expenditure, at constant price 2000
P_ex	Price level of export of goods and services, at constant price 2000
P_im	Price level of import of goods and services, at constant price 2000
Lend_r	Lending interest rate, % p.a.

4.4 Data and Estimation of Parameters

At this stage, we have aggregated all mentioned sectoral data into one overall Thai industry in order to appropriately analyses at the macro level. We used macroeconomic and socioeconomic data from the Input-Output Tables, National Accounts of the Office of the National Economic Social and Development Council (NESDC or NESDB in previous), the Labor Force Surveys of the National Statistical Office of Thailand (NSO), Bureau of Trade and Economic Indices, Ministry of Commerce, the Bank of Thailand (BOT) and also various international organizations such as the World Bank, during the study period 1975-2015. In order to compute the share of high level of human capital (*HC_H*), we classified the high-moderate-low education levels from the International Standard Classification of Education (ISCED) classification and skilled-unskilled occupations from the ISCO-08 of the International Standard Occupational Classification (ISOC). High level of the human capital is identified from the summation of the number of high-educated skilled labor, moderate-educated skilled labor and high-educated unskilled labor. Real wage rate is the average wage bills per person per year adjusted by the consumption price indices (*p_pce*). All real values are at constant price of the year 2000. Basic statistics are shown in Table 4-7 below.

Table 4-7. List of variables used in estimation of labor demand-supply by human capital

Variables	***Period***	***Obs.***	***Mean***	***Max.***	***Min.***	***S.D.***
K	1975-2010	8	9.55 e+09	2.53 e+10	1.23 e+09	8.96 e+09
Kr	1975-2010	8	1.02 e+10	1.96 e+10	2.94 e+09	6.07 e+09
L	1975-2015	9	3.11 e+07	3.86 e+07	2.11 e+07	6.42 e+06
HC_H	1975-2015	9	3.00 e+06	6.91 e+06	4.85 e+06	2.25 e+06
HC_L	1975-2015	9	2.81 e+06	3.32 e+07	2.06 e+07	4.42 e+06
W	1975-2010	8	3.70 e+04	9.06 e+04	4.53 e+03	3.13 e+04
Wr	1975-2010	8	3.62 e+04	6.27 e+04	1.17 e+04	1.87 e+04
ZZI	1975-2010	8	9.37 e+09	2.75 e+10	6.18 e+08	9.54 e+09
ZZIr	1975-2010	8	9.58 e+09	2.13 e+10	2.35 e+09	6.81 e+09
GDP	1975-2010	8	4.05 e+09	1.10 e+10	3.48 e+08	3.81 e+09
GDPr	1975-2010	8	4.26 e+09	8.54 e+09	1.32 e+09	2.64 e+09
PCE	1975-2010	8	2.38 e+09	5.89 e+09	2.55 e+08	2.10 e+09
PCEr	1975-2010	8	2.29 e+09	4.08 e+09	6.61 e+08	1.32 e+09
GFCF	1975-2010	8	1.15 e+09	2.59 e+09	6.61 e+07	9.69 e+08

GFCFr	1975-2010	8	1.15 e+09	2.22 e+09	2.00 e+08	7.29 e+08
GCE	1975-2010	8	5.10 e+08	1.70 e+09	3.52 e+07	5.60 e+08
GCEr	1975-2010	8	4.65 e+08	1.13 e+09	1.04 e+08	3.27 e+08
EX	1975-2010	8	2.32 e+09	7.14 e+09	5.46 e+07	2.65 e+09
EXr	1975-2010	8	2.18 e+09	5.79 e+09	1.16 e+08	2.14 e+09
IM	1975-2010	8	2.45 e+09	6.77 e+09	7.84 e+07	2.57 e+09
IMr	1975-2010	8	2.38 e+09	5.47 e+09	2.09 e+08	2.02 e+09
VSTK	1975-2010	8	1.47 e+08	5.31 e+08	1.55 e+07	2.08 e+08
VSTKr	1975-2010	8	1.28 e+08	3.67 e+08	2.47 e+07	1.42 e+08
CPI	1975-2015	9	0.8344	1.4265	0.2631	0.4025
P_pce	1975-2015	9	0.9256	1.5041	0.3862	0.4115
P_gfcf	1975-2015	9	0.9046	1.5385	0.3302	0.4608
P_gce	1975-2015	9	0.9395	1.6802	0.3398	0.4866
P_ex	1975-2015	9	0.8756	1.3259	0.4706	0.3230
P_im	1975-2015	9	0.8508	1.3337	0.3743	0.3564
LEND_R	1980-2010	7	10.95	16.10	4.30	5.22

Remark: See the description and notation above in (4.3.5)

Source: Author

4.5) Model and Counterfactual Analysis

This section constructs and solves a comprehensive macroeconomic model with the input-output framework. Firstly, the human capital differences among industries are certainly weak. Secondly, there are no utility functions for households and then consumption functions are not derived directly from a maximization of utility. Then, the equilibrium equations of demand and supply of human capital can be estimated. Its distinguished labor with two-level nested-CES functions by education levels and skills. The model covers both the supply and demand sides of the economy but assumes the final demand is exogenously given. Simultaneous calibration of the parameters is done through the seemingly unrelated regression. Model are solved through the Parsing Analytic Jacobian procedure and coefficient are estimated with the dynamic runs of the model. The within sample performance is evaluated through Dynamic-Deterministic Simulation. Accordingly, model performs quite well in tracking the historical paths of the key variables.

Model's Equations

(1) GDP (Income side)

LOG(GDPR_THA) = 1.0357 + 0.3109 * LOG ((W_THA * L_ALL) / P_THA) + 0.5358 * LOG (R_THA * KR_THA) + 0.0983 * LOG (DEP_THA / P_THA) + 0.0577 * LOG (INDTAX_THA / P_THA)

(2) Aggregate Demand-Supply

LOG(P_THA) = - 4.1033 + 0.6172 * LOG(PCER_THA) + 0.6367 * LOG(GFCFR_THA) + 0.0055 * LOG(GCER_THA) + 2.2845 * LOG(EXR_THA) - 2.5618 * LOG(IMR_THA) + 0.1907 * LOG(VSTKR_THA) - 0.8675 * LOG(ZZIR_THA)

(3) Capital

LOG(KR_THA) = - 3.0175 + 0.5156 * LOG (KR_THA(-1)) + 0.6813 * LOG(GFCFR_THA)

(4) Wage Function (Inverse Demand Function)

LOG(WR_THA) = - 19.6574 + 0.5632 * LOG(ZZIR_THA) + 0.5993 * LOG(L_ALL)

(5) Human Capital

LOG(L_ALL) = 0.0387 + 0.9984 * LOG(HC_L_THA) + 2.6890e-08 * (HC_H_THA)

(6) Private Consumption

LOG(PCER_THA) = 3.4417 - 0.0755 * LOG (LEND_R - (P_THA - P_THA(-1)) / P_THA(-1)) + 0.8254 * LOG(GDPR_THA)

(7) Gross Fixed Capital Formation

LOG(GFCFR_THA) = - 23.2052 + 1.0474 * LOG(LEND_R) + 2.1272 * LOG(GDPR_THA) - 0.2632 * LOG(GFCFR_THA(-1))

(8) Government Expenditure

GCER_THA = 1 * GCE_THA / P_GCE

(9) Export of Goods and Services

LOG(EXR_THA) = - 96.3837 + 0.0332 * LOG ((P_EX * EX_USD) / P_GDP_WORLD) + 3.7867 * LOG(GDPR_WORLD) + 0.3647 * D1995

(10) Import of Goods and Services

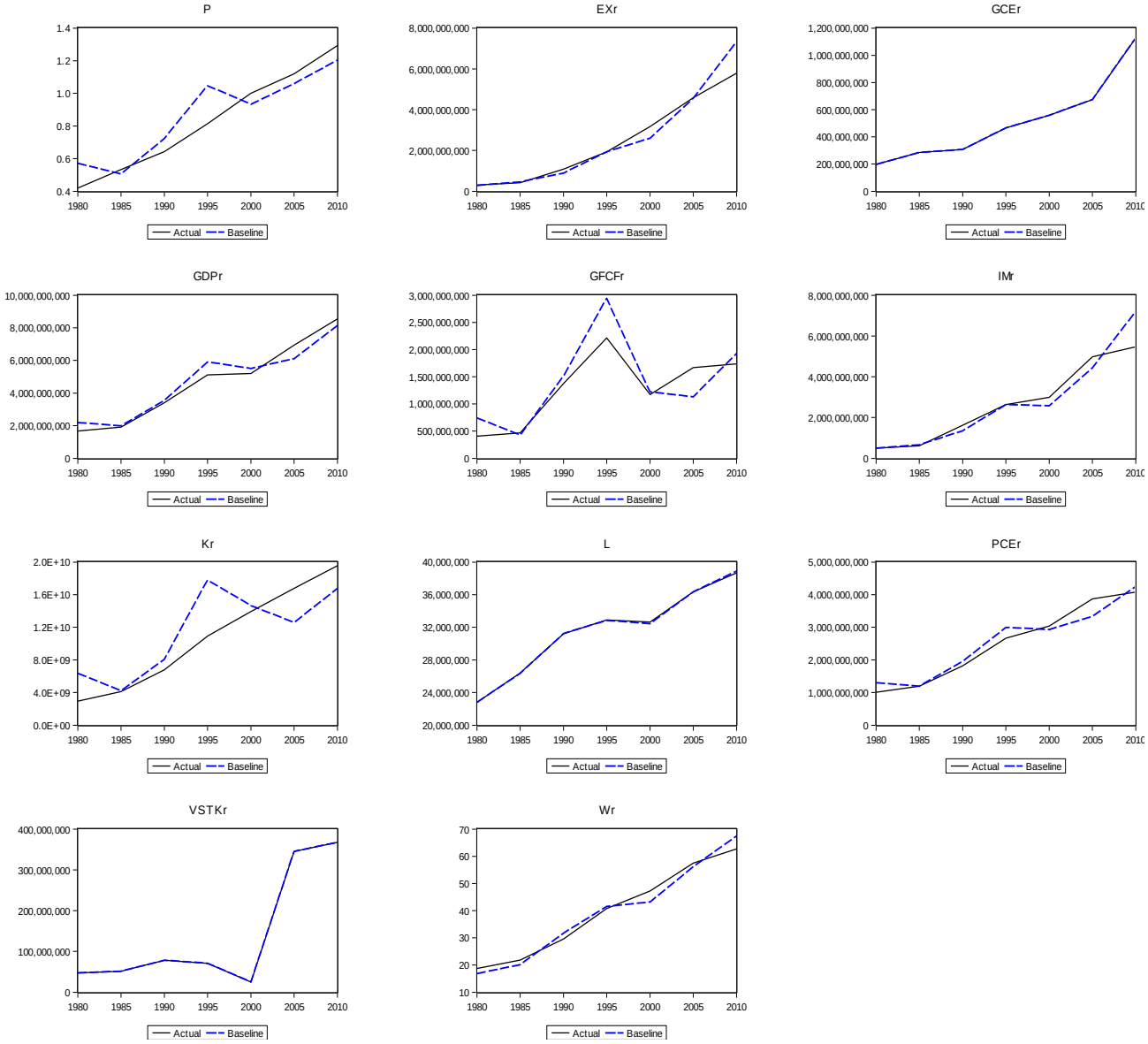
LOG(IMR_THA) = - 77.0315 - 0.6948 * LOG (P_IM / P_GDP_WORLD) + 3.1696 * LOG(GDPR_WORLD) + 0.4158 * D1995

(11) Changes in Inventories

VSTKR_THA = 1 * VSTK_THA / P_PCE

Baseline Simulation

Fig. 4-11. Baseline model simulation compared with actual, 1980-2010



Source: Author

The Counterfactual Scenario (Scenario #1)

The counterfactual scenario is to shift the composition of the workforce by upgrading 1 percent of human capital accumulation (by increasing 1 percent of low-human capital (*HC_L*) to high-human capital (*HC_H*)) in Thai economy throughout all historical path 1980-2010.

Simulation Result

As Figure 4-11 and Table 4-8, 4-9, 4-10, after establishing the baseline path for the key variables during 1980-2010, the effect of the counterfactual scenario within sample is simulated while holding population structure, labor force participation rate, and technological advances is controlled. The model presents the response from the key variables according to the disturbance of upgrading the proportion of high-educated labor into the model. The empirical investigation based on the simultaneous simulation and analysis explained the consequences of human capital growth in Thai economy. The estimates within the sample period shown that the counterfactual human capital or enhancing the low-educated labor to obtain higher education *positively affects the growth of the average real wages, total employment, real aggregate demand-supply and real GDP* of Thai economy. This implies that the upgrading of human capital leads to higher overall labor productivity and real wages growth. Given the elasticity of substitution between high-educate and low-educated workers is greater than one, an expansion in the educational attainment and supply of high-educated workers lowers relative wage rate, and subsequently increase the demand for high-educated workers, leading to the equilibrium in the labor market. The increase in the supply of higher-educated labor leads to growth of human capital accumulation simultaneously.

Further important question is how much of the growth of average real wages, total employment, aggregate demand-supply and real output that would be attributed from the optimal growth of human capital at the equilibrium point. The empirical result has shown that, since general price level has been adjusted and converted to the new equilibrium, human capital growth has shown *positive and significant* impacts on the average real wage, total employment, real aggregate demand-supply and real GDP for Thai economy during 1980-2010. To illuminate the effects of human capital accumulation patterns on average real wage growth that increase in human capital level is estimated to evidently *lead to increase in long-term average real wage*. (see Table 4-8) Since human capital accumulation is a life-long process and a key driver of income and economic welfare. This empirical confirmed human capital theory of various scholars that investment in education with acquiring the skills affects one's age-earning profile or the path of earnings over one's lifetime. For example, labor who leave school early, then enter to the labor market as low-educated human capital, earn market wages for more years on average than those who has an opportunity to take advantage of extended year of schooling or on-the-job training. But those in the latter group typically earn higher wages over their lifetimes.

Table 4-8. Scenario#1 simulation of average real wages, 1980-2010 (at constant price 2000)

Unit: Baht/person/year

Wr	*Baseline*	*Scenario#1*	*Delta (%)*
1980	16,876	16,936	0.4
1985	20,093	20,175	0.4
1990	31,729	31,880	0.5
1995	41,533	41,736	0.5
2000	43,156	43,361	0.5
2005	56,167	55,455	0.5
2010	67,431	67,793	0.5

Remark: Scenario#1; if upgraded 1 percent of human capital accumulation.
Source: Author.

The employment growth has been responded to the investment in human capital. Investing in workers has had a record of generating better employment conditions in its economies. It can be consequently explored that if human capital level is improving, supply of talented worker and labor productivity rises. Since higher educated worker can handle and utilize advance technologies to produce and yield larger output. Lowering the average cost of production will lead to increase in revenue and profit for companies and industries. Industries will require higher demand for labor then employ additional worker which causing the higher total employment in the economy. Theoretically, they will increase the number of workers until the marginal revenue is equal to the marginal unit cost of labor. Empirically, this simultaneous estimation confirmed that human capital growth has *positively significant* factor influencing the rising of labor demand and the total employment. The counterfactual increase in human capital investment in term of upgrading the number of educated workers *leads to increase in total employment growth*. (see Table 4-9)

Table 4-9. Scenario#1 simulation of total employment, 1980-2010 (Persons)

L	*Baseline*	*Scenario#1*	*Delta (%)*
1980	22,803,940	22,939,820	0.6
1985	26,354,350	26,534,060	0.7
1990	31,239,620	31,488,060	0.8
1995	32,844,630	33,112,130	0.8
2000	32,439,960	32,696960	0.8
2005	36,346,810	36,658,320	0.9
2010	38,904,530	39,253,630	0.9

Remark: Scenario#1; if upgraded 1 percent of human capital accumulation.
Source: Author.

Since we have explored that human capital have a strong positive correlation with productivity and economic growth. Economic growth is an increase in economy's efficiency and ability to produce goods and services. When economy expanded and employed more workers that on the other hands, they are consumer. Household and consumer tend to increase their purchase of both durable goods and extra services. Growth of spending creates a positive effect leading to the enhancement in production, new investment and employment. The spending, investment and employment will lead to higher aggregate demand and supply throughout the economy. Consequently, the model has confirmed the *positive relationship* between human capital growth and increase in real GDP. The counterfactual scenario quantitatively exposed that if we upgrade the human capital accumulation, it would elevate the real private consumption growth (PCEs), real gross fixed capital formation growth (GFCFr), real capital stock growth (Kr) and expand the real gross domestic products (GDPr). (See Table 4-10) In conclusion, Thai economy could expand and yield higher growth.

Table 4-10. Scenario#1 simulation of real private consumption, real investment, real capital stock and real GDP, 1980-2010 (Billion Baht, at constant price 2000)

Real Private Consumption (PCEr)				*Real Gross Fixed Capital Formation (GFCFr)*			
Year	***Baseline***	***Scenario#1***	***Delta (%)***		***Baseline***	***Scenario#1***	***Delta (%)***
1980	1,305.07	1,306.92	0.1	***1980***	741.49	744.14	0.4
1985	1,194.43	1,196.88	0.2	***1985***	424.87	426.72	0.4
1990	1,953.19	1,958.44	0.3	***1990***	1,510.12	1,518.84	0.6
1995	2,993.33	3,002.63	0.3	***1995***	2,942.30	2,961.38	0.6
2000	2,933.94	2,943.76	0.3	***2000***	1,219.56	1,228.01	0.7
2005	3,331.69	3,344.08	0.4	***2005***	1,127.90	1,136.64	0.8
2010	4,251.86	4,269.00	0.4	***2010***	1,931.61	1,947.71	0.8

Real Capital Stock (Kr)				*Real Gross Domestic Product (GDPr)*			
	Baseline	***Scenario#1***	***Delta (%)***		***Baseline***	***Scenario#1***	***Delta (%)***
1980	6,361.34	6,376.85	0.2	***1980***	2,188.34	2,192.02	0.2
1985	4,206.55	4,224.34	0.4	***1985***	1,980.55	1,985.48	0.2
1990	8,063.92	8,113.25	0.6	***1990***	3,545.05	3,556.57	0.3
1995	17,768.87	17,903.51	0.8	***1995***	5,901.12	5,923.30	0.4
2000	14,655.54	14,782.05	0.9	***2000***	5,509.23	5,531.55	0.4
2005	12,581.70	12,704.20	1.0	***2005***	6,111.27	6,138.72	0.4
2010	16,778.80	16,958.52	1.1	***2010***	8,143.03	8,182.68	0.5

Remark: Scenario#1; if upgraded 1 percent of human capital accumulation.

Source: Author.

Chapter 5
Conclusions and Policy Implications

5.1) Conclusions

The epoch of economic development of Thailand in the past has been relied much on physical capital investment and abundant cheap labor to support the labor-intensive industry. However, after the Asian Financial Crisis in 1997-1998, the financial system and capital accumulation processes were suddenly collapsed. Thailand had lost the ability to build its capital-intensive industries. Although Thailand had to advance its production but then turned to delay the necessary investment and eventually replaced with cheap and abundant of low skilled labor from neighboring migrants.

The investment in human capital seems to be improved since it has been reported by international organizations that there was the rising of the average year of schoolings and the mean wages of labor. However, low academic achievement passed negative consequences for students' future labor-market and income prospects that why this study hypothesized that education investment intensity and transitional of labor in term of quality improvement from low to higher education in Thailand was inactive to support advanced industries and produce higher growth.

Firstly, we applied the human capital augmented Solow Growth models to investigate the contribution of human capital in Thailand during 1980-2010. The study restricted our focus to human capital investment in the form of education, thus ignoring investment in health, training, experiences and among other things. The Labor Force Survey of Thailand during 1975-2015 were obtained and nominated the human capital investment by the education investment intensity levels. As a result, likewise various studied, ***we affirmed that human capital growth positively and significantly raised the income per capita and economic development in Thailand during 1980-2010. Nevertheless, the rate of return to the human capital investment intensity was relatively diminutive compared to the rate of return to labor head and capital inputs.***

Since the overall rate of return to the human capital investment in Thailand during 1980-2010 was small comparatively, we have continually suspected that sectoral economic activities and transformation of human capital in key industries should not similar and roles of human capital in each industrial development would have variation. Then, we continue to examine the sectoral analysis by disaggregated human capital investment intensity into 5 key industries; agricultures,

light manufacturing, heavy manufacturing, public utilities and constructions and trade and services sector. Human capital variable in this part is proxied by the number of labors nested by human capital level with fragmented key 5 industries. Later, we estimated the sectoral contributions of human capital. As we have previously doubted, the supply side analysis significantly insisted that contribution of human capital growth on key industries were significant and divergence. Besides, during 1980-2010, agriculture sector in Thailand deployed abundant of low educated labor and its human capital generated lowermost contributions to its growth. Light manufacturing and utilities sectors gradually improved and employed more middle-educated labor which their human capital supported moderate advancement. Therewith, human capital growth in heavy manufacturing and service industries in Thailand preceded the high endowment to their sectoral growth. ***Analytically, it ensured that the more education and competence labor has, the more efficiency and sectoral growth of industry obtains.***

Thereafter, we have doubted that what should probably be the sub-optimal level of the mean years of schooling of Thailand during the high growth era in the past. We tried to benchmark the development of Thailand with forerunner countries such as OECD countries and developed countries in East Asia such as Korea, Taiwan, Hong Kong and Singapore. We applied the panel analysis while separated all countries into 4 groups; OECD, Non-OECD, ASEAN, and Thailand. The model was simulated and shown that growth of income per capita is *significantly positive* with the growth of 'mean years of schooling'. Then, the counterfactual estimation on the condition that Thailand during the high growth period 2000-2017 would growth similar to the forerunner country like Taiwan during 1970s-1990s, ***the suboptimal level of the mean years of schooling of Thailand should be 6.9 years from the year 2000 and rapidly extended to 8.3 years at the year 2015.*** It can be implied that during the year 2000-2017, supposing that Thai economy and income per capita would growth similar to the Taiwanese economy, given the capital growth and the other endowments are being constant, ***the employed labor in Thailand should obtain the level of education at least at the junior high school level***.

On the demand side to match with the above supply side analysis, this study attempted to add up the explanation on the historical path of economic development by examine sources of growth and the causes of structural change from the demand side of Thailand during 1980-2010. ***We found that after the Asian Financial Crisis in 1997, the output growth of almost all industries was deteriorated. The domestic demand expansion had been shrunk but export expansion had replaced as main sources of industrial growth in Thailand. Thai manufacture has progressed and dense in its inter-industrial relationships over the period of 1995-2010.***

As the integration of supply and demand side analysis, we have combined all mentioned sectoral data into one overall Thai industry in order to appropriately analyses at the macro level. The equilibrium of demand and supply of human capital is estimated. Its newly distinguished labor with two-level nested-CES functions by education levels and skills. The model covers both the supply and demand sides of the economy but assumes the general price is exogenously given from the capital and financial market. The impact of the counterfactual scenario within sample is simulated while holding population structure, labor force participation rate, physical capital stock and technological advances is controlled. The model presents the response from the key variables according to the disturbance of upgrading the 1 percent proportion of low to high-educated labor into the model. The empirical investigation based on the simultaneous simulation and analysis explained the consequences of human capital growth in Thai economy. The estimates within the sample period has shown that ***the counterfactual human capital or enhancing the low-educated labor to acquire higher education positively shifts the growth of the average real wages***. This implies that the upgrading of human capital leads to higher overall labor productivity and real wages growth. Given the elasticity of substitution between high-educate and low-educated workers is greater than one, an extension in the educational attainment and supply of high-educated workers lowers relative wage rate, and subsequently increase the demand for high-educated workers, leading to the equilibrium in the labor market. ***Besides, the increase in the supply of higher-educated labor also leads to growth of human capital accumulation simultaneously***.

Furthermore, the most essential question is how large of the growth of real wages, total employment and aggregate demand-supply that would be attributed from the optimal growth of human capital at equilibrium point. The empirical result has shown that, human capital growth has shown positive and significant impacts on the average real wage growth, total employment and real aggregate demand-supply for Thai economy during 1980-2010. To illuminate the effects of human capital accumulation patterns on real wage growth that ***the raise in proportion of high-human capital level is estimated to apparently lead to significant increase in long-term average real wage growth***.

The employment growth has been responded to the investment in human capital. Investing in workers has had a record of generating better employment conditions in its economies. It can be consequently examined that if human capital is improving, supply of talented worker and labor productivity rises. Since higher educated worker can handle and take advantage of the advance technologies to produce and yield larger or faster output. Lowering the average cost of inputs will manage to increase in revenue and profit for companies and industries. Industries will require

higher demand for labor then employ additional worker which generate higher total employment in that economy. Theoretically, they will increase the number of workers until the marginal revenue is equal to the marginal unit cost of labor. ***Empirically, the simultaneous estimation supported that human capital growth has positively significant factor influencing the rise of labor demand and total employment. Increase in human capital investment in term of upgrading the number of educated workers leads to increasingly enlarge in total employment expansion.***

Since we have explored that human capital have a strong positive correlation with productivity and economic growth. Economic growth is an increase in economy's efficiency and ability to produce goods and services. When economy expanded and employed more workers with higher real wages, that on the other hands, they are consumer in the economy. Wealthier household and consumer tend to increase their purchase of both durable goods and additional services. Growth of spending creates a positive effect leading to the enhancement in production, gross sales, new investment and addition employment. The spending, investment and employment will lead to higher aggregate demand and supply throughout the economy. ***Consequently, the model has confirmed the positive relationship between human capital growth and increment in real private consumption, real gross fixed capital formation, real capital stock, and real gross domestic products (GDPr). The counterfactual analysis proved that if we increased the human capital accumulation, the real GDP would hike all through the economy during the disturbance period.***

Finally, this study confirmed that human capital accumulation has robustly and significantly affected to the growth of real wages, total employment, real GDP and finally leaded to an economic expansion. Nonetheless, beyond this study, the other resources enhance on human capital, knowledge and labor spillover effects from foreign firms, improvement of quality of education, such as, quality of schools, teachers, teaching materials, accessibilities, education policy and institutions are also the decisive determinant of human capital growth which should be conducted in further study.

5.2) Policy Implications

Since the main empirical finding confirmed that higher human capital leads to significant growth in productivity, real wages, total employment and aggregate demand and supply. Therefore, Thai government should provision to increase the human capital accumulation and upgrade worker's productivity through additional years of secondary and tertiary education and return rate to schooling and training which raise capability of labor to handle more advance equipment and

production technologies. Although, education and training are costly both in term of physical capital and time, if the value of higher education and extra skills is high enough, low and medium skilled workforce and their employers may find it profitable to invest in education and training and become higher skilled one.

Hence, supply of human capital cannot be boosted within a short period. Government should prepare since earlier decades through the national population planning, educational reform and emphasizing on training by doing. Even though, 8.3 years of the suboptimal target year of schooling in 2015 seems challenges, government should improve the accessibility of higher education for labor, such as the ease of access to individual financing of higher education and on-the-job training to raise their productivity and encourage motivation for on-line learning as part-time education along with other key factors such as saving and capital accumulation.

Lastly, government should foster the quality of education rather than just the number of student's head passing through the current conventional education system. Related essential factors such as improving the quality of schools, finding and encouraging to obtain qualified teachers, teaching time and technologies and resources, accessibilities, education development policy and budget allocation are the decisive determinants of human capital growth which also need weight of further research evidences.

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Appendix 1

Table A1-1. Classifications and aggregations of 5 key sectors (for Chapter 3)

No.	*Classifications*	*I-O (58x58)*	*Sectors*
1	Agricultures	001-009	Agriculture, Forestry, Fishery, Mining, Quarrying
2	Manufacturing - Light	010-018	Food, Beverages, Textile, Paper, Printing, Wood, Rubber, Plastic
3	Manufacturing - Heavy	019-034	Chemical, Petroleum, Non-Metallic, Metals, Machinery, Electronics, Automobiles, Transportation Equipment, Other Manufacturing
4	Utilities and Constructions	035-044	Electricity, Water Works, Construction
5	Services	045-058	Trade, Transportation, Communication, Services, Unclassified

Source: Input-Output Tables of Thailand, 58x58 sectors, NESDB.

Table A1-2. The nomination of human capital investment intensity by education investment level

	Education Levels	Human Capital Investment Intensity
1	None	low intensity
2	Less than elementary	low intensity
3	Primary	low intensity
4	Lower secondary	low intensity
5	Upper secondary - general	moderate intensity
6	Upper secondary - vocational	moderate intensity
7	Upper secondary - teaching	moderate intensity
8	Diploma - general	moderate intensity
9	Diploma - vocational	moderate intensity
10	Diploma - teaching	moderate intensity
11	Bachelor - general	high intensity
12	Bachelor - vocational	high intensity
13	Bachelor - teaching	high intensity
14	Master	high intensity
15	Doctoral	high intensity
16	Others	not classified
17	Unknown	not classified

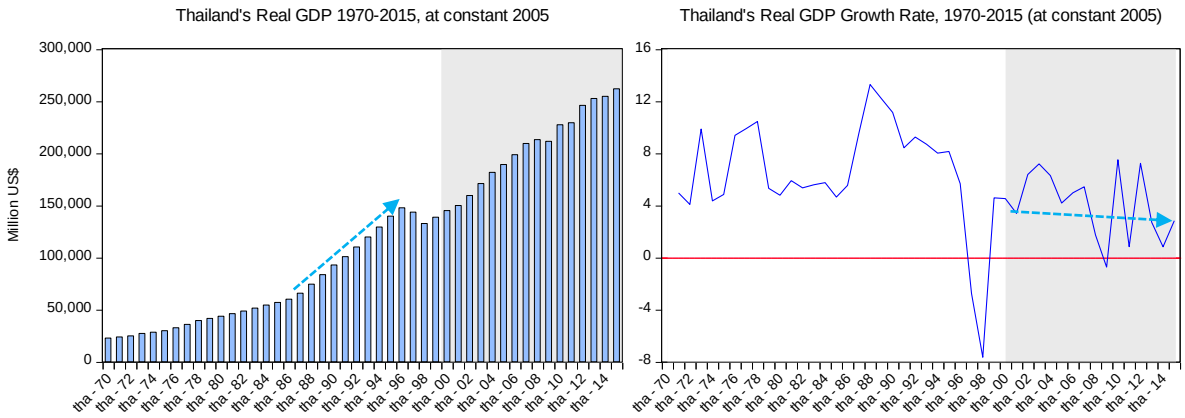
Source: ISCED, NSO, Author.

Table A1-3. Skilled-Unskilled labor matching criteria

	Occupations	Skill Classification
1	Legislators, semi or officials, and managers	Skilled
2	Professionals	Skilled
3	Technicians and associate professionals	Skilled
4	Clerks	Unskilled
5	Service workers and shop and market sales workers	Unskilled
6	Skilled agricultural and fishery workers	Unskilled
7	Craft and related trades workers	Unskilled
8	Plant and machine operators and assemblers	Unskilled
9	Elementary occupations	Unskilled
99	Unknown	not classified

Note: ISOC-08 and LFS
Source: ISOC, NSO and Author.

Fig.A1-1. Thailand's real GDP and growth, 1970-2015 (US$ million at constant price 2005)



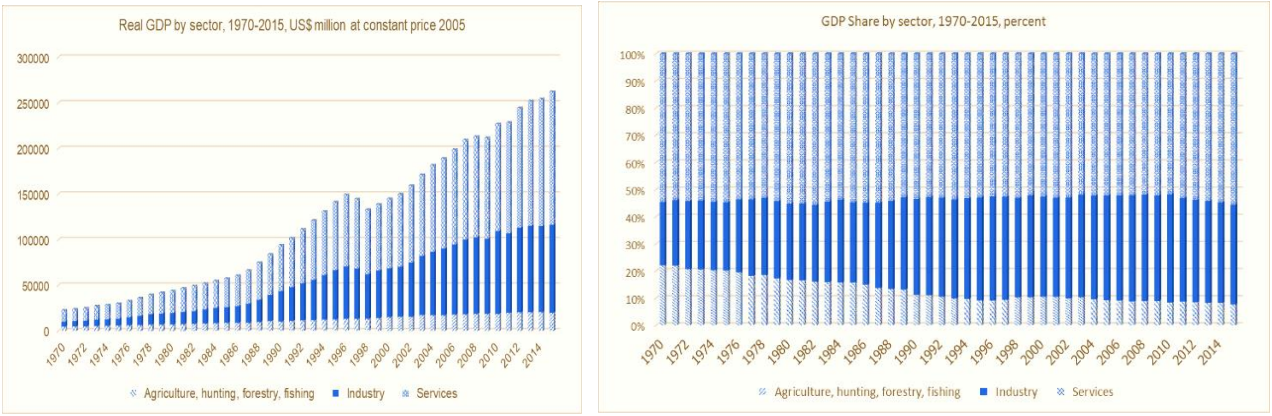
Source: Compiled data from UNCTAD-Stat, accessed July 2017.

Table A1-4. Value added share by sector, 1970-2015 (US$ million, at constant price 2005, percent)

Year	*Agriculture*	*Industry*	*Services*
1970	22.39	23.71	55.29
1975	20.36	25.60	55.30
1980	16.81	28.44	55.59
1985	15.83	29.85	55.05
1990	11.19	35.53	53.45
1995	9.13	38.05	52.83
2000	10.52	37.00	52.59
2005	9.20	38.63	52.17
2010	8.29	39.99	51.57
2015	7.63	36.67	55.32

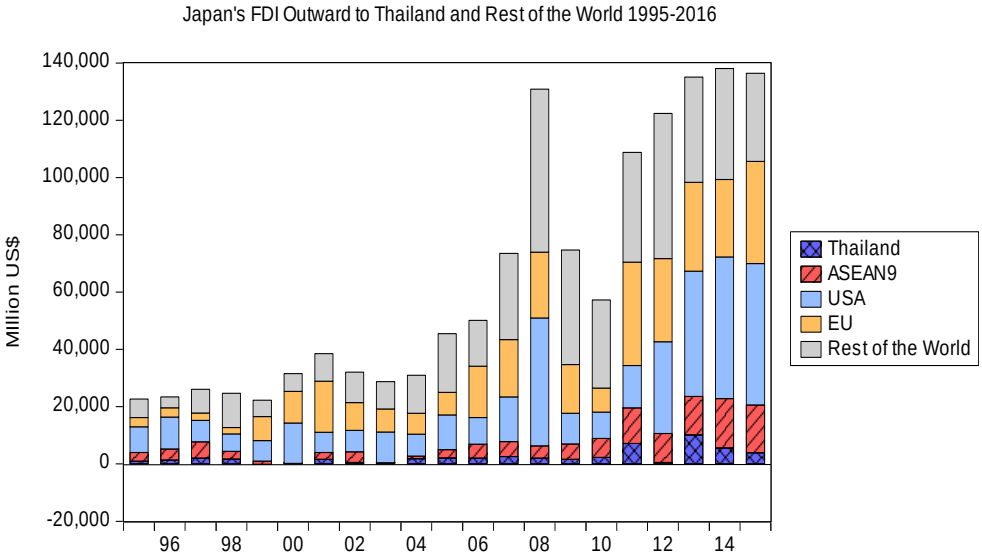
Source: Compiled data from UNCTAD-Stat, accessed July 2017.

Fig.A1-2. Thailand's Real GDP by sector and share, 1970-2015 (US$ million, constant 2005)



Source: Compiled data from UNCTAD-Stat, accessed July 2017.

Fig.A1-3. Japan's FDI outward to Thailand and rest of the World, 1995-2016



Source: Compiled data from JETRO, Japan (www.jetro.or.jp), accessed July 2017.

Table A1-5. Share of new registered foreign investment in Thailand by nationality, accumulation 2012-2016 (%)

Foreign Investment	*share (%)*	
1) Thai investment	84	
2) Foreign investment	16	
2.1) Japan		31.6
2.2) Singapore		5.8
2.3) USA		5.2
2.4) China		4.0
2.5) Netherland		3.5
2.6) Others		

Source: Company Registration Report 2012-2016, Ministry of Commerce, Thailand. Accessed August 2017.

Table A1-6. Classification of new sectors (for Chapter 4 – demand side analysis)

No.	Classification	58 x 58 sectors	New Code
1	Agriculture	(001-011)	01
2	Mining and Quarrying	(012-014)	02
3	Food Manufacturing	(015-022)	03
4	Textile Industries	(023-024)	04
5	Paper Industries and Printing	(025-026)	05
6	Chemical Industries	(027-029)	06*
7	Petroleum Refineries	(030)	07
8	Rubber and Plastic Products	(031-032)	08*
9	Non-Metallic Products	(033-034)	09
10	Basic Metal	(035-036)	10
11	Fabricated Metal Products	(037)	11
12	Industrial Machinery	(038)	12*
13	Electrical Machinery and Apparatus	(039)	13*
14	Motor Vehicles and Repairing	(040)	14*
15	Other Transportation Equipment	(041)	15
16	Other Manufacturing	(042-044)	16
17	Electricity and Water Works	(045-046)	17
18	Construction	(047-048)	18
19	Trade	(049)	19
20	Services (Restaurants and Hotels)	(050)	20
21	Transportation and Communication	(051-052)	21
22	Services (Banking, Insurance, Real	(053-057)	22
23	Unclassified	(058)	23

Source: Author

Table A1-7. Producer price index by production activity (PPI-CPA), base year 2010

No.	*PPI-CPA Code*	*Production Activities*	*1995*	*2000*	*2005*	*2010*	*2015*
1	0000000000000000	All sectors	51.0	60.6	76.5	100.0	102.6
2	1000000000000000	Agriculture	24.6	26.8	47.8	99.9	101.9
3	2000000000000000	Mining and Quarrying	63.0	68.9	103.0	100.1	112.3
4	3010000000000000	Food, Beverages, Tabacco	50.6	58.1	71.1	100.0	110.0
5	3020000000000000	Textile and Products	78.1	91.6	93.6	99.9	107.7
6	3030000000000000	Leather Products	90.9	97.6	100.3	100.0	104.2
7	3040000000000000	Saw Mills and Wood Products	56.4	67.9	81.5	100.0	104.5
8	3050000000000000	Paper Products and Printing	70.0	92.1	91.9	99.9	103.6
9	3060000000000000	Petroleum	26.3	47.8	86.5	100.1	97.0
10	3070000000000000	Chemical	61.1	77.7	92.3	100.1	102.4
11	3080000000000000	Rubber and Plastic Products	49.3	59.4	69.4	99.9	81.0
12	3090000000000000	Non-metallic Products	60.0	78.9	83.7	100.0	102.8
13	3100000000000000	Basic Metal and Metal Products	47.2	59.1	86.5	99.9	98.4
14	3101000000000000	Basic Metal	46.2	53.8	86.4	99.8	96.0
15	3102000000000000	Fabricated Metal Products	49.1	68.6	86.6	99.9	102.0
16	3110000000000000	Industrial Machinery	80.7	89.1	97.4	100.0	105.1
17	3120000000000000	Electrical Machinery and Apparatus	85.7	99.0	101.3	100.0	97.4
18	3130000000000000	Motor Vehicles and Equipment	76.2	90.9	95.7	100.0	105.2
19	3131000000000000	Motor, Body, and Parts	76.0	90.1	95.1	99.9	105.6
20	3132000000000000	Other Transportation	77.2	94.8	99.0	100.0	102.5
21	3140000000000000	Other Manufacturing	39.5	44.3	58.3	99.7	108.9

Source: Bureau of Trade and Economic Indices, Ministry of Commerce, Thailand., Accessed August 2017.

Table A1-8. Thailand's GDP deflator, base year 2010

Year	GDP deflator (base year 2002)	Inflation, GDP deflator (annual %)	*GDP deflator (base year 2010)
1975	27.73	3.49	21.12
1980	41.27	12.70	31.43
1985	50.48	2.18	38.45
1990	63.89	5.77	48.66
1995	83.21	5.74	63.38
2000	96.49	1.33	73.49
2005	111.18	5.09	84.69
2010	131.29	4.08	100.00
2015	143.91	0.59	109.61

Remark: * Computed GDP deflator
Source: Complied data from GDP deflator, base year 2002, World Development Indicator, World Bank. (Accessed August 2017)

Table A1-9. Total backward linkages (Input multiplier), 1980-2010

Input Multipliers	***1980***	***1985***	***1990***	***1995***	***2000***	***2005***	***2010***
1. Motor Vehicles and Repairing	2.0017	1.8098	1.7597	1.9624	2.0864	2.1738	2.2693
2. Electrical Machinery and Apparatus	1.9290	1.9275	1.7532	1.7750	1.9550	2.0308	2.4977
3. Industrial Machinery	1.8843	1.9074	1.9577	2.0641	2.0031	2.0556	2.1391
4. Rubber and Plastic Products	1.9031	2.1247	2.0938	2.3958	2.4429	2.4104	2.3527
5. Chemical Industries	1.7256	1.9341	1.9576	2.0615	2.0277	1.9048	2.0227
Changes (%)							
1. Motor Vehicles and Repairing		*-9.6*	*-2.8*	*11.5*	*6.3*	*4.2*	*4.4*
2. Electrical Machinery and Apparatus		*-0.1*	*-9.0*	*1.2*	*10.1*	*3.9*	*23.0*
3. Industrial Machinery		*1.2*	*2.6*	*5.4*	*-3.0*	*2.6*	*4.1*
4. Rubber and Plastic Products		*11.6*	*-1.5*	*14.4*	*2.0*	*-1.3*	*-2.4*
5. Chemical Industries		*12.1*	*1.2*	*5.3*	*-1.6*	*-6.1*	*6.2*

Source: Author's calculation

Table A1-10. Total forward linkages (Output multiplier), 1980-2010

Output Multipliers	***1980***	***1985***	***1990***	***1995***	***2000***	***2005***	***2010***
1. Motor Vehicles and Repairing	1.5236	1.4390	1.4616	1.4267	1.5435	1.4942	1.5151
2. Electrical Machinery and Apparatus	1.2529	1.3401	1.4309	1.3375	1.5117	1.6986	2.0634
3. Industrial Machinery	1.2979	1.4374	1.6214	1.4304	1.3700	1.6637	1.5317
4. Rubber and Plastic Products	1.3836	1.3670	1.2766	1.4733	1.5585	1.4629	1.4962
5. Chemical Industries	1.4522	1.3603	1.5130	1.6059	1.9143	1.8363	2.2531
Changes (%)							
1. Motor Vehicles and Repairing		*-5.6*	*1.6*	*-2.4*	*8.2*	*-3.2*	*1.4*
2. Electrical Machinery and Apparatus		*7.0*	*6.8*	*-6.5*	*13.0*	*12.4*	*21.5*
3. Industrial Machinery		*10.7*	*12.8*	*-11.8*	*-4.2*	*21.4*	*-7.9*
4. Rubber and Plastic Products		*-1.2*	*-6.6*	*15.4*	*5.8*	*-6.1*	*2.3*
5. Chemical Industries		*-6.3*	*11.2*	*6.1*	*19.2*	*-4.1*	*22.7*

Source: Author's calculation

Table A1-11. The power of dispersion index, 1980-2010

Sectors	*1980*	*1985*	*1990*	*1995*	*2000*	*2005*	*2010*
1. Motor Vehicles and Repairing	1.1093	0.9631	0.9570	1.0160	1.0554	1.0927	1.0818
2. Electrical Machinery and Apparatus	1.0638	1.0258	0.9535	0.9189	0.9890	1.0208	1.1907
3. Industrial Machinery	1.0391	1.0151	1.0647	1.0686	1.0133	1.0333	1.0197
4. Rubber and Plastic Products	1.0495	1.1307	1.1387	1.2404	1.2358	1.2117	1.1216
5. Chemical Industries	0.9516	1.0293	1.0647	1.0673	1.0257	0.9575	0.9642

Source: Author's calculation

Table A1-12. The sensitivity of dispersion index, 1980-2010

Sectors	*1980*	*1985*	*1990*	*1995*	*2000*	*2005*	*2010*
1. Motor Vehicles and Repairing	0.8402	0.7658	0.7949	0.7386	0.7808	0.7511	0.7223
2. Electrical Machinery and Apparatus	0.6909	0.7132	0.7782	0.6925	0.7647	0.8538	0.9836
3. Industrial Machinery	0.7157	0.7650	0.8818	0.7405	0.6930	0.8363	0.7302
4. Rubber and Plastic Products	0.7643	0.7275	0.6943	0.7628	0.7884	0.7353	0.7132
5. Chemical Industries	0.8008	0.7239	0.8229	0.8314	0.9684	0.9230	1.0741

Source: Author's calculation

Table A1-13. Computed employed persons in each sector, 1996, 2005, 2010

Code	*Sectors*	*1996**	*2005*	*2010*
01	Agriculture	16,127,108	11,244,637	12,244,221
02	Mining and Quarrying	47,117	42,313	34,234
03	Food Manufacturing	692,167	1,128,342	1,175,354
04	Textile Industries	918,923	966,143	813,999
05	Paper Industries and Printing	100,879	148,095	152,149
06	Chemical Industries	176,247	148,095	121,719
07	Petroleum Refineries	8,620	10,578	11,411
08	Rubber and Plastic Products	142,729	243,299	235,832
09	Non-Metallic Products	268,369	310,294	277,673
10	Basic Metal	226,740	77,574	83,682
11	Fabricated Metal Products	177,426	296,190	285,280
12	Industrial Machinery	14,586	162,199	174,972
13	Electrical Machinery and Apparatus	346,259	401,972	426,018
14	Motor Vehicles and Repairing	442,815	130,465	174,972
15	Other Transportation Equipment	13,132	49,365	45,645
16	Other Manufacturing	804,803	913,252	836,822
17	Electricity and Water Works	142,889	151,621	125,523
18	Construction	2,171,980	1,755,983	1,898,063
19	Trade	4,341,523	6,621,959	7,413,478
20	Services (Restaurants and Hotels)	953,774	1,036,665	1,030,812
21	Transportation and Communication	1,039,442	3,159,359	3,476,613
22	Services (Banking, Insurance, Real Estate, other Services)	3,074,301	6,230,565	6,983,656
23	Unclassified	19,487	28,209	15,215
	Total	32,251,316	35,257,173	38,037,343

Noted: * Referred from Limskul (2001)

Source: Computed from Labor Force Survey 2005, 2010

Appendix 2

Table A2-1. Summary of Thailand's National Economic and Social Development Plan on Human Capital (Education and Health)

Plan	Situation and Limitations	Objectives and Goals
4th Plan (1977-1981)	Population and Labor - Population was increased from 25.4 million in 1977 to 28.9 million in 1981. - Growth of labor 2.3 percent per annual (labor force increased from 19.2 to 21.6 million persons, or average 0.48 million persons per annual) - Labor migrated from rural to Bangkok and urban are to find better jobs and higher wages. - Labor force in urban growth 7.4 percent while in rural growth 1.8 percent. - Minimum wages adjustment were 3 times: Jan, 1974 adjusted to 16 Baht, June, 1974 to 20 Baht, and Jan, 1975 to 25 Baht. Education and Skill **- Lack of schools, books, teaching materials and teachers.** - Short-term training courses were not well-planned along with the demand for employment and required occupations. - About 50 percent of student in short course dropped out because of poor and lack of interests. **- Secondary and higher educated labor had larger unemployment ratio (of total graduated persons) from 25.3 percent (18,708 of 73,896 persons) in 1973 to 42.5 percent (43,665 of 102,760) persons in 1975.** Health - Extremely high sickness ratio of the Respiratory Diseases: 92,791 persons per 100 thousand. - Extremely high ratio of medical doctor per rural population: 1:30,863 persons. - Very low supply of medical doctor: 385 doctors per year. - High death rate of child under ages 6 because of the malnutrition from lack of protein: 55,000 persons in 1974.	Population and Labor - Reduce the population growth from 3 percent to 2.5 percent during the 3rd Plan to 2.1 percent during the 4th Plan. - Average unemployment rate was targeted at lower 6 percent or 1.1-1.2 million persons. - Set priority to population policy, birth control, education through curriculum adjustment and law amendment. **- Adjust minimum wages by occupation rather than by area or province.** **- Booth and support the investment environment and incentives in labor-intensive industry.** Education and Skill **- Develop training courses to meet with demand in labor market.** **- Support technology transferring onto industrial sectors and large farming.** Health - Increase human resources ratio per population, such as, doctors, pharmaceutical, dentists, nurses, public health officers. - Increase access ratio to public health in the rural area to 20 percent. - Decrease the maternal and infant mortality rate 20 percent. - Improve nutrition in child ages under 5.

5th Plan (1982-1986)	Population and Labor - Working age population growth was still high at 3.2 percent which higher than the country average. - There was higher labor participation and migration to industry sector, but their quality was low and under the standard level. - Most of labor in agriculture had low productivity, low education, low living standard and low income. Education and Skill - Compulsory Education was not covered country-wide and quality of education and schools in rural area was still low. - Short-term training courses were not well-planned along with the needs for employment and required occupations because of under quality of government and public services. - Most of labor force was low quality or unskilled. Their education was lower primary level. 71 percent of labor force was low income labor. - Low teacher-pupils ratio - Lack of schools, books, teaching materials and teachers. Health - Death rate decreased from 10.1 in 1967 to 5.4 persons per thousand in 1977. - 60 percent of medical doctors (3,500 doctors) were in Bangkok but 40 percent in rural areas. - Medical doctor per Bangkok population ratio was 1:1,200, but 1:17,000 in rural population in 1979.	Population and Labor - Reduce the population growth target to 1.5 percent in 1986. - Working-age population (26-64 years old) will growth at 3.2 percent. Education and Skill - Increase enrolment rate of education; increase 35.4 percent in kindergarten, 100 percent in primary, 48.3 percent in secondary, 30.9 percent in higher secondary and 4.8 percent in tertiary. - Increase government budget on education to GDP ratio to 3.5 **- Support tax deduction for expenses of the labor skills development project and school lunch project.** **- 10 percent of farmer should obtain higher education and living standard.** - Provide training in various occupations and set up the Skill Standard or Vocational Qualification in 10 skills: electric welder, mechanic, electrical wiring technician, gas welder, auto mechanic, fine mechanic, refrigeration and air-conditioning technician, broadcasting technician, carpenter and construction, pipe and sanitary technician. Added in the 5th Plan for 5 skills: bricklayer, plasterer, auto-denter, auto-sprayer, heavy mechanic. - Support academic institution and university to organize human resource development training course for labor and youth. Health - Increase human resources ratio per population, such as, doctors, pharmaceutical, dentists, nurses, public health officers. - Provide clean water to cover from 64 percent of population in 1982 to 95 percent by 1986.
6th Plan (1987-1991)	Population and Labor - Population growth rate was 2.1 percent in the last year of the 4th Plan. - Population growth rate was 1.7 percent in the last year of the 5th Plan. - Labor force growth 3.0 percent in average per year. - 90 percent of employed workers were facing the underemployment, which increased from 10 million in 1982 to 11.3 million in 1984, and 75 percent was in agriculture sectors. Education and Skill - Growth of labor with higher education was increased. School-age population decreased since population growth plan was accomplished. Health - 9 percent increase in providing free public health services for low-income person in rural area. - Child malnutrition rate reduced to 0.7 percent.	Population and Labor - Reduce the population growth target to 1.3 percent by 2000. - Support overseas employment, reduce cost and enhance labor protection. - Enhance immigration control for foreign labor. Education and Skill - Support children in rural area to obtain education higher than compulsory level. - Provide short-term training in various occupations by non-formal education system. - Set up the Skill Standard or Vocational Qualification. - Support self-employment while improve internal labor market efficiency. **- Regulate the foreign companies operated in Thailand to transfer technology to Thai workers effectively.** Health - Set long-term health promotion target according to the Basic Minimum Needs Indicators (BMN or Jor.Por.Thor. in Thai) - Increase and improve local hospital and sub-district public health center.

7th Plan (1992-1996)	Population and Labor - Population growth rate was 1.4 percent in the last year of the 6th Plan. - Employment in industry sectors increased to 0.55 million workers per year. - Population leaving under the poverty line was 23.7 percent. Education and Skill - Labor obtained higher education. - 97 percent of population covered with 6-years compulsory education. - Literacy rate was 86 percent which highest in ASEAN. - Secondary school enrollment rate was still low at 46.2 percent. Health - Infant mortality rate was still high at 29 persons per thousand population.	Population and Labor - Reduce the population growth target to 1.2 percent by the last year of the 7th Plan. (population will be approx. 61 million persons) - Extend retirement age for teacher and professor from 60 to 65 years old. - Provide short-term training in various occupations to match with demand and needs. - Improve labor welfare system and protection laws. - Increase child labor age from 13 to 15 years old. - Decrease percent of population leaving under the poverty line to 20 percent. Education and Skill - **Extend the basic compulsory education from 6 years to 9 years.** - Set secondary school enrollment target to at least 73 percent by the last year of the plan. - Increase graduate ratio in required occupations, such as, doctors, pharmaceutical, dentists, engineer, scientist and workers in service sectors. Health - Reduce infant mortality rate from 29 to 23 persons per thousand population.
8th Plan (1997-2001)	Population and Labor Education and Skill - Graduation ratio in science and technology per social science was 31/69 Health	Population and Labor Education and Skill - Increase graduation ratio science and technology per social science to 40/60 - Increase short-term training in various occupations to 50 percent by the year 2001. - Regulate the foreign companies operated in Thailand to transfer technology to Thai workers effectively. - Support technological cooperation with international firms. - Support foreign experts and specialists to work in Thailand in academic field. Health - Expand the Social Security to cover entrepreneur with 10 workers and over.
9th Plan (2002-2006)	Population and Labor - Population leaving under the poverty line was increased from 11.4 percent (or 6.8 million) in 1996 to 15.9 percent (or 9.9 million) in 1999. - Number of unemployment increased 1 million persons higher than before the Asian Financial Crisis in 1997. - Child population decreased from 23.0 percent in 2002 to 21.9 percent in 2006. - Elderly population increased from 9.8 percent in 2002 to 10.7 percent in 2006.	Population and Labor - Set labor productivity growth target at 3 percent per annual. Labor productivity growth in agriculture at 0.5 percent per annual. Labor productivity growth in industry at 2.5 percent per annual. - Increase new job not less than 0.23 million jobs per annual. Education and Skill - Population age over 15 have average year of schooling not less than 9 years by year 2006. - At least 50 percent of labor obtained secondary school by the year 2006.

	Education and Skill - Population age over 15 had average year of schooling from 6.6 years in 1996 to 7.0 years in 1998. - 68.4 percent of labor age over 15 had education level not higher than primary school. Health	- Promote investment in R&D in public and private sectors to be higher than 0.4 percent of GDP. - Promote investment in R&D by increase not less than 1.5 percent of government budget. - Increase R&D researcher ratio to 3.5 persons per 10 thousand of population. - Improve quality of teaching in science and technology to reach the standard. - Improve education system and promote Life-Long-Learning behavior. Health - Expand and develop the social security system to cover under-privileged persons. - Improve quality of health services in both of public and private hospital and health center. - Promote the alternative and applied Thai traditional medical system.

Source: Author summarized from various National Economic and Social Development Plans, NESDB, Thailand.

Appendix 3

Sampling Surveys and In-depth Interviews

In addition to the empirical results in chapters 3 and 4, for better understanding, the author conducted supplementary field surveys in 5 target industries, consisting of foods, textiles, chemicals, electronics, and automobile industries. I have created a Thai and English questionnaire on the Google Forms website in order to facilitate the respondents and easy to retrieve the data. The questionnaire can be submitted both of online and offline, offline by sending the file via e-mail, and online by forwarding URL to allow the respondent to fill in online. Target number of questionnaires is 20 questionnaires and in-depth interviews in 5 industries.

The author randomly collected data from questionnaires and interviewed executives in Thailand for 2 periods (1) during December 2018 - January 2019 and (2) during March - April 2019. Due to the limited time and resources, I was able to collect 11 questionnaires conducted in-depth interviews with 6 top executives in 5 target industries. It can be summarized as below;

Table A3-1. Number of questionnaires and in-depth interviews, 2018-2019

Manufacturing	***Questionnaire (companies)***	***Interview (companies)***	***Interview Date***
Foods	3	1	December 28, 2018
Textiles	1	1	January 8, 2019
Chemical	3	1	December 17, 2018
Electronics	-	1	January 10, 2019
Automobiles (Parts)	1	2	December 21, 2018 March 15, 2019
Automobile (Trade)	1	-	
Printing	1	-	
Oil & Gas	1	-	
Total	**11**	**6**	

Source: Author

According from the questionnaire surveys and in-depth interviews, it can be summarized as follows;

1. Upon the sample group, Thai manufacturing has an average establishment year of 34 years, utilizing an average of 330 workers and labor. Labor cost is 27.7 percent of total cost and total annual cost per labor is 1.1 million Baht (30 thousand USD.). Average labor hourly cost is 487 Baht per hour (16.2 USD.) while average labor productivity measured by output per hour worked is 597 Baht (20 USD.).

2. Most of the manufacturing in Thailand has rarely invested on human capital and the education intensity of the employees. Most of the workers in the office graduated with a diploma and mean year of schooling is 14 years, but most factory labor graduated only at grade 9 or below and mean year of schooling is 9 years. For manager level, in the office side, most graduated with a bachelor's degree with an average experience of about 17 years. The factory side, mostly graduating with a bachelor's degree with an average experience of about 18 years. Since they are the manufacturing industry therefore, they focus on the knowledge and experience of the factory manager slightly more than the office manager.

3. Mostly they have low investment on human resources development. Company provides at least the compulsory training courses required by industrial and labor laws such as 5S., safety protocols, firefighting practice. There are training courses on productivity enhancement such as product standards, quality assurance, machine tools, marketing, communications and team buildings. Thus, average annual training cost is 136 thousand Baht. per company. Average annual R&D expenditure cost is 1.12 million Baht. per company.

Table A3-2. Output, labor cost and labor productivity by industry, 2018

No.	*Industry*	*Age*	*Labor*	*Annual hour worked*	*Change in output*	*Change in total cost*	*Labor cost ratio*	*Labor cost ratio (last year)*	*Change in labor cost*	*Total cost per labor*	*Labor hourly cost*	*Labor Productivity (Output per hour worked)*	
		(years)	*(persons)*	*(hours)*	*(%)*	*(%)*	*(ratio of total cost)*	*(ratio of total cost)*	*(%)*	*(THB)*	*(THB)*	*(THB)*	*(USD)*
01	Chemical	52	30	69,888	-16.7	-16.7	44.4	37.0	20.0	300,000.0	128.8	143.1	4.8
02	Food	43	68	148,512	-32.4	-31.1	27.1	17.9	51.3	248,552.9	113.8	123.1	4.1
03	Automobile (Trade)	15	500	1,248,000	11.1	11.1	n.a.	n.a.	n.a.	1,400,000.0	560.9	801.3	26.7
04	Oil & Gas	80	300	624,000	14.3	16.7	4.3	45.0	-90.5	2,333,333.3	1,121.8	1,282.1	42.7
05	Food	2	20	77,376	900.0	775.0	n.a.	n.a.	n.a.	175,000.0	45.2	51.7	1.7
06	Chemical	27	193	326,976	0.7	1.8	20.2	21.8	-7.6	1,094,806.1	646.2	658.4	21.9
07	Chemical	39	180	413,920	-0.8	-0.8	16.0	15.0	6.7	3,146,666.7	1,368.4	1,425.4	47.5
08	Automobile (Parts)	32	250	624,000	8.0	4.2	30.0	30.0	0.0	1,000,000.0	400.6	432.7	14.4
09	Printing	16	48	119,808	18.4	21.2	17.5	18.2	-3.8	833,333.3	333.9	484.1	16.1
10	Food	42	1,532	3,823,872	0.8	0.6	15.2	14.5	4.5	1,357,049.6	543.7	549.2	18.3
11	Textile	25	520	1,285,440	-11.1	-11.1	75.0	74.1	1.3	230,769.2	93.4	622.4	20.7

Remark: 1) Data from sampling surveys during December 2018.
2) At exchange rate 1 USD. = 30 THB.

Source: Author.

Summary of In-depth Interviews (6 Cases)

1) Company A: Adhesive Manufacturing, Chemical Industry

(Interviewed date: December 17th, 2018)

Adhesive manufacturing (industrial glue) is in the chemical industries. 40 years experiences, 100% Thai company which a top executive is a successor (2nd generation) who followed his father produced adhesive and glue for industrial uses. Company A's total sales in 2017 was approximately 600 million baht. This is one of the low-profile and promising industries in Thailand.

Their export proportion are about 40% of its total sales, exports to 27 countries, such as Asia (30-40%), Japan, Australia, New Zealand, Middle East and Latin America. Company has growth rapidly and raised fund from the Market for Alternative Investment (MAI) since last 2 years to expand the business and look over one Singaporean sticker manufacturing in Thailand. Merging with foreign manufacturing seem to be the best solution for enhancing local production technology.

Human capital is the most significantly importance for this industry. There are 180 labor input which costs 16% of total cost. Total cost per labor is the highest at about 3 million Baht per labor head per year. Although labor hourly cost is the highest at 1,368.4 Baht per hour., labor productivity measured by output per hour worked is also the highest among samples at 1,425.4 Baht per hour or about 47.5 USD per hour.

Company A put great importance on human capital and research and development (R&D) which requires high level of knowledgeable personnel. Company was seeking and hired a chairman of the executive board from the outsider who is an expert in the adhesive industry in Thailand. Moreover, company is employing office workers who graduated from bachelor's degree, master's degree to doctorate (30, 10, 2 percent of total labor, respectively) and among them are researchers up to 23 persons or 13 percent. As well as hiring a foreign expert, an American-Taiwanese citizen, aged 60 years, who retired from the glue manufacturing company in the United States come to be the head of R&D department.

Since the company understands the importance of human capital (knowledge, skill and the education of the human resources) therefore the employment qualifications for manager level are relatively high. Both of general and plant managers must graduate at least a master's degree. The

general manager (50 years old) who have previous research and development experience, and plant manager (47 years old) with experience in adhesive production who was promoted from being a production manager within the factory.

The company also focuses on training which consists of both 11 internal and 17 external trainings. Company provides various trainings for example, basic trainings such as ISO system, safety system, firefighting, first-aid, basic chemistry, specific trainings such as sale, budgeting, strategy, positive thinking and technical trainings such as Lean, Kaizen, and On the Job Training (OJT). There are some technical trainings provided by suppliers.

For training needs assessment, company determines the training needs and topics from the operational level. However, about 2-3 years ago, there has been a trial to set topics by assigning from top executives (top-down). But it seemed that it didn't work well, most of staffs were low-attention, therefore, we decided to change back to the bottom-up system. However, clarified processes of training needs and topics were advanced. Each department, between the head-subordinate needed to discuss in every quarters to decide what is a weakness and problems that needed to be trained or resolved such that HR department can provide desired training matched with the needs.

2) Company B: Motorcycle Brake Manufacturing, Automobile Industry

(Interviewed date: December 21st, 2018)

Company B produces brake system and parts for motorcycles. A 32-year-old SMEs business originally produces OEM parts and spare parts for Japanese Honda and Yamaha motorcycles. Lately, when customers had changed models frequently and reduced purchasing prices, problem had been raised, and company began to develop replacement parts, created their own brand, and expanded their customer bases. Currently, about 30% of raw materials are imported from foreign countries for example chemicals imported from Europe and China, parts and equipment are imported from Japan and Taiwan. Another 70% used domestic raw materials such as steel, recycled aluminum bars and chemicals. Annual sales in 2018 are 270 million Baht, and around 8% increase from the last year. (approximately 9 million USD) Their 70-80% of market share was from Honda and 20-30% was from Yamaha’s customers.

Company is a family business, Chinese-Thai cartel management system, operated since the father's generation. His father was a metal's fitter and turner who experienced in factory and domestic sales. His mother helped to take care of accounting and general jobs in the office. Current executive (Interviewee) is a 45-year-old son, taking care of the business after his father died. He graduated a bachelor's degree in engineering and acting as the Managing Director who handling the overall business, especially in the production line and marketing. His 40-year-old daughter graduated a bachelor's degree in accounting. She helps in accounting and various internal office works.

Currently, there are 225 employees, 20 office staffs, most of them graduated with a bachelor's degree and 205 technicians and workers in the factory, mostly graduated at primary level and 40 temporary contract immigrants. The cost of labor is 30 percent of the total cost. The labor cost per unit is about 400 Baht per hour, while labor productivity is relatively low, with the output per hour worked is only 432 Baht (around 14 USD)

Important human resources of the company are a 35-year-old factory manager who was promoted from the assistant factory manager's position. He graduated with a bachelor's degree in industrial engineering and have 10 years' experience in this factory. Another valued personnel is foreign sales managers who graduated with a bachelor's degree from the ABAC University (English as a medium of teaching) She has been working since the father's generation. Next to the managing director, she is the only one who can communicate with customer in both English and Chinese. In some busy periods, there is a shortage of staff who can communicate with foreign customers.

As a family business SMEs, the shortage of skilled workers, such as undergraduate engineers and vocational technician level has always been a major problem. It is hard to maintain a bachelor's degree or employees with good English skills. They are frequent job-hopper. Moreover, vocational technicians in Thailand are always choose the big and famous companies, therefore, this company prefer worker from high school graduates and foreign immigrant workers and provide them on-the-job-training (OJT)

However, hiring foreign immigrant labor has pro and con. At present, there are 50 foreign workers with the Burmese nationality. Although most Burmese workers are hard-working, they can produce more excellent pieces and rarely change jobs compared with Thai workers. Most Thai workers are indolent. However, utilizing foreign immigrant workers have complex problems to deal with, for example, the legal process of applying for a work permit is inconsistent, official documents and forms are being changed frequently. Sometimes it takes several months or may be

a year to wait for a work permit granted. Occasionally Burmese workers back to their hometown and return, even though the document is correct, the checkpoints do not allow. There are causing difficulties in recruiting and employing good immigrant labors.

After employing high school graduates or foreign workers, company will focus on providing on-the-job-training (OJT) and various fundamental training, such as work safety, fire extinguishers etc. For any technical specific skill upgrading, the operation unit will propose and granted for the technical training courses. Thus, if there is any trouble or problem happen more frequent, the manager may observe and request an additional training.

In 2018, there was more training activities has been organized than 2017, due to applying the addition of standardized systems such as T.I.S, ISO9001, T.T.M (Thailand Trusted Mark), T.L.S (Labor Standards). The annual training budget is increased from 30 thousand Baht to 100 thousand Baht, however, there is still no targeted annual training budget in a form that is clearly defined as a percentage of sales or profits. It depends on economic and managerial evaluation.

3) Company C: Snack Manufacturing, Food Industry

(Interviewed date: December 28st, 2018)

I had a superb chance to interview with the top executive of the well-known snack manufacturing, longer than 40-year-old, 100% Thai company with 2,700 million Baht (90 million USD) of total annual sale in latest year. He is the 2nd generation and eldest successor of this giant local family business. Export growth was 10 percent comparted to last year and market proportion is 80 percent in domestic and 20 percent in overseas such as China, Hong Kong, Taiwan, and ASEAN countries. Company C is currently concentrating in penetrate to new oversea territories and also developing digital marketing for domestic consumers, therefore human capital with soft-skills and international competences are necessary.

Food industry is labor-intensive industry. There are 1,532 employees since output growth and profit was solely driven by increasing of labor input and sale amount significantly. The fact that their labor productivity is rather low at 18 USD per hour worked compared with other industries. Since most of workers have been working since the father regime. Aging, slow, low-tech workers are the worries. The leader seemed to recognize these constraints and trying to adapt the '*new change*' by applying 'outside-in strategy' on global standards and human resources development strategies.

There are 3 systematic training and development strategies; (1) Bottom-up strategy: department or division manager proposes training needs and development plan for the next fiscal year. Personnel department is allocated the target budget of 2-3 million Baht per year. For example, the fried department will request training module to reduce waste. (2) Top-down strategy: top executive directs to the personnel department to provide additional skills and human intelligence trainings such as oversea marketing, digital marketing, hiring experts to support obtaining the 'Global Standards for Food Safety (BRC)' program to serve 'the King of Nut policy', production quality assurance, English language course, and (3) Compulsory training courses: such as Food Safety, firefighting, first aid, 5S., annual seminars and outing to stimulate passion and team work building.

4) Company D: Textile Manufacturing, Textile Industry

(Interviewed date: January 8th, 2019)

Company D is a large-scale textile manufacturing. 25-year-old with 520 employees and workers, sales in 2018 over 800 million baht (25 million USD), focused on selling to major customers both domestic and exported to many countries especially China and Japan. Company D established in a couple years before the Asian Financial Crisis and the Baht's devaluation. A large number of textile businesses and textile factory in Thailand had been closed or relocated to neighboring countries such as Laos, Cambodia and Vietnam.

However, this company choose to seize opportunities while many manufacturers in Thailand collapsed or moved away, but this factory was leapfrogging, expanding and developing its production technology by purchasing bulky lots of second hand machineries with very low cost from textile factories that have been shut down in Japan. They imported all machines and parts to Thailand and repaired them. Half of the machines used in the production line, while the other half uses as a spare part. As a result, company can produce at lower unit cost and improve product quality to reach Japanese and global standards. Their labor hourly cost is 93.4 THB, but the labor productivity measured by the output per hour worked is high as 622.4 THB or 20.7 USD. With confidence in the made-in-Japan's machines, products can be sold to major customers especially Japanese customers.

The interviewee is the first-generation business owner. The experience of being a mechanical technician is considered as the major strength of this company. Because the owner

understands technical system of all machines and can either control, repair and replace. The factory emphases on using a large number of machines with the least amount of labor. The key success factors of business are "good quality, good services, good innovation and good price". In terms of employees and workers, they have Job Description (JD), Work & Instruction (WI) at all levels to lead to setting up the Key Performance Indicators (KPIs) for evaluation and training.

Since Company D has paid much importance to human capital. In terms of human resource development, he suggested that it should be considered ways to input knowledge for each worker in addition to compulsory trainings. For example, how to develop specific skills for each individual, how can employers support the advancement of each person's skills. It seems that most of the training programs is done in wide-ranging, putting a bold face, then it is too general. Thus, how to be specific, individual, and tailor to suit for each worker's target potential and also their lifestyle. Professional Qualifications System for each skill must be seriously taken into account and implemented in all industries.

5) Company E: Electrical Cabinet Manufacturing, Metals and Electronics Industry

(Interviewed date: January 10th, 2019)

Company E is producing electrical cabinet under its own brand and selling both domestic and export abroad. The 2nd generation-young CEO recently took care the business after the parents who has been in this business for over 30 years. Modernized company is currently preparing to raise funds from the stock market to invest and expand the business which will focus on purchasing high-tech machineries and automation system. The CEO graduated with a bachelor's degree in engineering. 7 years ago, he was a trainee in the production department firstly and he went on training in business management. When company was moving to a new factory, he became the CEO who focusing on developing ERP system, warehouse systems, re-order points, in order to increase the efficiency of their own warehouse with fastest delivery system, so called "Morning order, Afternoon deliver"

More than 500 employees and workers of the company, consisting of 40 office workers, whom graduated with a vocational certificate. The level of HR, procurement, financial accounts are the longstanding people who can be trusted since the parent period. However, they are lack of essential skills of this era. The have to develop new skills such as English. CEO have his brother who has good English skills to assist and take care of business development and international sales

to foreign customers in Thailand, such as Japan and Europe. At the factory side, there will be a production manager, who is a cousin, 15 years' experience, graduated a bachelor's degree in marketing but had been obtained on the job training (OJT) for many years. Therefore, he is understanding the whole production processes. For factory labor, most of them graduated from grade 9 or lower and 30-40% are foreign immigrant workers (Laos) who had been employed without any skills but trained by OJT system.

The company's main labor policy is not to increase labor in the factory, if resigned, company will not employ any additional. Thus, they focus on purchasing and developing new machinery and automation systems from Japan and Germany. There are several labor problems for example, late coming, leaving without notice, requesting higher wage all times, higher welfare costs and more employee benefit by laws, more complicated management, lacking of young labor, sexual affair and group brawling. There are presently problems in the factory from the social media, such as chained Ponzi, direct selling, informal loan, which if the workers borrow money informally, if they are not able to pay back money in time, it is often affecting the company, such as more fraud problems happen.

Recently, the company has more focused on HR systems than in the parent's era. However, most of HR activities are HR management, there is rarely HR development or training programs out of compulsory activities. Last year, they have initiated the "Core Value" workshop among manager and head level. They are inviting experts to train on "FIST 4.0" which is Flexible, Innovation, Speed, and Trustworthy. Company is trying to motivate higher productivity by the 'Payment upon Competency' system or the additional payment based on the ability to work with more difficulty tasks, the introduction of Radar Chart and multi-skills development. In the near future, they will apply regular skill examinations and skill trainings.

6) Company F: Auto-parts and Brake, Automobile Industry

(Interviewed date: March 15th, 2019)

Company F is a specialized Japanese manufacturer of brakes and engine components for all vehicles, from light-duty to heavy-duty. There is a parent company producing automotive parts in Japan. Manufacturing plant in Thailand established since 1990. They are now diversifying vertically our production range to cover all major production processes including aluminum die

casting, precision machining and product assembly. Their products consist of engine pumps, high precision parts, chassis part, bracket and others. This company will focus on the concept “3 + 2G” or “3 + 2Gen”. They are “Genba”, production in real locations, “Genbutsu” the real thing, “Genjitsu”, the real situation, “Genri”, theoretical principles and “Gensoku”, rules and regulations in practice.

This Japanese company is one of the best practice models in human capital management and development in Thailand. For example, (1) There have implemented the Skills Standard, and Competency Evaluation, jointed with the regional Institution for Skill Development, Ministry of Labor, in 5 skills such as forklift controlling, measurement tools, etc.

(2) There is an Individual Skill Matrix and Operator Skill Chart, divided into hard & soft skills. They conduct the Annual Test, 360-degree Evaluation on Employee Satisfaction by linking up with the adjustment of salary, wages, bonuses and welfare.

(3) There is the in-house Smart Training Center to train the new employee and used by other training programs such as production process development, basic instrument, communication (soft skill), quality awareness, safety training, accident prevention and accident simulator (called “Safety Dojo”)

(4) There is the preparation of the successor by initiating various activities such as the cross-function project among assistant manager levels and above, finding external young stars in conjunction with local technical colleges, and providing scholarships and organizing internship for technical colleges students.

Table A3-3. Year of schooling, experience and training cost by industry, 2018

Code	Officer's Mean Years of schooling	Labour's Mean Years of schooling	Office Manager's Years of schooling	Office Manager's Years of Experiences	Plant Manager's Years of schooling	Plant Manager's Years of Experiences
	(years)	(years)	(years)	(years)	(years)	(years)
01	14	9	16	>10	16	>10
02	18	9	18	10	14	15
03	18	12	18	10	18	10
04	18	18	18	20	18	20
05	16	12	16	10	16	10
06	14	9	16	10	16	20
07	16	12	18	20	18	20
08	18	16	16	18	16	20
09	14	9	16	25	12	30
10	16	9	16	30	16	20
11	12	9	16	20	18	20

Code	Training (In-house)	Avg. Cost	sub-total	Training (outside)	Avg. Cost	sub-total	Total Training Cost	Total R&D Expenditures
	(times/year)	(THB)	(THB)	(times/year)	(THB)	(THB)	(THB)	(THB)
01	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
02	1	50,000	50,000	n.a.	n.a.	n.a.	n.a.	n.a.
03	4	6,000	24,000	2	8,000	16,000	40,000	n.a.
04	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
05	4	5,000	20,000	1	6,000	6,000	26,000	300,000
06	4	15,000	60,000	4	15,000	60,000	120,000	230,000
07	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
08	6	20,000	120,000	11	8,000	88,000	208,000	5,000,000
09	1	30,000	30,000	n.a.	n.a.	n.a.	n.a.	50,000
10	15	20,000	300,000	20	5,000	100,000	400,000	n.a.
11	7	2,000	14,000	2	5,000	10,000	24,000	20,000

Remark: 1) Data from sampling surveys during December 2018.
2) At exchange rate 1 USD. = 30 THB.

Source: Author.

Appendix 4

Fig. A4-1. An official letter to NSO requesting LFS database, 2019

ที่ 2562 / 005

ห้อง 210 คณะเศรษฐศาสตร์
มหาวิทยาลัยไซตามะ
เมืองไซตามะ ประเทศญี่ปุ่น

26 เมษายน 2562

เรื่อง ขอความอนุเคราะห์ข้อมูลเพื่อการทำวิทยานิพนธ์

เรียน ผู้อำนวยการสำนักงานสถิติแห่งชาติ

เอกสารแนบ รายละเอียดชื่อข้อมูลที่ต้องการ

เนื่องด้วย นายวันวิวัฒน์ เกศวา นักศึกษาปริญญาเอก ชั้นปีที่ 3 คณะเศรษฐศาสตร์ มหาวิทยาลัยไซตามะ จังหวัดไซตามะ ประเทศญี่ปุ่น ดำเนินการศึกษาวิจัยเรื่อง *Impacts of Human Capital Growth on Industrial Development in Thailand* ภายใต้การกำกับดูแลของคณาจารย์ Professor Dr. Masaharu NAGASHIMA, Professor Dr. Hiroyuki TAGUCHI และ รองศาสตรจารย์ ดร.กิตติ ลิ่มสกุล คณะเศรษฐศาสตร์ มหาวิทยาลัยไซตามะ ซึ่งในการศึกษาวิจัยจำเป็นจะต้องใช้ข้อมูลสถิติ จึงมีความจำเป็นอย่างยิ่งที่จะต้องขอความอนุเคราะห์ข้อมูลที่สำนักงานสถิติแห่งชาติได้จัดทำขึ้น

ในการนี้ จึงใคร่ขอความอนุเคราะห์ ข้อมูลดิบการสำรวจภาวะการทำงานของประชากรรายไตรมาส ตั้งแต่ปี พ.ศ. 2523 (หรือ ค.ศ. 1980) ไตรมาสที่ 1 จนถึง ปัจจุบัน

จึงเรียนมาเพื่อโปรดพิจารณาอนุเคราะห์ด้วย จักเป็นพระคุณยิ่ง

ขอแสดงความนับถือ

(รองศาสตราจารย์ ดร.กิตติ ลิ่มสกุล)
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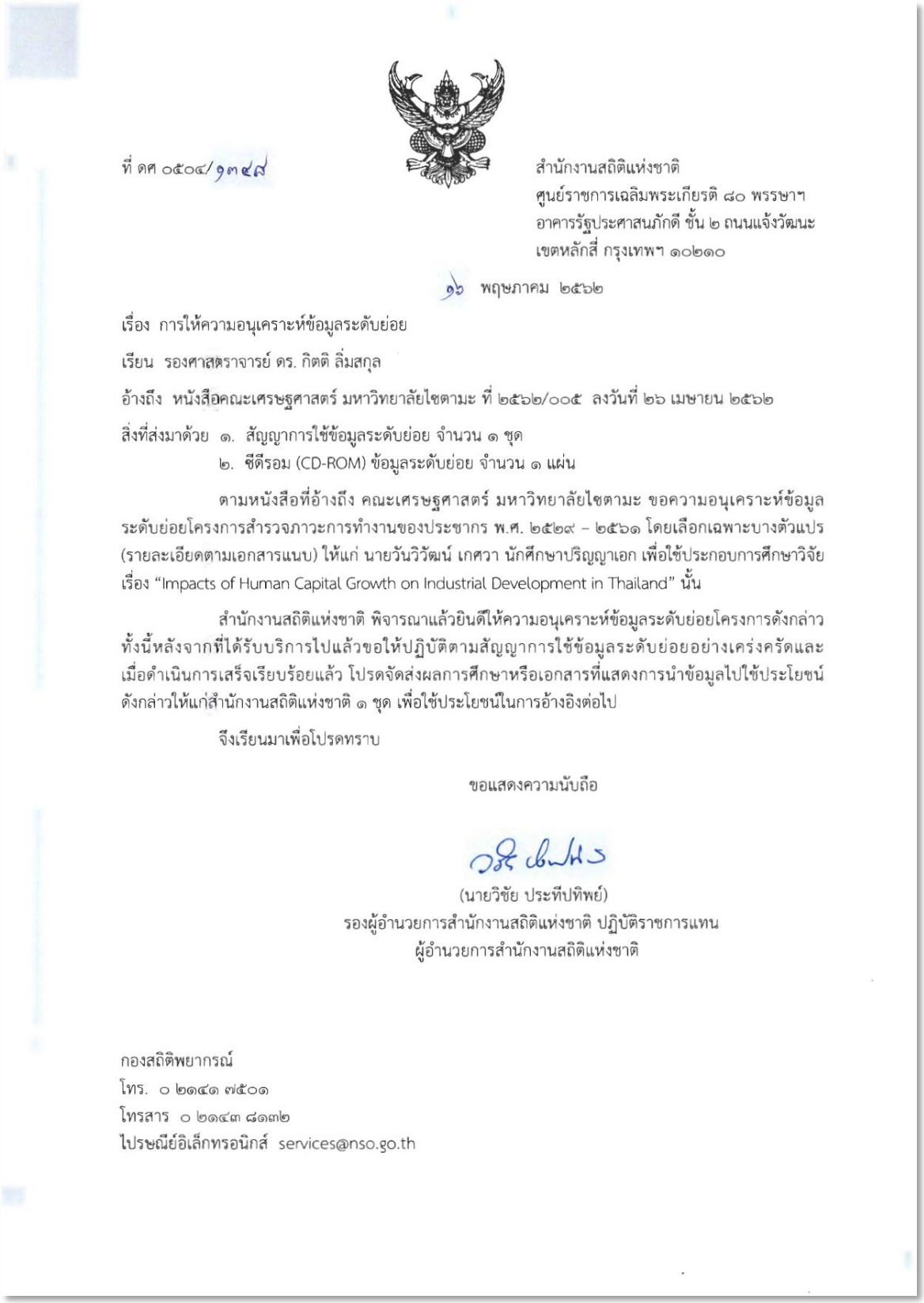
Fig. A4-2. An official approval letter from NSO, 2019



ที่ ดศ ๐๕๐๔/๑๓๔๘

สำนักงานสถิติแห่งชาติ
ศูนย์ราชการเฉลิมพระเกียรติ ๘๐ พรรษาฯ
อาคารรัฐประศาสนภักดี ชั้น ๒ ถนนแจ้งวัฒนะ
เขตหลักสี่ กรุงเทพฯ ๑๐๒๑๐

๑๖ พฤษภาคม ๒๕๖๒

เรื่อง การให้ความอนุเคราะห์ข้อมูลระดับย่อย

เรียน รองศาสตราจารย์ ดร. กิตติ ลิ่มสกุล

อ้างถึง หนังสือคณะเศรษฐศาสตร์ มหาวิทยาลัยไชตามะ ที่ ๒๕๖๒/๐๐๕ ลงวันที่ ๒๖ เมษายน ๒๕๖๒

สิ่งที่ส่งมาด้วย ๑. สัญญาการใช้ข้อมูลระดับย่อย จำนวน ๑ ชุด
๒. ซีดีรอม (CD-ROM) ข้อมูลระดับย่อย จำนวน ๑ แผ่น

ตามหนังสือที่อ้างถึง คณะเศรษฐศาสตร์ มหาวิทยาลัยไชตามะ ขอความอนุเคราะห์ข้อมูลระดับย่อยโครงการสำรวจภาวะการทำงานของประชากร พ.ศ. ๒๕๒๙ – ๒๕๖๑ โดยเลือกเฉพาะบางตัวแปร (รายละเอียดตามเอกสารแนบ) ให้แก่ นายวันวิวัฒน์ เกศวา นักศึกษาปริญญาเอก เพื่อใช้ประกอบการศึกษาวิจัย เรื่อง "Impacts of Human Capital Growth on Industrial Development in Thailand" นั้น

สำนักงานสถิติแห่งชาติ พิจารณาแล้วยินดีให้ความอนุเคราะห์ข้อมูลระดับย่อยโครงการดังกล่าว ทั้งนี้หลังจากที่ได้รับบริการไปแล้วขอให้ปฏิบัติตามสัญญาการใช้ข้อมูลระดับย่อยอย่างเคร่งครัดและเมื่อดำเนินการเสร็จเรียบร้อยแล้ว โปรดจัดส่งผลการศึกษาหรือเอกสารที่แสดงการนำข้อมูลไปใช้ประโยชน์ดังกล่าวให้แก่สำนักงานสถิติแห่งชาติ ๑ ชุด เพื่อใช้ประโยชน์ในการอ้างอิงต่อไป

จึงเรียนมาเพื่อโปรดทราบ

ขอแสดงความนับถือ

(นายวิชัย ประทีปทิพย์)
รองผู้อำนวยการสำนักงานสถิติแห่งชาติ ปฏิบัติราชการแทน
ผู้อำนวยการสำนักงานสถิติแห่งชาติ

กองสถิติพยากรณ์
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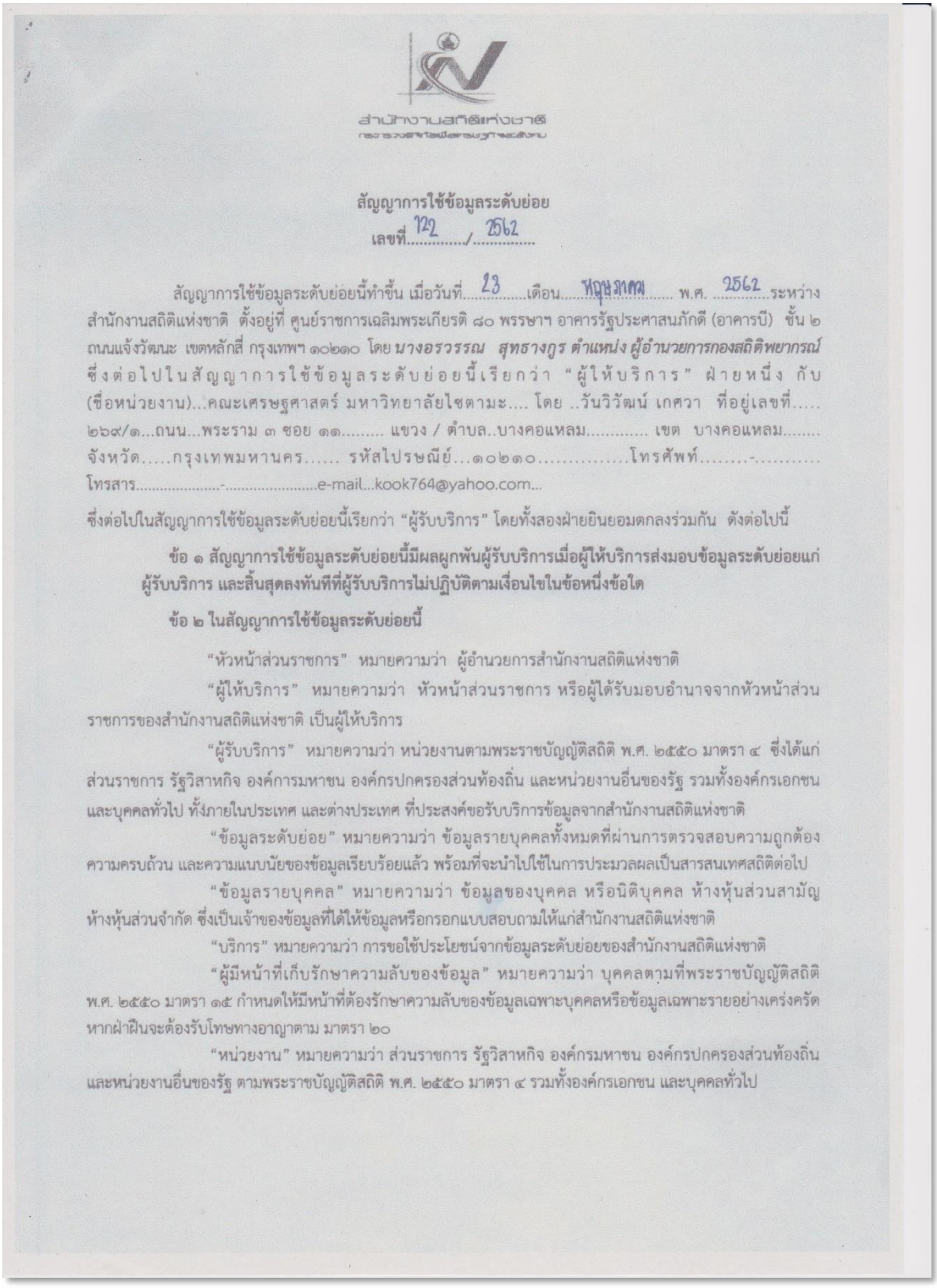
โทรสาร ๐ ๒๑๔๓ ๘๑๓๒
ไปรษณีย์อิเล็กทรอนิกส์ services@nso.go.th

Fig.A4-3. An official contract for use of database between NSO and author, 2019

Contract - Page 1



สำนักงานสถิติแห่งชาติ

สัญญาการใช้ข้อมูลระดับย่อย
เลขที่ 129 / 2562

สัญญาการใช้ข้อมูลระดับย่อยนี้ทำขึ้น เมื่อวันที่ 23 เดือน พฤษภาคม พ.ศ. 2562 ระหว่าง สำนักงานสถิติแห่งชาติ ตั้งอยู่ที่ ศูนย์ราชการเฉลิมพระเกียรติ ๘๐ พรรษาฯ อาคารรัฐประศาสนภักดี (อาคารบี) ชั้น ๒ ถนนแจ้งวัฒนะ เขตหลักสี่ กรุงเทพฯ ๑๐๒๑๐ โดย *นางอรวรรณ สุทธางกูร ตำแหน่ง ผู้อำนวยการกองสถิติพยากรณ์* ซึ่งต่อไปในสัญญาการใช้ข้อมูลระดับย่อยนี้เรียกว่า "ผู้ให้บริการ" ฝ่ายหนึ่ง กับ (ชื่อหน่วยงาน)...คณะเศรษฐศาสตร์ มหาวิทยาลัยไชตามะ.... โดย ..วันวิวัฒน์ เกศวา ที่อยู่เลขที่..... ๒๖๙/๑...ถนน...พระราม ๓ ซอย ๑๑..... แขวง / ตำบล..บางคอแหลม..... เขต บางคอแหลม..... จังหวัด.....กรุงเทพมหานคร..... รหัสไปรษณีย์...๑๐๒๑๐.....โทรศัพท์.....-..... โทรสาร.....-.....e-mail...kook764@yahoo.com...

ซึ่งต่อไปในสัญญาการใช้ข้อมูลระดับย่อยนี้เรียกว่า "ผู้รับบริการ" โดยทั้งสองฝ่ายยินยอมตกลงร่วมกัน ดังต่อไปนี้

ข้อ ๑ สัญญาการใช้ข้อมูลระดับย่อยนี้มีผลผูกพันผู้รับบริการเมื่อผู้ให้บริการส่งมอบข้อมูลระดับย่อยแก่ผู้รับบริการ และสิ้นสุดลงทันทีที่ผู้รับบริการไม่ปฏิบัติตามเงื่อนไขในข้อหนึ่งข้อใด

ข้อ ๒ ในสัญญาการใช้ข้อมูลระดับย่อยนี้

"หัวหน้าส่วนราชการ" หมายความว่า ผู้อำนวยการสำนักงานสถิติแห่งชาติ

"ผู้ให้บริการ" หมายความว่า หัวหน้าส่วนราชการ หรือผู้ได้รับมอบอำนาจจากหัวหน้าส่วนราชการของสำนักงานสถิติแห่งชาติ เป็นผู้ให้บริการ

"ผู้รับบริการ" หมายความว่า หน่วยงานตามพระราชบัญญัติสถิติ พ.ศ. ๒๕๕๐ มาตรา ๔ ซึ่งได้แก่ ส่วนราชการ รัฐวิสาหกิจ องค์การมหาชน องค์กรปกครองส่วนท้องถิ่น และหน่วยงานอื่นของรัฐ รวมทั้งองค์กรเอกชน และบุคคลทั่วไป ทั้งภายในประเทศ และต่างประเทศ ที่ประสงค์ขอรับบริการข้อมูลจากสำนักงานสถิติแห่งชาติ

"ข้อมูลระดับย่อย" หมายความว่า ข้อมูลรายบุคคลทั้งหมดที่ผ่านการตรวจสอบความถูกต้อง ความครบถ้วน และความแนบนัยของข้อมูลเรียบร้อยแล้ว พร้อมที่จะนำไปใช้ในการประมวลผลเป็นสารสนเทศสถิติต่อไป

"ข้อมูลรายบุคคล" หมายความว่า ข้อมูลของบุคคล หรือนิติบุคคล ห้างหุ้นส่วนสามัญ ห้างหุ้นส่วนจำกัด ซึ่งเป็นเจ้าของข้อมูลที่ได้ให้ข้อมูลหรือกรอกแบบสอบถามให้แก่สำนักงานสถิติแห่งชาติ

"บริการ" หมายความว่า การขอใช้ประโยชน์จากข้อมูลระดับย่อยของสำนักงานสถิติแห่งชาติ

"ผู้มีหน้าที่เก็บรักษาความลับของข้อมูล" หมายความว่า บุคคลตามที่พระราชบัญญัติสถิติ พ.ศ. ๒๕๕๐ มาตรา ๑๕ กำหนดให้มีหน้าที่ต้องรักษาความลับของข้อมูลเฉพาะบุคคลหรือข้อมูลเฉพาะรายอย่างเคร่งครัด หากฝ่าฝืนจะต้องรับโทษทางอาญาตาม มาตรา ๒๐

"หน่วยงาน" หมายความว่า ส่วนราชการ รัฐวิสาหกิจ องค์กรมหาชน องค์กรปกครองส่วนท้องถิ่น และหน่วยงานอื่นของรัฐ ตามพระราชบัญญัติสถิติ พ.ศ. ๒๕๕๐ มาตรา ๔ รวมทั้งองค์กรเอกชน และบุคคลทั่วไป

ข้อ ๓ วัตถุประสงค์ และระยะเวลาการใช้ข้อมูลระดับย่อย

๓.๑ ผู้รับบริการมีความประสงค์ขอใช้ข้อมูลระดับย่อย
โครงการสำรวจภาวะการทำงานของประชากร พ.ศ. ๒๕๒๙ – ๒๕๖๑ โดยเลือกเฉพาะบางตัวแปร เพื่อใช้ประกอบการศึกษาวิจัย เรื่อง "Impacts of Human Capital Growth on Industrial Development in Thailand" นั้น

๓.๒ ระยะเวลาการใช้ข้อมูลระดับย่อย ตั้งแต่วันที่.....เดือน.....พ.ศ. ..... ถึง วันที่.....เดือน.....พ.ศ. .....

ข้อ ๔ ระยะเวลาของสัญญาการใช้ข้อมูลระดับย่อย

สัญญาการใช้ข้อมูลระดับย่อยฉบับนี้มีผลบังคับใช้เมื่อได้ลงนามในสัญญาการใช้ข้อมูลระดับย่อย และจะสิ้นสุดลงเมื่อผู้รับบริการได้ส่งผลงานให้แก่สำนักงานสถิติแห่งชาติแล้ว

ข้อ ๕ ผู้รับบริการต้องปฏิบัติตามหลักเกณฑ์การขอรับบริการข้อมูลระดับย่อยของผู้ให้บริการ

โดยรายละเอียดหลักเกณฑ์และการคิดค่าใช้จ่าย(ถ้ามี) ให้เป็นไปตามเอกสารแนบท้ายสัญญาการใช้ข้อมูลระดับย่อยนี้

ข้อ ๖ หน้าที่ของผู้รับบริการ

เมื่อผู้รับบริการได้รับข้อมูลระดับย่อยไปจากผู้ให้บริการแล้ว ผู้รับบริการย่อมผูกพันตนเป็น "ผู้มีหน้าที่เก็บรักษาความลับของข้อมูล" ตาม พ.ร.บ. สถิติ ๒๕๕๐ และจะต้องถือปฏิบัติตามข้อกำหนดดังต่อไปนี้อย่างเคร่งครัด

๖.๑ ผู้รับบริการต้องใช้ข้อมูลระดับย่อยตามวัตถุประสงค์ และเงื่อนไขที่กำหนดไว้ในสัญญาการใช้ข้อมูลระดับย่อยนี้เท่านั้น หากมีการใช้ข้อมูลระดับย่อยไม่เป็นไปตามวัตถุประสงค์ ผู้ให้บริการมีสิทธิเลิกสัญญานี้

๖.๒ ผู้รับบริการต้องใช้ข้อมูลระดับย่อยเพื่อประโยชน์สำหรับการจัดทำสถิติ วิเคราะห์ หรือวิจัย และผู้รับบริการจะต้องไม่นำข้อมูลไปหาประโยชน์ใด ๆ นอกเหนือวัตถุประสงค์ที่ระบุไว้ในข้อ ๓ เท่านั้น เว้นแต่ได้รับอนุญาตเป็นลายลักษณ์อักษรจากผู้ให้บริการ

๖.๓ ผู้รับบริการต้องศึกษาและทำความเข้าใจกับรายละเอียดของโครงการสำมะโน/สำรวจต่าง ๆ และข้อจำกัดทางด้านวิชาการก่อน เพื่อป้องกันการนำข้อมูลระดับย่อยไปใช้ผิดจากหลักวิชาการ

๖.๔ ผู้รับบริการต้องส่งรายงานผลการวิเคราะห์ ผลงานวิจัย วิทยานิพนธ์ หรือข้อมูลที่จัดทำขึ้นเพิ่มเติมจากข้อมูลระดับย่อยที่ขอรับบริการให้สำนักงานสถิติแห่งชาติ จำนวน ๑ ชุด ภายใน ๖๐ วัน หลังจากสิ้นสุดระยะเวลาตาม ข้อ ๓.๒ และหากไม่ส่งผลงานดังกล่าว สำนักงานสถิติแห่งชาติขอสงวนสิทธิ์ในการพิจารณาให้บริการข้อมูลในครั้งต่อไป

๖.๕ ผู้รับบริการต้องรักษาความลับของข้อมูลระดับย่อยอย่างเคร่งครัด และต้องรับผิดชอบในความเสียหายใด ๆ ที่เกิดจากการรั่วไหลของข้อมูลระดับย่อย

๖.๖ ผู้รับบริการต้องจัดให้มีระบบความปลอดภัย (Security) เพื่อป้องกันการเข้าถึงข้อมูลระดับย่อยอย่างรัดกุมเพียงพอ

๖.๗ ผู้รับบริการจะต้องให้ความคุ้มครองและปกป้องผู้ให้บริการ ให้ปลอดพ้นจากการเรียกร้องค่าเสียหาย ความเสียหาย หรือ ค่าใช้จ่ายใด ๆ อันเกิดจากการนำข้อมูลระดับย่อยไปใช้

๓

ข้อ ๗ ข้อห้ามของผู้รับบริการ

ห้ามผู้รับบริการทำสำเนา ดัดแปลง ขาย ให้เช่า ให้ประโยชน์ อนุญาต หรือกระทำการใด ๆ ต่อข้อมูลระดับย่อยที่ขอรับบริการตามสัญญาการใช้ข้อมูลระดับย่อยนี้ แก่ผู้อื่น หรือให้ผู้อื่นได้ข้อมูลระดับย่อยดังกล่าวด้วยวิธีการใด ๆ เว้นแต่จะได้รับอนุญาตเป็นลายลักษณ์อักษรจากผู้ให้บริการ

ข้อ ๘ ความรับผิดในความเสียหายของผู้รับบริการ

๘.๑ ผู้รับบริการต้องรับผิดชดใช้ค่าเสียหายที่เกิดจากการรั่วไหล หรือผลกระทบด้านต่าง ๆ รวมทั้งความเสียหายอย่างใด ๆ ที่เกิดจากการนำข้อมูลระดับย่อยไปใช้

๘.๒ หากผู้รับบริการไม่ปฏิบัติตามหน้าที่ในข้อ ๖ หรือฝ่าฝืนข้อห้ามในข้อ ๗ ให้ถือว่าผู้รับบริการไม่ปฏิบัติตามข้อตกลง และผู้รับบริการตกลงยินยอมชดใช้ค่าเสียหายอย่างใดๆ ที่เกิดขึ้นต่อผู้ให้บริการอันเนื่องมาจากการไม่ปฏิบัติตามสัญญาการใช้ข้อมูลระดับย่อยนี้

ทั้งนี้ ความรับผิดของผู้รับบริการยังมีอยู่แม้ความผูกพันตามสัญญาการใช้ข้อมูลระดับย่อยจะสิ้นผลไปแล้ว หากปรากฏในภายหลังว่ามีการรั่วไหลของข้อมูลระดับย่อย หรือ เกิดกรณีตาม ข้อ ๖.๗

ข้อ ๙ ข้อมูลและผลงานวิจัย

๙.๑ ข้อมูลระดับย่อยที่ผู้รับบริการได้รับจากผู้ให้บริการ ตามสัญญาการใช้ข้อมูลระดับย่อยนี้ เป็นลิขสิทธิ์ของผู้ให้บริการแต่เพียงผู้เดียว

๙.๒ ผลงานการวิเคราะห์ หรือผลงานการวิจัยต่าง ๆ ที่เกิดจากการใช้ข้อมูลระดับย่อยตามสัญญาการใช้ข้อมูลระดับย่อยนี้ เป็นของผู้รับบริการ ทั้งนี้ ผู้รับบริการยินยอมให้ผู้ให้บริการมีสิทธิเข้าดูและขอใช้ประโยชน์ในผลงานดังกล่าวได้ โดยแจ้งให้ผู้รับบริการทราบ

สัญญาการใช้ข้อมูลระดับย่อยนี้ทำขึ้นเป็นสองฉบับ มีข้อความถูกต้องตรงกันทุกประการ ซึ่งคู่สัญญาการใช้ข้อมูลระดับย่อยทั้งสองฝ่ายได้อ่านและเข้าใจข้อความโดยละเอียดแล้ว จึงลงลายมือชื่อไว้เป็นหลักฐาน และคู่สัญญาการใช้ข้อมูลระดับย่อยทั้งสองฝ่ายต่างยึดถือสัญญาการใช้ข้อมูลระดับย่อยนี้ไว้ฝ่ายละหนึ่งฉบับ

ผู้รับบริการ	
ลงชื่อ.....(นักศึกษา/ผู้วิจัย)	ลงชื่อ..... ผู้ให้บริการ
(นายวันวิวัฒน์ เกศวา)	(นางอรวรรณ สุทธางกูร)
ตำแหน่ง นิสิตปริญญาเอก	ตำแหน่ง ผู้อำนวยการกองสถิติพยากรณ์
ลงชื่อ.....พยาน	ลงชื่อ.....พยาน
(รองศาสตราจารย์ ดร. กิตติ ลิ่มสกุล)	(นางโสมน้อย บุราเจริญ)
ตำแหน่ง อาจารย์ที่ปรึกษา	ตำแหน่ง ผู้อำนวยการกลุ่มบริการและเผยแพร่ข้อมูลสถิติ

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