Research and Development – 3

RCP
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Macro- and Mesoeconomic Effects of Investment in Vocational Education

Feng Xiao

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Imprint

Editors

Paryono Paryono, Bandar Seri Begawan, Brunei Darussalam
Thomas Schröder, Shanghai, China
Georg Spöttl, Bremen, Germany

Author

Feng Xiao, Shanghai. China

Participating Researchers

Huang Lanjin, Shanghai, China
Zhu Yanyuan, Shanghai, China
Sirilak Hanvatananukul, Bangkok, Thailand
Bounseng Khammounty, Vientiane, Laos
Tran Hong Van, NamDinh, Vietnam

RCP Secretariat and
GIZ office in Shanghai/ China

Chinese-German Building 1109
Tongji University, 1239 Siping Street
200092 Shanghai, China
T + 86 (0) 21 6598 0423
F + 86 (0) 21 6598 5145
E giz-china@giz.de
W www.giz.de

Project:

Regional Cooperation Platform for Vocational Teacher Education in Asia (RCP)
GIZ-Programme Director: Helmut Schönleber
Director of RCP Secretariat: Dr Thomas Schröder

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List of Abbreviations

BMZ	Federal Ministry for Economic Cooperation and Development
CNY	Chinese Renminbi Yuan
GDP	Gross Domestic Product
GIZ	Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH
GSO	General Statistical Organization
IMF	International Monetary Fund
MoE	Ministry of Education
MoET	Ministry of Education and Training
MoLISA	Vietnamese Ministry of Labour - Invalids and Social Affairs
NPF	National Product Function
PDR	People's Democratic Republic
RCP	Regional Cooperation Platform for Vocational Teacher Education in Asia
USD	US- Dollar

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Executive Summary

National or regional growth potential mainly depends on production factors. Continuous technological innovation rather than non-renewable production factors is the fundamental driver for the sustainable development of economies.

Whether embodied in physical capital or labour skills, technological innovation fundamentally comes from the acquisition, accumulation, inheritance and application of knowledge, which is known as human capital accumulation and its output effect. General and vocational education has a significant impact on it. Therefore, human capital accumulation is the key factor influencing national or regional growth potential. General and vocational education is the main access to it.

This article is the research result of the P6, regional cooperation platform (RCP). With the participation of Chinese researchers and RCP coordinators from Lao PDR, Thailand and Vietnam, the research team chose typical emerging and developing economies as objects, looks for reasonable proxies of human capital accumulation, and then constructed econometric models to measure the contribution of general and vocational education on human capital accumulation and national output growth.

The results show that general and vocational education has a positive impact on the aggregate output of China, Thailand and Vietnam. It yields greater returns of human capital than physical capital stock. As far as the different development level and human capital constitution of the studied countries, each country's output effects in terms of general and vocational education has its own feature: general and vocational higher education as well as vocational secondary education have the most significant output effect in China; secondary education including vocational secondary education has the most positive impact on Thailand's aggregate output; elementary education and vocational training contribute most to Vietnam's national output growth. These results can provide reference for the education and industry development policy-makers in China and the Southeast Asian countries.

We are extremely grateful for the subsidization by the federal ministry for economic cooperation and development (BMZ), to P6 research works and their publication, the support of the RCP Secretariat, established in Tongji University by GIZ, for the research team and cooperation of RCP coordinators from Lao PDR, Thailand and Vietnam. For all this we wish to express our most sincere thanks to all the organizations and people mentioned above.

Last but not least, we hope this research can promote and further vocational education cooperation in the Southeast Asian countries.

1 Introduction

1.1 Research objectives

The main objectives of this research have been: to construct econometric models according to different development levels as well as data availability of Asian emergency and developing countries, such as China, Lao PDR, Thailand and Vietnam; to perform a qualitative and quantitative analysis of general and vocational educations' impact on national output growth of the nations studied nations studied; to provide scientific suggestions for education particularly regarding vocational education policy makers of the nations mentioned above.

1.2 Research contents

In accordance with the above objectives, and the different development levels and data availability of the nations studied, this article endeavours to solve the following two questions:

Find appropriate proxies of human capital to reflect the mechanism of general and vocational education on human capital accumulation;

Construct econometric models to analyse general and vocational educations' impact on aggregate output.

It is widely acknowledged that human capital accumulation has a positive impact on long term economic growth (Schultz, 1961a; Becker, 1964). As economists find that human capital is a very important factor to explain TFP[1], many empiricists have demonstrated a significant positive correlation between human capital accumulation and TFP (Balogh et al., 1963; Griliches and Jorgenson, 1966; Lucas, 1988).

Taking it as the major means to accumulate human capital2, general and vocational education is one of the most important factors contributing to national output growth (Griliches, 1964 and 1970; Tilak, 1989; Jung and Thorbecke, 2003). In previous studies, many education indices have been used as proxies of human capital3. There are great differences between the results of studies which use diverse proxies: some economists find a significant positive correlation between human capital accumulation and economic growth (Mankiw et al., 1992; Bassanini and Scarpetta, 2002; Florida et al., 2008) while others demonstrate the correlation to be either negative or positive but insignificant (Benhabib and Spiegel, 1994; Pritchett, 1996; Bils and Klenow, 2000). Although it does not actually exist a widely accepted proxy of human capital (Cohen and Soto, 2007), "average schooling years" is a commonly used index (Barro and Lee, 2010).

1 Aukrust (1959) finds that human capital can explain parts of residuals of production function and 1.81% of Norway's economic growth can be attribute to human factor.

2 In addition to education, experience, such as learning by doing, is also one of the major approaches promote the human capital accumulation (Arrow, 1962; Lucas, 1988). But this research focuses on the relationship between education and output rather than includes learning by doing. Because learning by doing is hard to measure (Dinopoulos and Thompson, 2000; Park, 2006) and schooling implies greater ability to absorb advanced technology (Barro, 2010).

3 Such as school enrollment ratios and literacy rates in Romer (1989), Barro (1991) and Mankiw *et al.* (1992), average schooling years in Barro and Lee (1993, 1996, 2001, 2010), Cohen and Soto (2007). The advantage and disadvantage of education indices are discussed in Barro and Lee (1993), Pritchett (1996).

But this method has some limitations in analysing human capital stock and the economic growth of rapid industrializing economies. The reason for this is that rapid industrializing increases national income, and as a result, education expenditure rises significantly. An incremental part distributed to the school-age population to improve their education situation, has a significant impact on average schooling years and the distribution of labours' educational attainment (Park, 2006).Taking China as an example, there has been an clear increase in the average employee's schooling years and a great change of proportional distribution of labour at different education levels (Feng *et al*., 2012) over the past decades. Obviously, that dispersion should be taken into consideration in choosing the appropriate proxy to reflect human capital stock. However, using both average and dispersion indexes also have limitations: their multicollinearity reduces the reliability of model explanation (Deng and Tang, 2010). Therefore, human capital proxy selection depends on the economic development level of the studied the nations studied.

Given the differences between the economic level of the nations studied and statistical data availability, the single method will be marred by data deficiencies, the authors constructed two econometric models to analyse the effect of education, particularly that of vocational education on the human capital accumulation and aggregate output. The results of different analytical procedures can become complementary and provide mutual authentication.

With reference to Feng *et al*. (2012), Model 1 used the average schooling years or dispersion of labours' educational attainment to measure the quality of human capital and its output effect; according to different development levels and labours' educational attainment data availability of the nations studied, the authors constructed Model 2 as a substitution: first they looked for proxies from the prospect of the whole of the society's education expenditure and then analysed its contribution to the national output growth. By referring to the ideas of Uzawa (1965) and Lucas (1988), the authors regard the education department as a dependent production department: the education expenditure is used to train students in schools; graduates from different education levels enter the labour market and become employees of various education backgrounds; then, with employees' participating in production, human capital accumulation realizes its output effect.

Models of the four nations studied are listed in Table 1.1.

Table 1.1: **Model construction**

Research objectives / Model	Model 1	Model 2
China	√[4]	√[5]
Lao PDR		√[6]

4 Feng *et al.* (2012) studies human capital's output effect from the perspective of labour education attainment, corresponding to Model 1.

5 Authors use Model 2 to analyzes China's human capital output effect and draw same conclusion of Model 1, which proves feasibility of Model 2 and provides reference for countries lack of labour education attainment data to analyse human capital output effect.

6 Since Lao PDR is lack of labour education attainment data, this research attempt to use model 2 to do the analysis. But there is great fluctuation in its education expenditure data and the result will be invalid since its data resource is incomplete. Therefore, authors didn't do further study but just enumerate the data we've got at present. After completion of Lao's data, we can do the analysis with Model 2.

Thailand	√	
Vietnam	√	

1.3 Research process

Research work will be carried out according to the following order:

- Construct national production function (NPF) of the nations studied
- Based on NPFs, analyze general and vocational education's output effect by comparative statics.

  Suppose an economy's aggregate output is decided by physical capital stock, pure labour and human capital stock. Production factors are treated as follows:
- Considering heterogeneity, authors make quality adjustment of physical capital to reflect the contribution of technical progress caused by quality improvement and investment strengthen.
- Given to labour surplus phenomenon in China (Hu & Yang, 2001; Cai, 2002; Feng *et al.*, 2012), national production function can't be deduced from the input-output relation directly. Therefore, authors utilize education expenditure of the whole society as the proxy of the human capital accumulation and divide labour into two types: lower secondary education and below as well as upper secondary education (including vocational secondary education) and up, in order to analyze how latter affect human capital accumulation, decrease the disturbance from the labour surplus phenomenon as well.
- As the production cycle of the education department is durationally long, a time-lag problem has to be taken into consideration (the current period's education expenditure cannot impact on human capital accumulation in the same term, and thus cannot influence the national production output during the self-same period)[7].
- Fiscal education expenditure is used intensively to approximate human capital accumulation[8]. But authors use the whole society education expenditure including fiscal education expenditure, society and household (individual) investment[9] to estimate the human capital accumulation and then analyse its effect on aggregate output. This approximation method can highlight the real effect of education investment on national economy output[10].

7 Wang *et al.* (2009) set the time-lag cycle as three years by using the statistics verification method, which still lacks system basis as well as principle basis and the article does not go further study to distinguish each time span of different education levels and their mutual connection, so it can't describe characteristics of the education system. In order to estimate the contribution of education production more pertinently, the study takes time-lag problem into consideration. According to different schooling years of each education levels, authors set different lag years to adjust data in order to reflect the reality. In addition, the system correlation between the education expenditure and GDP can be desalinated by corresponding data processing.

8 Zhou and Sun, 2002; Zhu and Hu, 2008; Hussin *et al.*, 2012.

9 In the studies of Thailand and Vietnam, authors still use fiscal education expenditure as the proxy of human capital because of data deficiency.

10 Take China as an example, big part of secondary vocational and higher education comes from household, which even outnumber fiscal education expenditure (see Figure 4.1).

Behaviour featuring different orientations. One being physical capital investment that mainly affects economic growth by accumulating capital stock. The other is human capital investment, by enlarging investment in educational institutions. The authors then made a comparative static analysis to observe which behaviour contributed more to the growth potentials of countries in the study.

1.4 Literature Review

1.4.1 Human capital accumulation

Solow (1957) found in the period 1909-1949 87.5% of American gross output per man hour could be attributed to technological progress and the remainder from growing physical capital. But TFP is still exogenous in the neoclassical Solow-Swan model[11]. In the mid-1980s, new growth theory sees TFP as endogenous. It holds that investment in human capital, innovation, and knowledge are significant contributors to economic growth[12].

With reference to the human capital conception of Schultz (1961) and Becker (1964) and the adjusting technology progress function of Uzawa (1965)[13], Lucas (1988) creates an endogenous economic growth model at the core of human capital. He divides labour into raw labour (tangible) and specified human capital (intangible). On the one hand, growth of human capital investment can increase labour's knowledge and skills and go on to contribute to his productivity. On the other hand, knowledge has positive externality and increasing human capital investment can produce scale effect. Therefore, human capital accumulation can be promoted by increasing investment, which can expand inputs scale, raise productivity and encourage economic growth.

In addition, Romer (1990) considered technological change to be the result of the intentional actions of people, such as research and development. Human capital accumulation and technical progress is thus deemed to be the main driver of economic growth. Grossman and Helpman (1991a, 1991b), Aghion and Howitt (1992) and Aghion *et al.* (2000) further develop the endogenous growth theory.

1.4.2 Proxy of human capital

The evaluation of education's output effects is quite different in empirical studies. Taking China as an example, Cai and Wang (1999) suggest that 23.7% of national output growth comes from human capital during 1982-1997 and its magnitude is equal to 1.9% of average annual national output growth. However,

11 Neoclassical growth theory, as devised by Solow (1956) and Swan (1956) and re-explained by Cass (1965) and Koopmans (1965), is a class of economic models of long-term economic growth set within the framework of neoclassical economics.

12 Positive externality of physical capital is also a significant contributor to economic growth. Romer (1986) finds that scale effect existed in economic growth by proving that although long-term economic growth relates to nation's output per capita and physical capital accumulation, inputs growth can't explain the output growth. Accordingly, Romer regards increasing TFP as externality of inputs, constructs endogenous growth model and explains TFP by scale effect. In fact, before Romer, Arrow (1962) also put forward a similar theory. Following on from there many new endogenous growth theories appeared, such as Brezis *et al.* (1993).

13 Uzawa (1965) assumes social resources are allocated to the education department by a certain proportion. The production function of the education department is constant returns to scale. It indirectly influences output by affecting technical level of other production department.

Song (2003) suggests that there is no significant effect of fiscal education expenditure and the average schooling years on economic growth. These differences are attributed to: different growth models, time spans and proxies of human capital. This last point is the main reason for the difference in conclusions. The following is a brief summary of indices which can be used as proxy of human capital.

- School enrolment ratio

School enrolment ratio is a widely used proxy of human capital in transnational studies[14]. For example, Barro (1991) uses primary and secondary school enrolment ratio as the proxy of human capital to study the contribution of human capital to GDP with data of 98 countries/regions during 1960-1985. He finds that there is a significant positive correlation between per capita GDP and initial human capital level. The shortcomings of this index are: 1) it is hard to determine time lag if future human capital is approximated by school enrolment. 2) as a long period of time elapses between school enrolment and human capital accumulation (Psacharopoulos and Arriagada, 1986), dropouts and immigration will introduce errors into the studies. Furthermore the accuracy of this index is questionable, especially in developing countries, as data are often higher than theactual value (Chapman and Boothroyd, 1988). As a result, the applicability and application range of this index remain unconfirmed.

- Adult literacy rate

Adult literacy rate is a commonly used proxy for human capital accumulation (Romer, 1989; Azariadis and Drazen, 1990). But this index also has some shortcomings: the main resource for gauging adult literacy rates is population census, which makes the data span very long and discontinuous. In the meantime, the adult literacy rate is not capable of reflecting the contribution of education after primary school to the national output growth.

- Educational attainment

Educational attainment is one of the most commonly used proxies of human capital accumulation. In previous empirical studies, average schooling years is often used as representation of labours' literacy background. For example, with reference to Psacharopoulos and Arriagada (1986), Kyriacou (1991) expanded the time span of data samples and explored the relation between labours' schooling years and the enrolment ratio of different forms of education. He then went on to construct a model to study the effect of human capital accumulation on aggregate output with the average schooling years as the proxy. Based their work on that, Benhabib and Spiegel (1994) discovered a positive but insignificant correlation between education level and economic growth. Since that time many scholars have expanded the time span and sample size, such as Barro and Lee (1993, 1996, 2001, 2010) who expanded the data sets of Psacharopoulos–Arriagada whereas Cohen and Soto (2007) improved the quality of data to measure output effect of human capital.

14 Tilak (1989) discusses the effect of education on output growth, poverty and pay differentials. He also gives clear elaboration about early related works.

- Education expenditure

As an important input of education, education expenditure is also a commonly used proxy of human capital accumulation. Cullison (1993), Zhou and Sun (2002), Zhu and Guo (2008) and Hussin *et al*. (2012) studied the effect of human capital on national output growth from the perspective of education expenditure and came to the conclusion that education contributes to the growth of GDP. But education expenditure usually just contains a fiscal part in pervious empirical studies, society donations as well as household expenditure are not taken into consideration. Incomplete data sources cannot reflect the real economic operation and fiscal education expenditure has a significant liner correlation with GDP, which will invalidate the regression result.

1.4.3 Social and private returns of education

Empirics which analyse the economic effect of education can be divided into two kinds: one analyses social returns while the other is analyses private returns. The former studies education's effect on national output growth from the macro perspective while the latter studies education's effect on individual, especially private income from a micro perspective.

- Social returns of education

Schultz (1961b) was the first economist to use the Cobb-Douglas production function to study education's contribution rate to American economic growth in the period 1929-1957. The result shows that 33% of American national income growth created by education. However, this method has some limitations. It supposes that marginal product of labour is equal to its cost, which means wage is the price of labour. As a matter of fact, it is not particularly reasonable to attribute all wage difference to labours' education background, as it can result in an overestimated rate of return on education investment.

Denison (1962) formulates the education simplified index method and revises the rate of return on education investment calculated by Schultz. This method has first to determine the income simplified index of different education levels, and then measure the education simplified index of base and reporting years, after that is the growth coefficient of the education index is calculated for the whole and each year, thus ultimately obtaining the national economic growth rate caused by increasing education. According to Denison's calculation, the contribution rate of education on American national income was 13.7% during 1929-1957.

Agiomirgianakis *et al*. (2002) examine the role of human capital on economic growth by using a large panel data that comprises 93 countries. The analysis indicated education to have a significant and positive long-term effect on economic growth. Moreover, its output effect was stronger as the education level increased. Zhu and Wang (2010) implemented panel data of China's provinces to measure the contribution rate of higher education on regional economic growth. The results showed that higher education made little contribution to China's national output growth during 1996-2006 and there is great gap between regions, education's contribution decrease from east to west. Feng *et al*. (2012) uses a

quality index instead of a quantity index to represent human capital stock and construct a national production function to explain China's national output. The results show that vocational education and higher education have a positive output effect. There are lots of empirics about education return on China's economic growth, such as Li (2006); Zeng (2009) and so on.

- Private returns of education

There are two main methods to measure the private returns of education. One is calculated by the internal rate of return, this index is the discount rate when an individual's education expenditure is equal to the discounted value of his income. The other is the Mincerian rate of return, which reflects increasing income attained by receiving one extra year of education (Mincer, 1958 and 1974). As the former method has strict data requirement, the latter is more widely used15. Most studies have proven that private return of education to be positive. For example, Psacharopoulos and Patrinos (2004) suggest the average return of education to be about 10% and this value is higher in poor and middle-income countries.

The classical Mincerian wage equation includes the effect of both schooling years and experience on individual income (Mincer, 1958 and 1974). The compensating differences model (Mincer, 1958) assumes individuals' initial states are homogeneous, jobs requiring more training need more income, and the compensation degree depends on the present value of income as well as different education expenditure. The accounting-identity model in Mincer (1974) is different from the former, this model assumes that income at any stage depends on previous investment, akin to the theory in Becker (1964), all of which consider the relationship between an individual's educational attainment and average income over a life time.

Although Mincer (1974) provides a practicable quantitative analysis method, it has some shortcomings. Heckman *et al.* (2003) discuss the theoretical foundations of the Mincer model and examine empirical support of it using American censuses data. 1940-1950 censuses data provide some support for Mincerian wage equation's divisibility and linearity, while 1960-1970 data support become softer and 1980-1990 data are actually inconsistent with it. Ni (2010) draws similar conclusion by using China's data during 2004-2008. The author suggests that Chinese urban residences' rate of return to education is on the rise without considering difference in industries. But if this difference is taken into consideration, particularly as some industries are monopolist, the impact of schooling years on income will be very small, The Mincerian rate of return is invalid and the contribution of education will be weaken. The obvious shortcoming of Mincerian wage equation is that it assumes education choice is made under conditions of complete information. If we introduce an uncertainty condition then the internal rate of return is not a proper index to measure the result from education investment.

15 Heckman *et al.* (2003), Li (2003), Fleisher and Wang (2004), Zeng (2004).

1.4.4 Output effect of vocational education

As vocational education has different employment orientation from general education, the output effects are different. Balogh (1969) draws the conclusion that vocational education has more value of investment than general education after analysing the human capital output effect of some African countries. Yan (1991) analyses the relationship between China's vocational education and labour productivity. By theoretical discussion and case study, he finds that compared with upper secondary school students, those who in vocational schools are more satisfied with their works if the jobs are related to their study. David and Francis (1996) studied occupational skills and global economic growth, and proposed that the development of vocational education can raise labour productivity and promote economic growth. Fan (1999) shows that vocational education, as the main source of education supply, can bridge the gap between education supply and demand. Sharmisha and Richard (2003) made an empirical analysis on the growth rate of different education and GDP during pre and post-war. They found that higher vocational college had a more positive impact on the long-term economic growth of Japan compared with other kinds of education. In China, many research studies have been made on education's economic impact （Fu, Xu 2005, Li, Ling 2007, Wang, Li 2008）

2 Economic and educational background

2.1 Education system

2.1.1 China

There are two types of education in China: formal and informal. As this article focuses on the output effect of the former, the following forms a brief introduction to it.

China's formal education system can be roughly divided into the following levels:

- Pre-elementary education refers to the schooling 3-5 year-old children receive in kindergarten. It is designed to prepare children for elementary school.
- 6-11 year-old children receive elementary education. This schooling is the first stage of nine-years of compulsory education and has a duration of six years.
- It is compulsory for pupils graduating from elementary schools attend a lower secondary school; the duration of which is three years.
- Those graduating from lower secondary school are free to go to work or study further at upper secondary school. Upper secondary education is divided into two forms: senior high school and vocational secondary school, each are for a period of three years. The former is higher education oriented while the latter mainly provides professional skills.
- Higher education includes junior college (three years), bachelor (four to six years), master degree and doctorate (at least two to three years). Graduates from senior high school and vocational secondary school are qualified to receive the above educations upon passing the entrance examination.

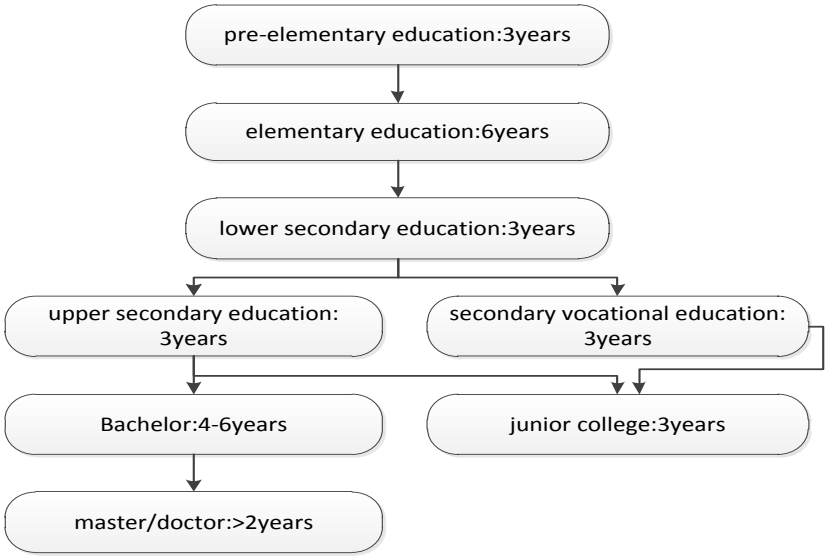


Figure 2.1: Education system of China

2.1.2 Lao PDR

Lao PDR also provides two types of education: formal and informal. The formal education system can be roughly divided into the following levels:

- Pre-elementary education lasts one to three years and is preparation for elementary school.
- Elementary education lasts six years, one year less than China.
- Those graduating from elementary school receive lower secondary education, for a period of four years, one more year than China.
- Those graduating from lower secondary schools can leave to find work or study further in upper secondary schools. There are two kinds of upper secondary education: senior high school and vocational secondary school, the course of study in both cases is three years.
- Higher education comprises junior college (three years), bachelor (four to six years), master and doctor (at least two years). Graduates from senior high school and vocational secondary school qualify for the above education upon passing the entrance examination.

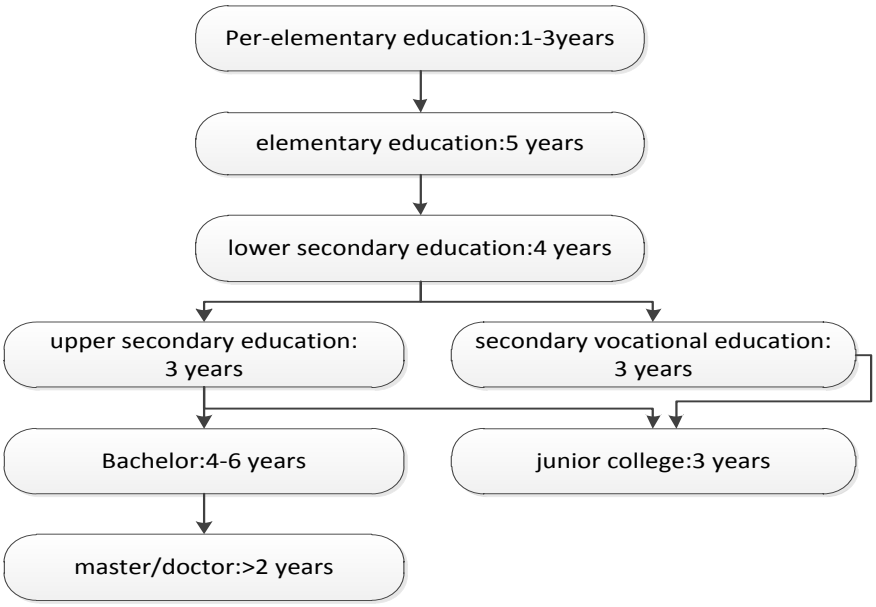


Figure 2.2: Education system of Lao PDR

2.1.3 Thailand

There are three types of education in Thailand: formal, non-formal and informal. The third mentioned here enables learners to learn by themselves according to their interests, potentialities, readiness and opportunities available from individuals, society, environment, media, or other sources of knowledge. According to data availability, the article just focuses on output effect of formal education.
Thailand's formal education system can be roughly divided into the following levels:

- At the pre-elementary level, students are offered a two-year course in public pre-elementary schools and a three-year course in private pre-elementary school.
- At the elementary level, students must attend at least six years education which is

compulsory.

- Lower secondary education offers a three-year course as a compulsory education.
- Upper secondary education is a three-year course as a fundamental stage for the students who will proceed to higher education. It also aims to prepare students to meet the labour market. There are two streams; vocational-oriented is provided in vocational and technical colleges for students who are good at skills whereas the academic stream is offered in general education schools for academically inclined students.
- Post-secondary education is divided into two levels; diploma and degree levels. At the diploma level, schools offer one to four-year courses for students who have completed upper secondary education. At the end of upper secondary three, the students in the vocational stream can enter either vocational institutions or universities to continue vocational courses to obtain a vocational diploma. On the other hand, students who have obtained their academic certificate in the academic stream, can proceed to colleges and universities and attend either vocational or academic courses. Degree level consists of two levels; undergraduate has a duration of four to six years while graduate degrees offer one to three-year courses to students at graduate diploma, master degree and doctoral degree levels.

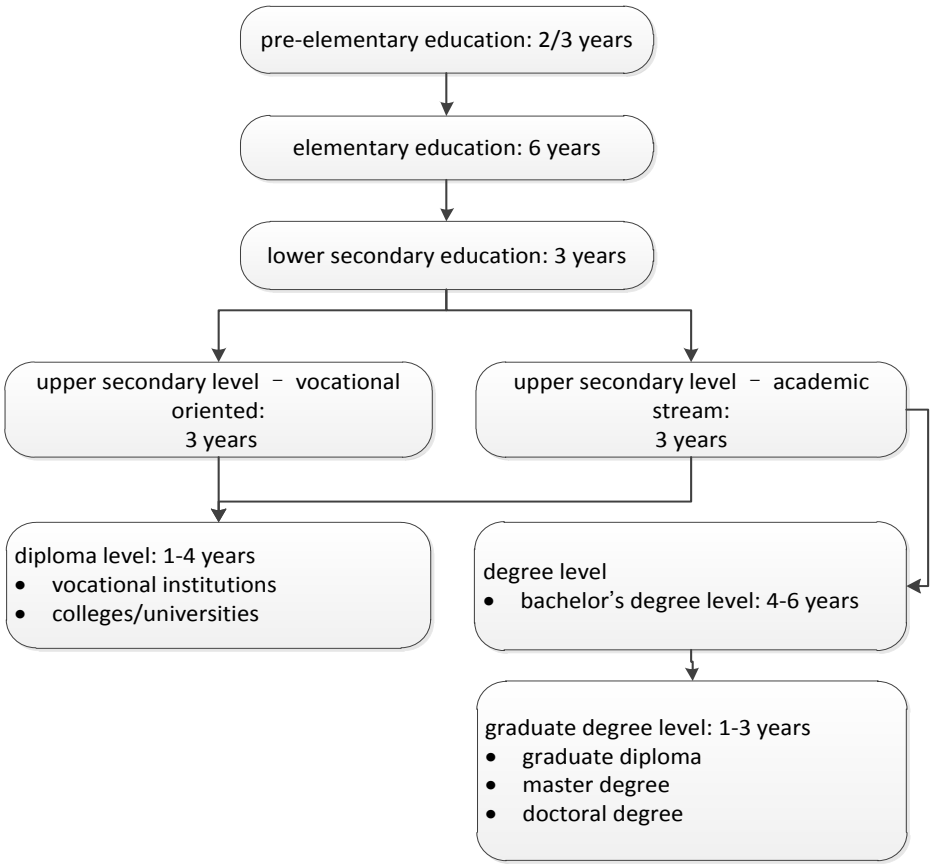


Figure 2.3: Education system of Thailand

2.1.4 Vietnam

There are two types of education in Vietnam: formal and informal. Vietnam's formal education system can be roughly divided into the following levels:

- Pre-elementary education of two to three years. This is preparation for elementary school.
- At elementary level, students undergo five years of compulsory elementary education.
- Those graduating from elementary schools can choose between lower secondary education (duration of four years) or vocational training that includes long-term training (one to three years) and short-term training (less than one year).
- Those graduating from lower secondary schools can go to work or go study in upper secondary schools. Upper secondary education can be divided into two kinds: senior high school (three years) and vocational secondary school (three to four) years.
- Higher education includes junior college (three years), bachelor (four to six years), master and doctor (at least two to three years). Graduates from senior high school and vocational secondary school qualify for such education when they pass the entrance examination.

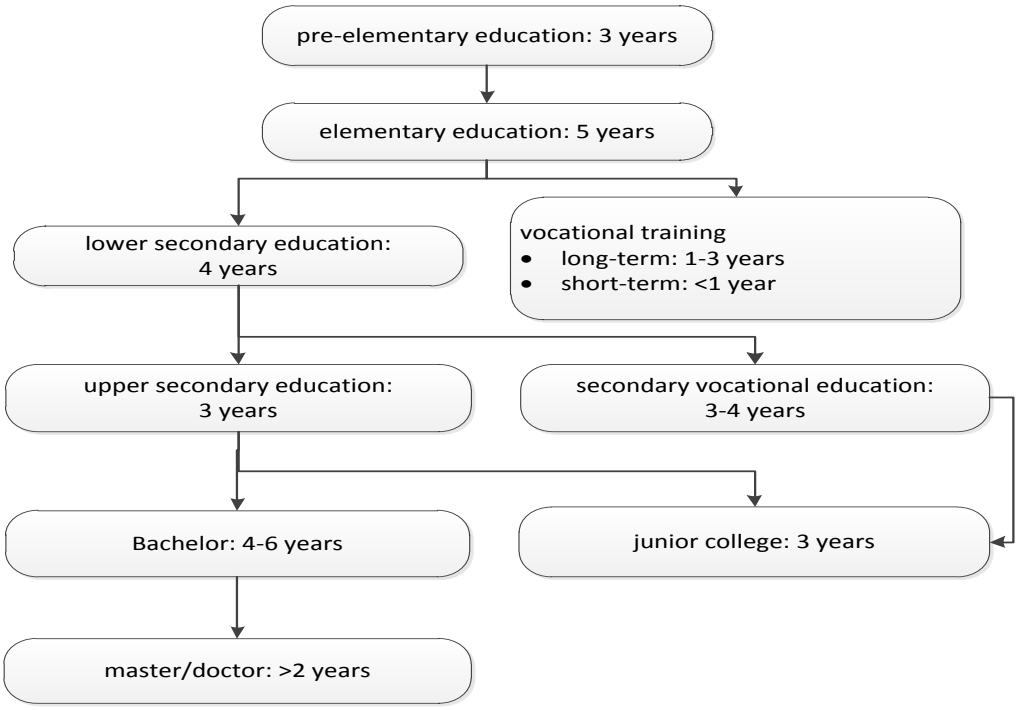


Figure 2.4: Education system of Vietnam

2.2 Economic status and industrial structure

2.2.1 China

Since 2010, China is the world's second biggest economy. Its average annual GDP growth rate was about 10% during 1990-2010. Its GDP ranks first of the four nations studied.

Table 2.1: **GDP of China, Lao PDR, Thailand and Vietnam**

1997 price, billion USD

	China	Lao PDR	Thailand	Vietnam
1990	770.16	2.09	117.60	27.61
1991	755.52	2.20	127.48	18.87
1992	833.19	2.30	138.41	18.37
1993	908.77	2.44	150.31	20.91
1994	687.02	2.63	164.93	22.08
1995	786.47	2.51	181.86	24.03
1996	869.06	2.35	189.34	26.28
1997	952.65	1.83	150.89	26.84
1998	1028.62	0.73	102.40	25.00
1999	1107.10	0.35	116.98	24.93
2000	1200.40	0.34	115.52	26.20
2001	1300.27	0.31	106.55	26.94
2002	1418.38	0.30	116.06	27.80
2003	1560.56	0.30	128.76	29.40
2004	1717.99	0.32	141.18	31.21
2005	1931.54	0.34	147.69	33.61
2006	2236.69	0.39	164.87	36.07
2007	2676.27	0.44	190.07	38.85
2008	3212.34	0.52	201.99	40.80
2009	3568.54	0.58	191.65	41.05

Source: China statistical yearbook, Thailand statistical yearbook[16], general statistical office of Vietnam (GSO) [17], IMF, World Bank

With aggregate output growing, China's industrial structure has also changed a great deal (Table 2.2 and Figure 2.5): there is an obvious decrease in primary industry's proportion of GDP, from 27% to 10%; secondary industry's proportion of GDP increased from 41% to 47% while tertiary industry's proportion rose from 32% to 43%. As far as composition of tertiary industry value-added (Table 2.3 and Figure 2.6), tradition business such as transport, storage and post, hotel and catering services are on the decline. But capital and technology intensive business such as real estate and others[18] (especially the latter) are increasing significantly. This phenomenon shows that China has gone through the transition from labour intensive production mode to one which is capital and technology intensive over the past two decades. This transformation has led directly to the change of the labour demand structure, which enlarges

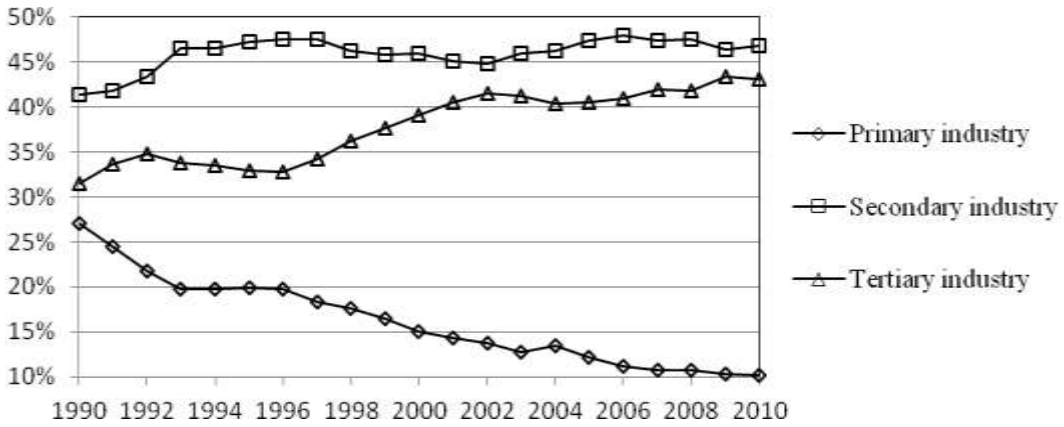
16 Data provided by Dr. Sirilak Hanvatananukul from Rajamangala University of Technology Thanyaburi.
17 http://www.gso.gov.vn.
18 Including: information transmission, computer services and software; leasing and business services; scientific research, technical services and geologic prospecting; management of water conservancy, environment and public facilities; services to households and other services; education; health, social security and social welfare; culture, sports and entertainment; public management and social organizations.

productivity difference of labour featuring different educational backgrounds. Furthermore, it changes output effect of human capital accumulation.

Table 2.2: **Composition of China's GDP**

	Primary industry	Secondary industry	Tertiary industry
1990	27%	41%	32%
1991	25%	42%	34%
1992	22%	43%	35%
1993	20%	47%	34%
1994	20%	47%	34%
1995	20%	47%	33%
1996	20%	48%	33%
1997	18%	48%	34%
1998	18%	46%	36%
1999	16%	46%	38%
2000	15%	46%	39%
2001	14%	45%	40%
2002	14%	45%	41%
2003	13%	46%	41%
2004	13%	46%	40%
2005	12%	47%	41%
2006	11%	48%	41%
2007	11%	47%	42%
2008	11%	48%	42%
2009	10%	46%	43%
2010	10%	47%	43%

Source: China statistical yearbook



Source: China statistical yearbook

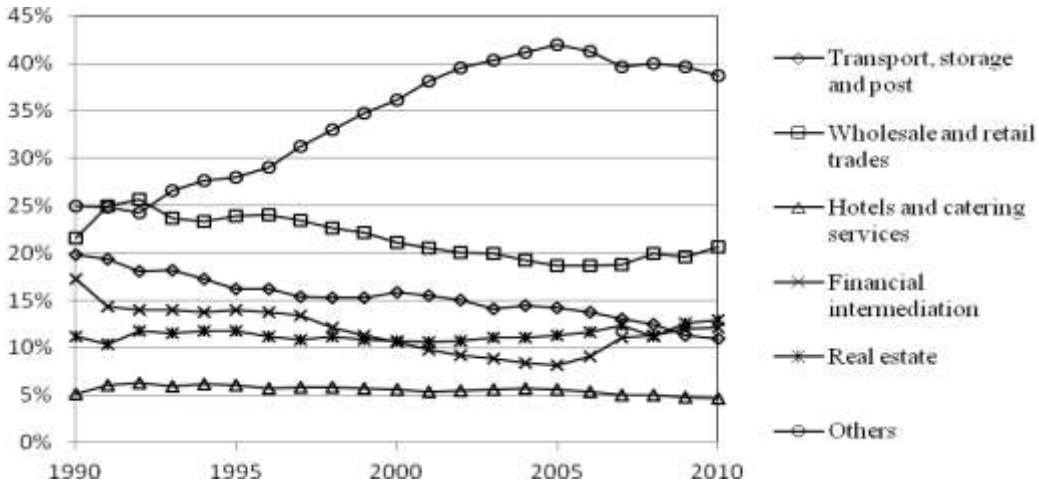
Figure 2.5: Composition of China's GDP

Table 2.3: **Composition of value-added of China's tertiary industry**

	Transport, storage and post	Wholesale and retail trades	Hotels and catering services	Financial intermediation	Real estate	Others
1990	20%	22%	5%	17%	11%	25%
1991	19%	25%	6%	14%	10%	25%

1992	18%	26%	6%	14%	12%	24%
1993	18%	24%	6%	14%	12%	27%
1994	17%	23%	6%	14%	12%	28%
1995	16%	24%	6%	14%	12%	28%
1996	16%	24%	6%	14%	11%	29%
1997	15%	23%	6%	13%	11%	31%
1998	15%	23%	6%	12%	11%	33%
1999	15%	22%	6%	11%	11%	35%
2000	16%	21%	6%	11%	11%	36%
2001	15%	21%	5%	10%	11%	38%
2002	15%	20%	5%	9%	11%	40%
2003	14%	20%	6%	9%	11%	40%
2004	14%	19%	6%	8%	11%	41%
2005	14%	19%	6%	8%	11%	42%
2006	14%	19%	5%	9%	12%	41%
2007	13%	19%	5%	11%	12%	40%
2008	12%	20%	5%	11%	11%	40%
2009	11%	20%	5%	12%	13%	40%
2010	11%	21%	5%	12%	13%	39%

Source: China statistical yearbook



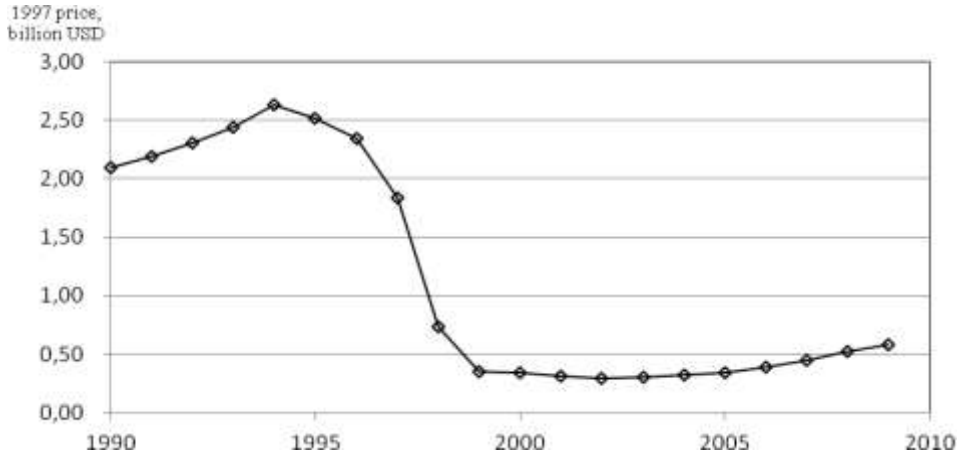
Source: China statistical yearbook

Figure 2.6: Composition of value-added of China's tertiary industry

2.2.2 Lao PDR

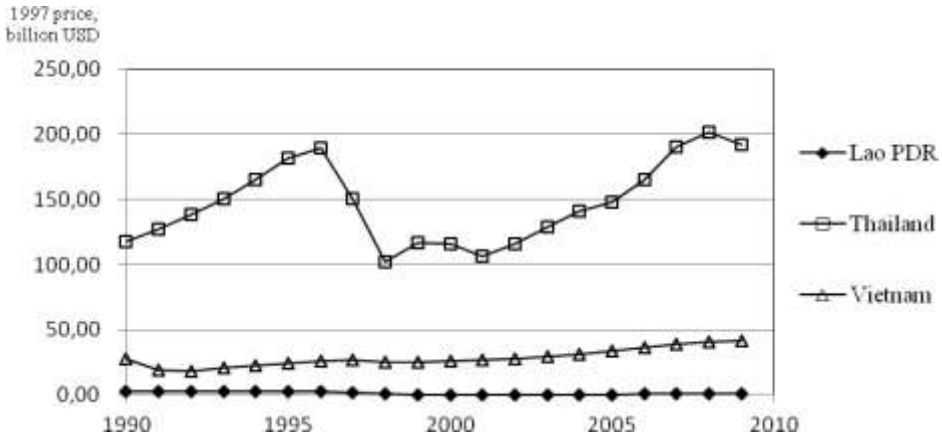
Lao PDR has the smallest GDP among the four nations studied (Table 2.1 and Figure 2.8). Its average annual GDP growth rate is even negative during 1990-2010 (Figure 2.7). But its industrial structure has experienced some changes over the past two decades: primary industry's proportion of GDP decreased from 61% to 31%; secondary industry's proportion increased from 13% to 35%, already exceeding tertiary industry; tertiary industry proportion has almost the same, from 13% to 35%. The economic

development status and industrial structure all show that Lao PDR is a comparatively unsophisticated developing country.



Source: IMF

Figure 2.7: GDP of Lao PDR



Source: IMF

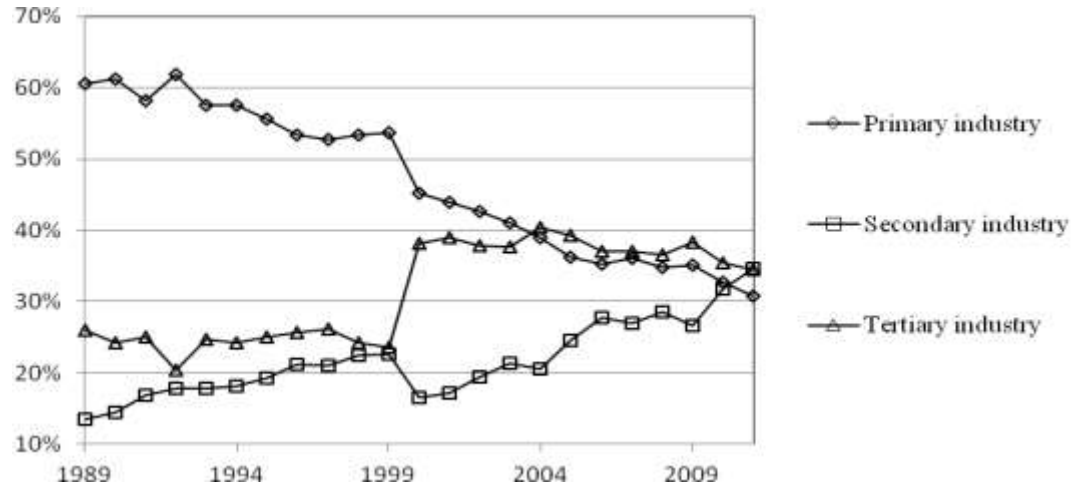
Figure 2.8: GDP of Lao PDR, Thailand and Vietnam

Table 2.4: **Composition of Lao PDR's GDP**

	Primary industry	Secondary industry	Tertiary industry
1989	60.6%	13.4%	26.0%
1990	61.2%	14.5%	24.3%
1991	58.2%	16.8%	25.0%
1992	61.8%	17.8%	20.4%
1993	57.5%	17.7%	24.7%
1994	57.6%	18.1%	24.3%
1995	55.7%	19.2%	25.1%
1996	53.4%	21.2%	25.6%
1997	52.8%	21.1%	26.2%
1998	53.3%	22.5%	24.2%
1999	53.7%	22.6%	23.7%

2000	45.2%	16.6%	38.2%
2001	44.0%	17.2%	38.9%
2002	42.7%	19.5%	37.8%
2003	41.0%	21.3%	37.7%
2004	39.0%	20.5%	40.5%
2005	36.2%	24.6%	39.2%
2006	35.3%	27.7%	37.0%
2007	36.1%	26.9%	37.0%
2008	34.9%	28.6%	36.6%
2009	35.0%	26.7%	38.3%
2010	32.8%	31.8%	35.5%
2011	30.8%	34.7%	34.5%

Source: World Bank

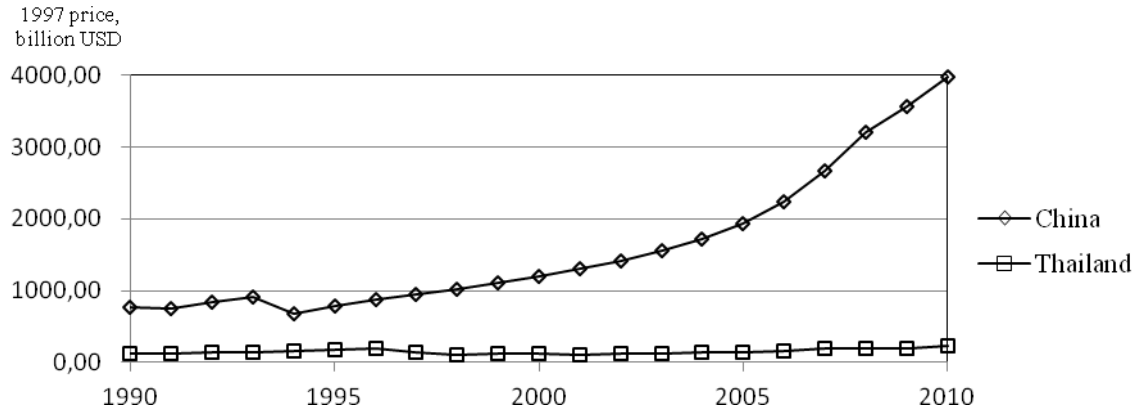


Source: World Bank

Figure 2.9: Composition of Lao PDR's GDP

2.2.3 Thailand

Although Thailand's GDP is obviously less than China's (Figure 2.10), it still has the leading position of the southeast countries (Figure 2.8). During 1990-2010, its average annual GDP growth rate was about 4%.



Source: China statistical yearbook, Thailand statistical yearbook and World Bank

Figure 2.10: GDP of China and Thailand

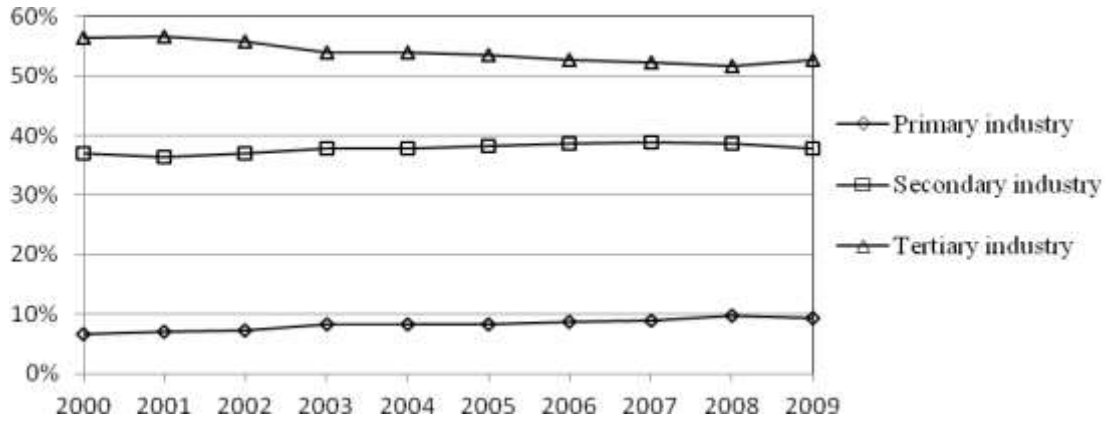
As far as GDP composition (Table 2.5 and Figure 2.11), there is no industrial upgrading trend over the past decades. Primary industry's proportion of GDP is even on the rise while tertiary industry's proportion decreases. From the view of industry it is the composition, manufacturing, wholesale and retail trade; repair of motor vehicles, agriculture, hunting and forestry, transport, storage and communications that are the pillar industries of Thailand. Thailand's manufacturing is still labour intensive, including food, beverage and primary commodities[19]. And the proportion of industries remains stable (Table 2.5-2.6 and Figure 2.11-2.12). Obviously, traditional businesses play an important role in the Thailand economic growth.

Table 2.5: **Composition of Thailand's GDP**

	Primary industry	Secondary industry	Tertiary industry
2000	7%	37%	56%
2001	7%	36%	57%
2002	7%	37%	56%
2003	8%	38%	54%
2004	8%	38%	54%
2005	8%	38%	54%
2006	9%	39%	53%
2007	9%	39%	52%
2008	10%	39%	52%
2009	9%	38%	53%

Source: Thailand statistical yearbook

19 See United Nations Industrial Development Organization.



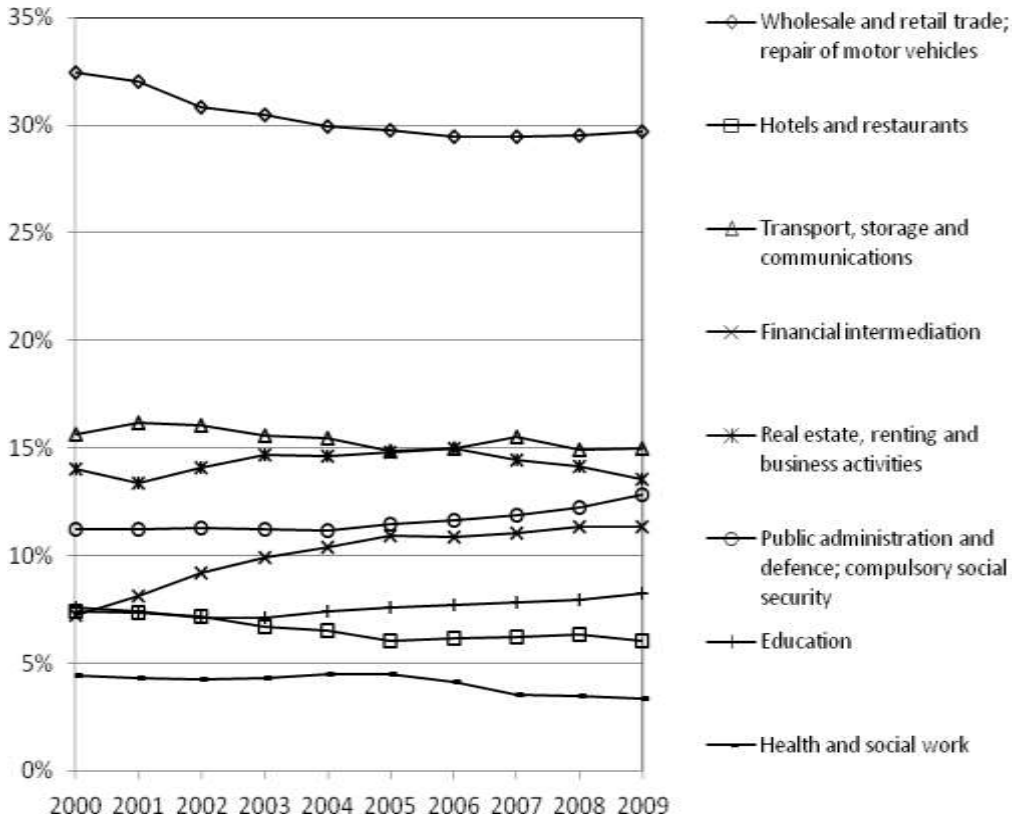
Source: Thailand statistical yearbook

Figure 2.11: Composition of Thailand's GDP

Table 2.6: **Composition of value-added of Thailand's tertiary industry**

	Wholesale and retail trade; repair of motor vehicles	Hotels and restaurants	Transport, storage and communications	Financial intermediation
2000	32%	7%	16%	7%
2001	32%	7%	16%	8%
2002	31%	7%	16%	9%
2003	30%	7%	16%	10%
2004	30%	7%	15%	10%
2005	30%	6%	15%	11%
2006	29%	6%	15%	11%
2007	29%	6%	16%	11%
2008	30%	6%	15%	11%
2009	30%	6%	15%	11%
	Real estate, renting and business activities	Public administration and defence; compulsory social security	Education	Health and social work
2000	14%	11%	8%	4%
2001	13%	11%	7%	4%
2002	14%	11%	7%	4%
2003	15%	11%	7%	4%
2004	15%	11%	7%	4%
2005	15%	11%	8%	4%
2006	15%	12%	8%	4%
2007	14%	12%	8%	4%
2008	14%	12%	8%	3%
2009	14%	13%	8%	3%

Source: Thailand statistical yearbook

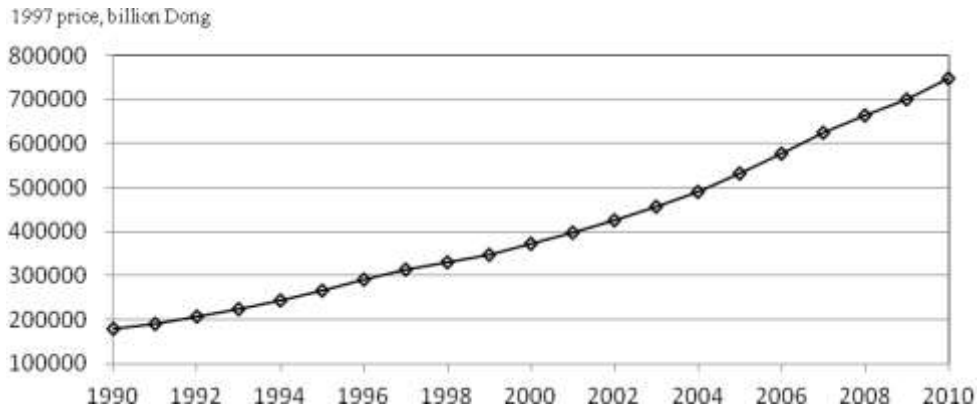


Source: Thailand statistical yearbook

Figure 2.12: Composition of value-added of Thailand's tertiary industry

2.2.4 Vietnam

Vietnam's GDP is at middle level in southeast countries (Figure 2.8) and it was on the rise between 1990-2010 (Figure 2.13), the average annual GDP growth rate is about 6%.



Source: general statistical office of Vietnam (GSO)

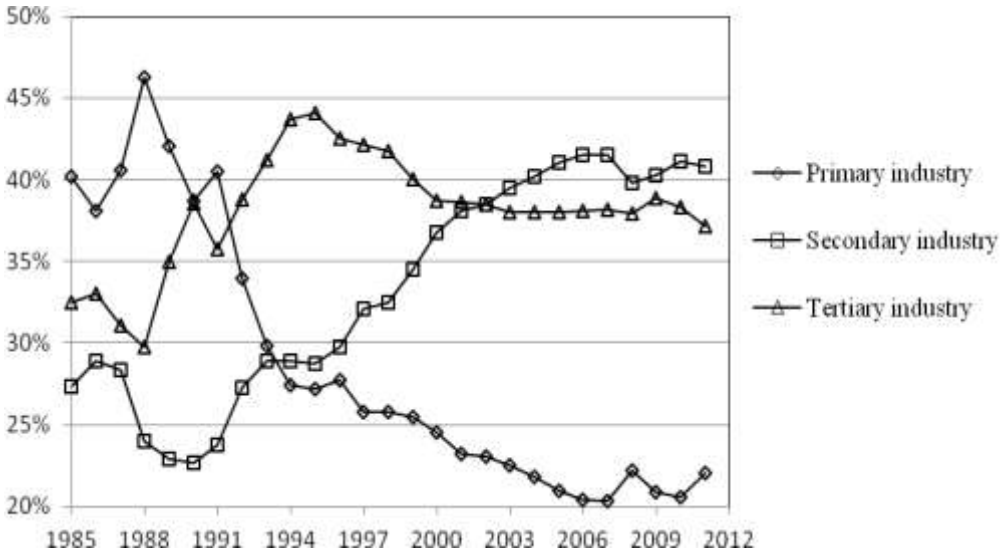
Figure 2.13: GDP of Vietnam

Vietnam's industrial structure has made great changes over the past two decades (Table 2.7 and Figure 2.14): there has been an obvious decrease in primary industry's proportion of GDP, from the largest proportion of industry in 1985 (40%) to the minimum proportion attained in 2011 (22%),. Secondary industry's proportion of GDP increased from 27% to 47%, attaining the largest GDP proportion; the change of tertiary industry's proportion is relatively small stabilising at around 38% over the past decades. All of this demonstrates that Vietnam is still in transition from a country based on an agrarian economy to and industrialised one.

Table 2.7: **Composition of Vietnam's GDP**

	Primary industry	Secondary industry	Tertiary industry
1985	40%	27%	32%
1986	38%	29%	33%
1987	41%	28%	31%
1988	46%	24%	30%
1989	42%	23%	35%
1990	39%	23%	39%
1991	40%	24%	36%
1992	34%	27%	39%
1993	30%	29%	41%
1994	27%	29%	44%
1995	27%	29%	44%
1996	28%	30%	43%
1997	26%	32%	42%
1998	26%	32%	42%
1999	25%	34%	40%
2000	25%	37%	39%
2001	23%	38%	39%
2002	23%	38%	38%
2003	23%	39%	38%
2004	22%	40%	38%
2005	21%	41%	38%
2006	20%	42%	38%
2007	20%	41%	38%
2008	22%	40%	38%
2009	21%	40%	39%
2010	21%	41%	38%
2011	22%	41%	37%

Source: World Bank



Source: World Bank

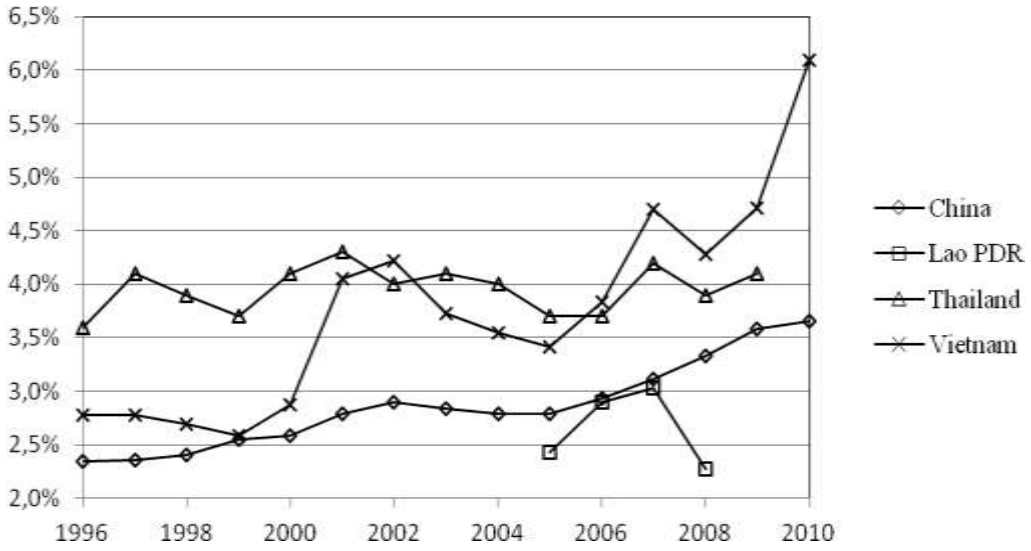
Figure 2.14: Composition of Vietnam's GDP

2.3 Education input and labour educational attainment

By comparing the data of the nations studied, it has been established that (Figure 2.15):

- During 1996-2010, China's fiscal education expenditure had an increased share of GDP from 2.3% to 3.7% and its scale also rose sharply commensurate to the GDP's fast growth. But compared with industrialized countries[20], China's fiscal education input is yet to be improved.
- The available data of Lao PDR during 2005-2008 shows that highest fiscal education expenditure is 3% of GDP while it decreased to 2.3% in 2008
- Thailand's fiscal education expenditure is basically stable at 4% of GDP during 1996-2009.
- Vietnam's fiscal education input showed a clear increase during 1996-2009. Its proportion of GDP rose from 2.8% to 6.1%.

[20] According to the OECD database, OECD countries' average fiscal proportion of GDP is around 6% in 2004.



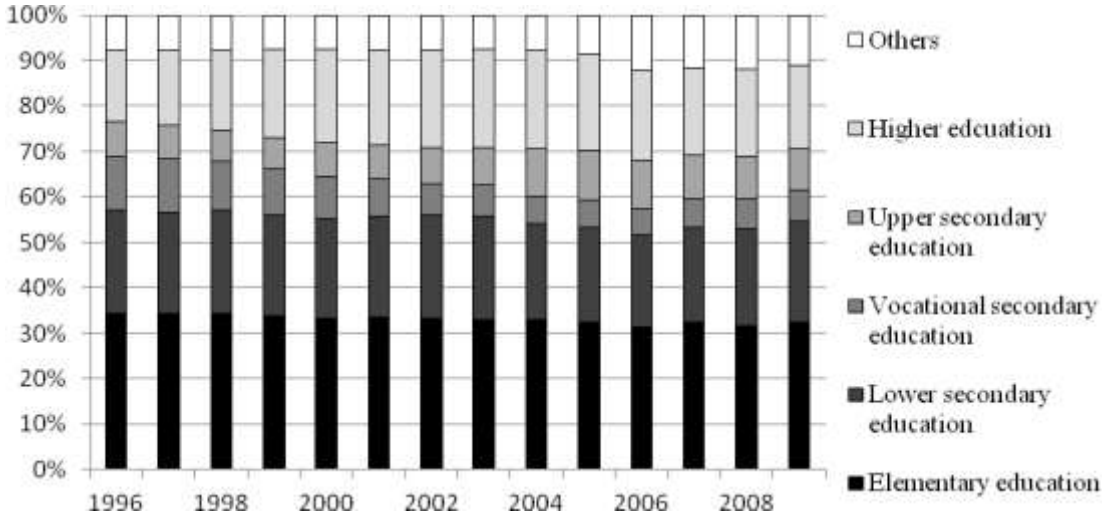
Source: China statistical yearbook, Ministry of education (MOE) - Thailand, Department of Planning and Finance, MoET; GSO - Vietnam, UIS

Figure 2.15: The four nations studied fiscal education expenditure proportion of GDP

Besides education expenditure, the nations studied have their own allocation proportion of different education levels:

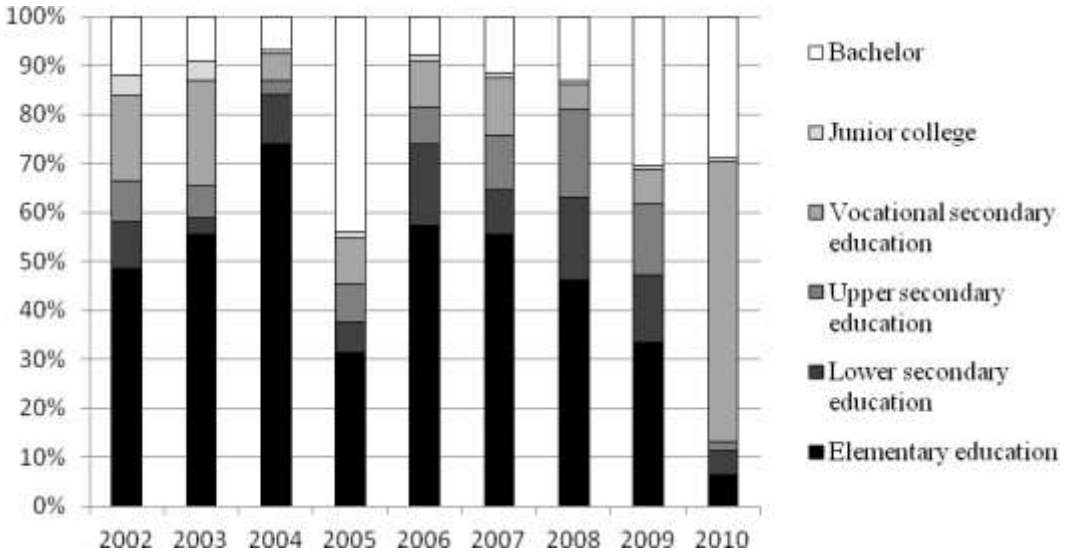
- During 1996-2009, China's compulsory education (including elementary and junior secondary education) proportion of GDP stabilized at 55%. Higher education input continued to rise while secondary vocational education input declines year by year (Figure 2.16) [21].
- Laos' fiscal education inputs at all education levels are irregular and fluctuated significantly (Figure 2.17) [22].
- During 1997-2004, Thailand's secondary education fiscal input rose slowly and the proportion of higher education displayed a trend of contraction (Figure 2.18) [23].
- Vietnam's fiscal education expenditure fluctuated sharply, especially in 1999, 2000 and 2004-2006. Not taking into consideration the data of those years, all education levels had a basically stable proportion of fiscal education expenditure. But vocational education and higher education presented a slightly downward trend[24] (Table 2.8 and Figure 2.9).

21 The decline of vocational secondary education reflects it is ignored.
22 Because Lao's data is lack of credibility, we first need to complete data and then use model 2 (in chapter 3) to construct econometric model of Lao PDR and do analysis.
23 This phenomenon is mainly associated with Thailand's economic structure. Labor intensive industries and businesses account for large proportion of GDP, which leads to great demand of skilled operators.
24 Because of great fluctuation of the Vietnam's education expenditure data, authors use model 1 to do the analysis, study the impact of education on Vietnam's human capital accumulation and national output growth from the perspective of labor's education attainment.



Source: China statistical yearbook

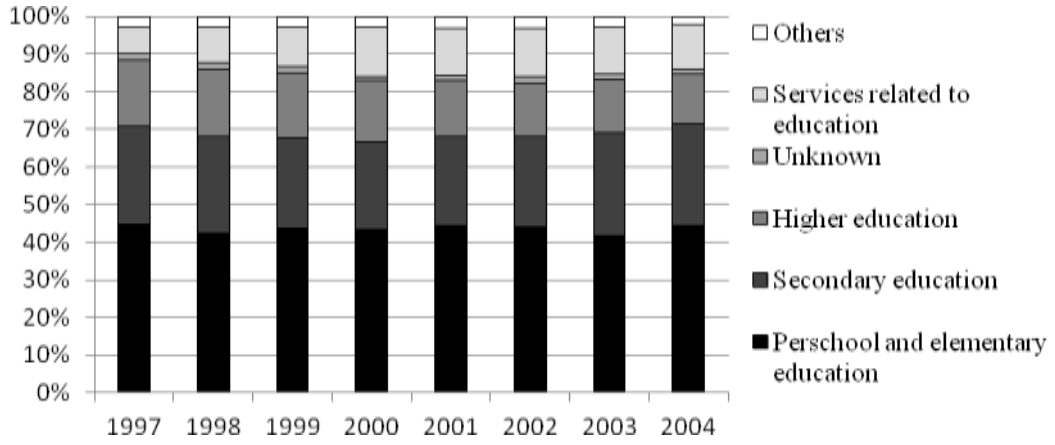
Figure 2.16: Allocation of China's fiscal education expenditure



Source: Investigation[25]

Figure 2.17: Allocation of Lao's fiscal education expenditure

[25] Lao's data provided by Dr.Bounseng Khammounty of Natioanl University of Laos.



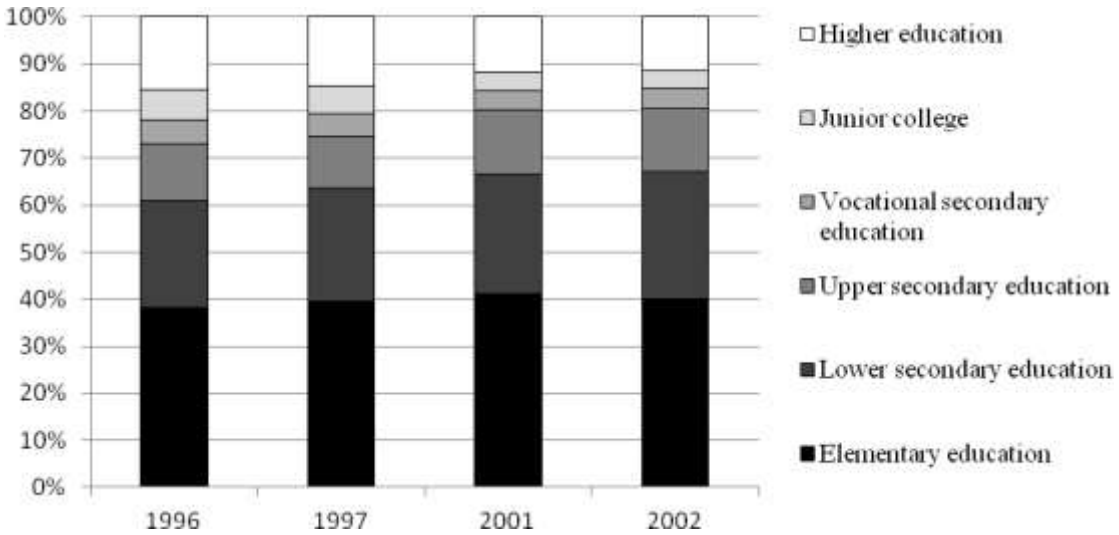
Source: Ministry of Education (MOE)

Figure 2.18: Allocation of Thailand's fiscal education expenditure

Table 2.8: **Allocation of Vietnam's fiscal education expenditure**

	Elementary education	Lower secondary education	Upper secondary education	Vocational secondary education	Junior college	Higher education	Others
1996	32%	19%	10%	4%	5%	13%	17%
1997	36%	22%	10%	4%	5%	13%	10%
1999	58%	35%	13%	3%	4%	13%	-26%
2000	61%	37%	14%	3%	4%	12%	-32%
2001	33%	20%	11%	3%	3%	9%	20%
2002	31%	21%	10%	3%	3%	9%	22%
2004	40%	29%	13%	5%	3%	13%	-2%
2006	46%	32%	15%	10%	4%	13%	-19%

Data source: General statistical organization (GSO) and Ministry of education and training (MoET)

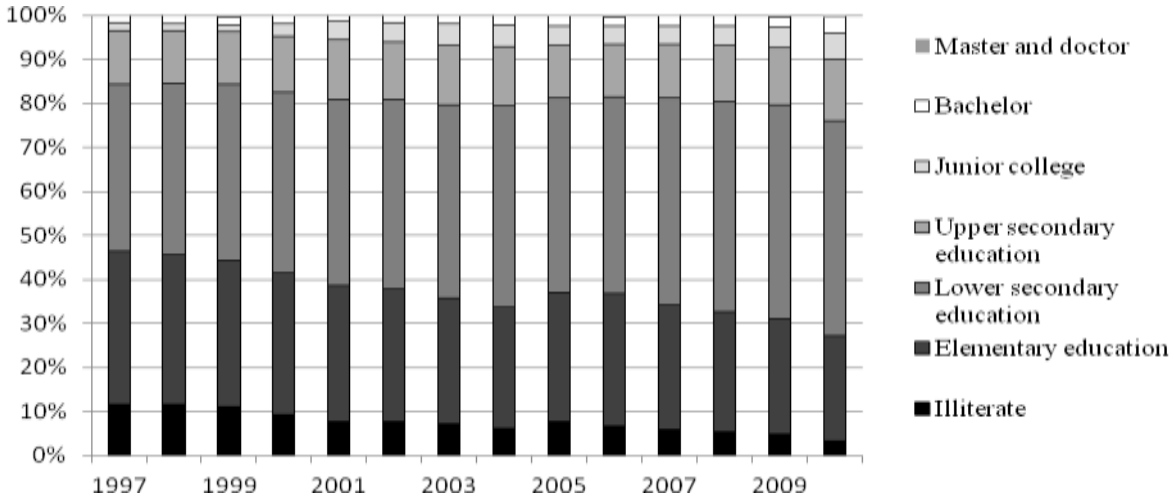


Source: General statistical organization (GSO) and Ministry of education and training (MoET)

Figure 2.19: Allocation of Vietnam's fiscal education expenditure

From the perspective of labour's educational attainment, it was found:

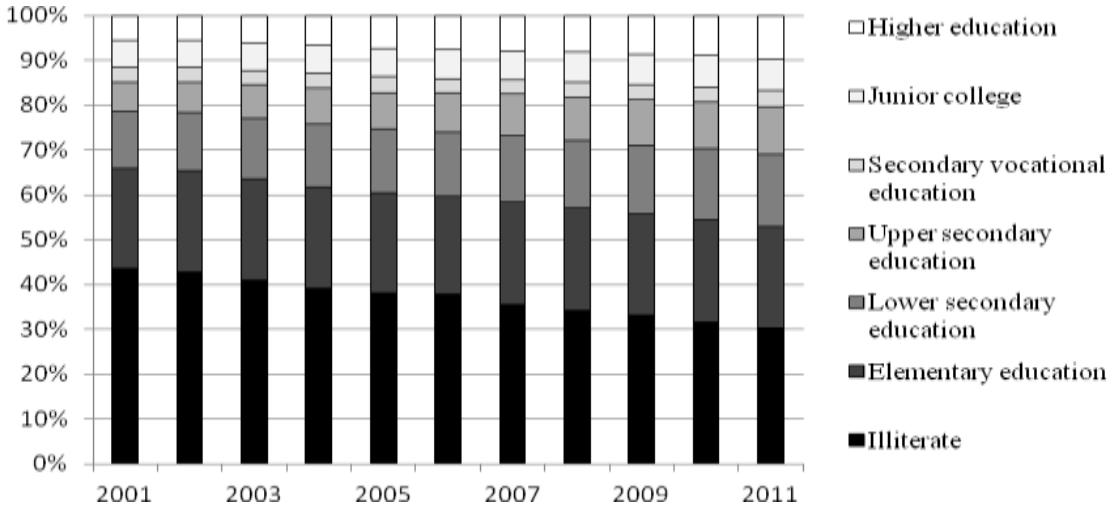
- During 1997-2010, the proportion of illiterate labour and those with elementary education decreased year by year, from 47% to 27%. Proportion of labour that have received junior secondary education or above increase significantly, 49% of employed population have junior high school degree while 10% of them have received higher general or vocational education[26]. But the growth rate of labour that received upper secondary education (including secondary vocational education) remained stable[27] in China.
- During 2001-2010, Thailand's labour educational attainment level showed an increase. The less educated proportion of labour's[28] decreased from 66% to 54% while those who have obtained secondary and higher education rose steadily and the proportion of labour with a vocational education degree[29] stabilized at 10% (Figure 2.21).
- During 1990-2010, the proportion of Vietnam's labour who received lower secondary education and higher education rose slowly while the number of the work force in possession of a senior high school degree or secondary vocational education background dropped slightly[30].



Source: China labour statistical yearbook

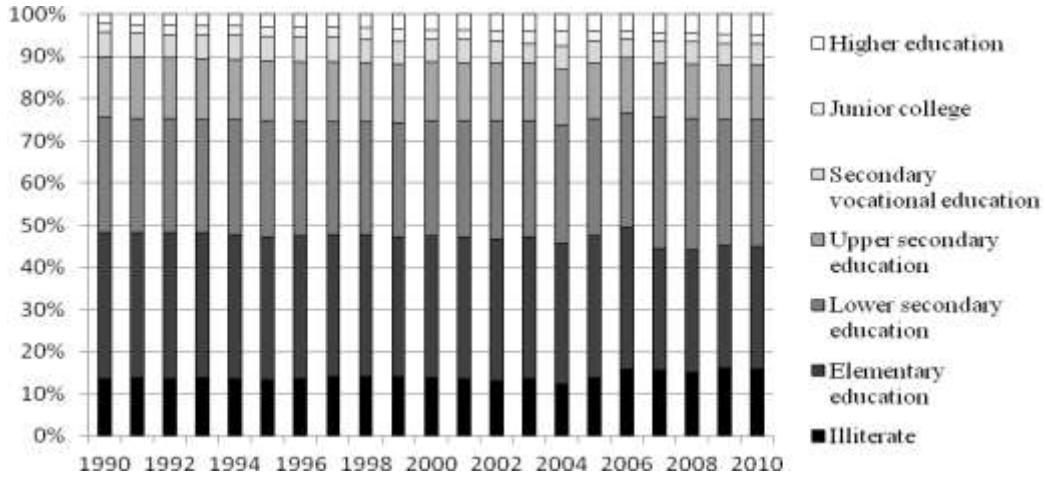
Figure 2.20: Labour educational attainment of China

26 Include junior college, bachelor, master and doctor.
27 These phenomena are associated with China's stable compulsory education input, increasing higher education input and decreasing vocational education input.
28 Include labors with pre-school and elementary education.
29 Include secondary and higher vocational education.
30 It may be caused by inadequate high school and vocational education input.



Source: Ministry of Education (MOE)

Figure 2.21: Labour educational attainment of Thailand



Source: Ministry of labour – invalids and social affairs (MoLISA)

Figure 2.22: Labour educational attainment of Vietnam

3 Model construction

3.1 Model 1: labour's educational attainment as proxy of human capital

Compared with labour's educational attainment data, classification of Thailand's education expenditure data is comparatively broad[31] while Vietnam's education expenditure data fluctuate sharply its time span is also discontinuous. Therefore, authors constructed Model 1 with the labour's educational attainment as a proxy of human capital and went on to study Thailand's and Vietnam's output effect of education. The national production function is assumed to take the form:

$$Y_t = f(K_t^*, L_t, H_t) \tag{3.1}$$

Where Y_t is gross domestic product in period t; K_t^* is effective capital stock after quality level adjustment[32]; L_t is labour force in period t; H_t is human capital stock (the sum of the human capital stock $h_{j,t}$ of different workers j in the period t):

$$H_t = \sum_{j=1}^{n} h_{j,t} \tag{3.2}$$

$h_{j,t}$ is accumulated either by full-time schooling $s_{j,t}$, or by experiences acquainted during work $x_{j,t}$. As it is difficult to gather learning-by-doing data and educational background is determinant in labour's learning-by-doing skills to some extent, the authors simply assume that $h_{j,t}$ is only dependent on $s_{j,t}$:

$$h_{j,t} = g\left(s_{j,t}, x_{j,t}\right) \approx g(s_{j,t}) \tag{3.3}$$

A series of empirical studies (Bils and Klenow, 2000) have found that $g(\cdot)$ is a monotonic function, adding additional schooling years to individual j increases the human capital stock proportionally. Using Taylor series expansion $g\left(s_{j,t}\right)$ could be approximated by the employees' average schooling years μ_t and dispersion σ_t^2. The economy's aggregate human capital stock H_t is then:

$$H_t \cong \sum_{j=1}^{L_t} g\left(s_{j,t}\right) \cong \sum_{j=1}^{L_t} \tag{3.4}$$

Simplify equation (3.4):

31 See Table 6.4
32 The calculation method of effective capital stock is in chapter 4.

$$h_t = \frac{H_t}{L_t} \cong g(\mu_t) + \frac{g''(\mu_t)}{2} \cdot \sigma_t^2 \qquad (3.5)$$

Equation (3.5) shows that h_t is a function of μ_t and σ_t^2, $h_t = h(\mu_t, \sigma_t^2)$. μ_t denotes the average schooling years (mean value, or human capital stock's average index) and σ_t^2 the dispersion (variance, or human capital stock's dispersion index), Measured as:

$$\mu_t = \sum_{i=0}^{6} m^{a_i} \cdot p_t^{a_i} \qquad (3.6)$$

$$\sigma_t^2 = \sum_{i=0}^{6} [(m]^{a_i} - \mu_t)^2 \cdot p_t^{a_i} \qquad (3.7)$$

The national production function is assumed to correspond to C-D function type. Now we take the logarithmic form of equation (3.1):

$$\ln Y_t \approx \alpha \cdot \ln K_t^* + (\beta + \gamma) \cdot \ln L_t + \gamma \cdot \ln h_t \qquad (3.8)$$

Transform equation (3.8) into per capita national production function:

$$\ln y_t \approx \alpha \cdot \ln k_t^* + \gamma \cdot \ln h_t \qquad (3.9)$$

By now, this paper establishes the logarithmic model. Taking this model as our starting point, we can use it to analyse the output effect of education investment.

3.2 Model 2: education expenditure as proxy of human capital

The education sector is defined as the human capital production department. Correspondingly, its output can be explained by its input factors. The production function of education sector is as listed:

(3.10)

ΔH is the output of education sector, which denotes the increment of human capital stock (H) for a period of time, denotes all production factors of education sector. Correspondingly, the cost function is as listed:

Ec

(3.11)

Edu stands for education expenditure.

Assuming the production function of the education sector is linear homogeneous and the factors price is not affected by the economic entities' education decisions at the micro level, the function of education expenditure/cost ($\mathbf{Edu}$) and education output ($\mathbf{\Delta H}$) is also linear homogeneous (as the single-variable function is linear):

$$\mathbf{Edu = h(\Delta H)} \tag{3.12}$$

Considering the duality of cost and production function, which means both of functions have the same information, the authors utilized the inverse function of equation (3.12) to reflect the input-output relation of education sector:

$$\mathbf{\Delta H = h^{-1}(Edu)} \tag{3.13}$$

Obviously, $\mathbf{\Delta H_t}$ not only relates to the education expenditure of the employee (who is the carrier of human capital stock) in the current period, it also involves all the past ones. For a given education level i, early education contains several stages: $\mathbf{i}$, $\mathbf{i-1}$, … (e.g. a person with senior high school degree has received primary, junior and senior high school education). Defining schooling years of different education levels as τ_i , τ_{i-1} , …, human capital increment with i education degree in period t is indicated as:

$$\mathbf{\Delta H_t^i = h^{-1}\left(\left(Edu_t^i, Edu_{t-1}^i, \dots Edu_{t-\tau_i+1}^i\right), \left(Edu_{t-\tau_i}^{i-1}, Edu_{t-\tau_i-1}^{i-1}, \dots Edu_{t-\tau_{i-1}+1}^{i-1}\right), \dots\right)} \tag{3.14}$$

in which $\mathbf{\Delta H_t^i}$ is the human capital increment with i education degree (e.g. elementary education, lower secondary education, upper secondary education, higher education). $\mathbf{Edu_t^i}$ is education expenditure of different education level i. There exists a delayed reaction of education expenditure in the process of measuring human capital accumulation, which means that the return of education expenditure of a student can just be reflected through his/her output effect when he/she is employed[33].

Finally, human capital accumulation, as an input factor, contributes to the aggregate output $\mathbf{Y_t}$. The national production function is:

$$\mathbf{Y_t = f(K_t^*, L_t, H_t^*)} \tag{3.15}$$

33 For example, a vocational secondary school student who graduated in 2000 has received 3 years (1998-2000) secondary vocational education and 9 years (1989-1997) compulsory education (which comprises elementary and lower secondary education). Therefore, per capita education expenditure of those education levels should be included in measuring human capital increment.

In which K_t^* stands for effective physical capital stock with quality adjustment[34] while L_t for pure labour input. The vector H_t^* denotes to heterogeneous human capital stock, which embodies the heterogeneity of labour's human capital due to different education levels.

$$H_t^* = (H_t^i, \forall i) \tag{3.16}$$

In equation (3.16), $i = 1, 2, 3, 4$ corresponds to compulsory education (including elementary and lower secondary education), upper secondary education, secondary vocational education and higher education.

In the supposition that the national production function accords with the Cobb-Douglas function, the differential function of equation (3.15) is:

$$\Delta Y_t \approx \alpha \cdot \Delta K_t^* + \beta \cdot \Delta L_t + \sum_{i=1}^{4} \gamma_i \cdot \Delta H_t^i \tag{3.17}$$

Taking China as an example, as there exists a disturbance from labour surplus among employees with low-levels of education, the authors simply considered the impact of human capital without pure labour with reference to Feng *et al.* (2012). Meanwhile, as over-expansionary investment has a great impact on China's economic growth（See Feng et al., 2012.）it has to be taken into the construction of the models. Authors use E_t to represent it. In view of the fact that most graduates from upper secondary schools will study further in colleges and universities, the equation (3.17) can be simplified as below:

$$\Delta Y_t \approx \alpha \cdot \Delta K_t^* + \beta \cdot \Delta E_t + \sum_{i=3}^{4} \gamma_i \cdot \Delta H_t^i \tag{3.18}$$

On the basis of equation (3.18), authors performed econometric analysis on the education output effect of China

34 Feng *et al.*(2012) has detailed discussion about it.

4 Data Pre-processing

4.1 China

4.1.1 Physical capital stock

In the system of national economic accounting, physical capital stock K_t is measured by the perpetual inventory method:

$$K_t - K_{t-1} = I_{N,t} = I_{B,t} - D_t = I_{B,t} - \delta_t \cdot K_t \qquad (4.1)$$

in which $I_{N,t}$ denotes net capital formation, $I_{B,t}$ for gross capital formation, D_t for capital depreciation, with average depreciation rate $\delta_t = \frac{K_t}{D_t}$.

Generally input factors are considered homogeneous into the national accounting system. While accompanied by technological progress, capital investment in different periods is of different quality levels, thus heterogeneous. Therefore, the authors made the quality adjustment to capital stock. We calculated the effective capital stock K_t^* to reflect the actual capital stock.

The way to calculate effective capital stock is as follows (Feng *et al.*, 2012):

First, we need to do the price adjustment of different periods' physical capital formation.

$$I_{N,t}^* = \frac{I_{N,t}}{p_t^{I,Y}},\ I_{B,t}^* = \frac{I_{B,t}}{p_t^{I,Y}},\quad p_t^{I,Y} = p_{t-1}^{I,Y} \cdot \frac{p_t^I}{p_t^Y} \qquad (4.2)$$

$I_{N,t}^*$ and $I_{B,t}^*$ respectively represents the effective unit of net and gross investment in the period t. $p_t^{I,Y}$ as the accumulated price index of capital, reflects the changed trends of investment goods' price index p_t^I relative to gross price index p_t^Y 35:

Secondly, according to the average depreciable life of physical capital[36], sum effective net investment $I_{N,t}$ up and can get initial physical capital stock K_{t0} :

$$K_{t0} = \sum_{\tau=t0-T}^{T} I_{N,t} \qquad (4.3)$$

35 The reason for price adjustment with accumulated price index of capital is: investment goods' price elasticity of demand is relatively high and its quality improve will embodies on the substitution of old products (technology) rather than driving price up.

36 In fact, different depreciation rates will not substantially influence regression result. By calculating data of 2011 China statistical yearbook, authors got that China's depreciation rate is 5% and depreciable life is about 20 years.

On the basis of the technological progress level implied in K_{t0} , we can use equation (4.2) to make the adjustment of physical capital formation and calculate effective capital stock K_t^* according to equation (4.4):

$$K_t^* = \frac{K_{t-1}^* + I_{B,t}^*}{1+\delta_t} = \frac{K_{t-1}^* + I_{B,t}^*}{1+\frac{D_t}{K_t}}, \quad K_{t0} = K_{t0}^*, \qquad t > 0 \tag{4.4}$$

As a result the data of China's effective capital stock during 1997-2009 is listed as follows:

Table 4.1: **Effective capital stock of China**

	p_t^{LY}	D_t	$I_{B,t}$		K_t^*
	index	1997 price, hundred million CNY			
1997	100.00	11070.80	25965.00	158593.79	158593.79
1998	100.67	11902.07	28825.23	175516.96	175336.45
1999	102.26	12775.89	31198.33	193939.40	193123.52
2000	102.94	13797.85	33899.26	214040.81	212366.16
2001	101.92	14889.60	37055.11	236206.33	233972.75
2002	100.54	16192.65	42568.11	262581.79	260261.95
2003	98.80	17752.58	50869.86	295699.06	294095.64
2004	95.86	19461.31	57915.19	334152.95	335003.69
2005	90.91	21592.88	63531.51	376091.58	382907.18
2006	84.29	24257.62	72513.94	424347.90	443574.92
2007	75.45	27602.26	79619.75	476365.39	519032.60
2008	68.25	30194.80	91038.61	537209.20	617704.02
2009	60.63	32945.32	112042.66	616306.54	761784.26

Source: China statistical yearbook, Data of GDP of China 1952-2004

4.1.2 Labour's Educational attainment

According to 1997-2010 labour's educational attainment data in China's labour statistical yearbook, the authors divided education into 7 levels, a_i denotes education levels, $i = 0, 1, \ldots, 6$ respectively indicate illiterate, elementary education, lower secondary education, upper secondary education (including vocational secondary education), junior college (including higher vocational education), bachelor and post-graduate. $p_t^{a^i}$ as the proportion of employees with a^i degrees.

Table 4.2: **China's composition of employment by educational attainment**

	a_0	a_1	a_2	a_3	a_4	a_5	a_6
1997	11.6%	34.8%	37.9%	12.1%	1.8%	1.5%	0.2%
1998	11.5%	34.2%	38.9%	11.9%	1.7%	1.6%	0.2%
1999	11.0%	33.3%	39.9%	11.9%	1.7%	1.9%	0.2%
2000	9.4%	32.1%	41.1%	12.7%	2.9%	1.6%	0.2%
2001	7.8%	30.9%	42.3%	13.5%	4.1%	1.4%	0.1%
2002	7.8%	30.0%	43.2%	13.1%	4.3%	1.6%	0.1%
2003	7.1%	28.7%	43.7%	13.6%	4.8%	1.9%	0.1%
2004	6.2%	27.4%	45.8%	13.4%	5.0%	2.1%	0.1%
2005	7.8%	29.2%	44.1%	12.1%	4.5%	2.1%	0.2%
2006	6.7%	29.9%	44.9%	11.9%	4.3%	2.1%	0.2%
2007	6.0%	28.3%	46.9%	12.2%	4.3%	2.1%	0.2%
2008	5.3%	27.4%	47.7%	12.7%	4.4%	2.3%	0.2%
2009	4.8%	26.3%	48.7%	12.8%	4.7%	2.5%	0.2%
2010	3.4%	23.9%	48.8%	13.9%	6.0%	3.7%	0.4%

Source: China labour statistical yearbook

According to China's education system (Figure 2.1), authors denote $z_{a_i,t}$ as the schooling years needed to finish a^i level of education, $m_{a_i,t}$ as the total schooling years needed. As China's education system remained stable during 1997-2010, its is assumed $z_{a_i,t} \equiv z_{a_i}$, $m_{a_i,t} \equiv m_{a_i}$. m_{a_i} is calculated as follows (result is in Table 4.3):

$$m_{a_0} = 0.$$

$$m_{a_1} = z_{a_1}.$$

$$m_{a_2} = z_{a_1} + z_{a_2}.$$

$$m_{a_3} = z_{a_1} + z_{a_2} + z_{a_3}.$$

$$m_{a_4} = z_{a_1} + z_{a_2} + z_{a_4}.$$

$$m_{a_5} = z_{a_1} + z_{a_2} + z_{a_3} + z_{a_5}.$$

$$m_{a_6} = z_{a_1} + z_{a_2} + z_{a_3} + z_{a_6}. \qquad (4.5)$$

Table 4.3: **Schooling years and total schooling years of China**

Year

	a_0	a_1	a_2	a_3	a_4	a_5	a_6
z_{a_i}	0	6	3	3	3	4	3
m_{a_i}	0	6	9	12	15	16	19

Source: authors set

Calculating human capital stock's average index μ_t and human capital stock's dispersion index σ_t^2 according to equation (3.6) and (3.7) as well as data in Table 4.2 and 4.3:

Table 4.4: **China's average and dispersion index of human capital**

	μ_t	σ_t^2	$\sigma_t^{2,a1+}$	$\sigma_t^{2,a2+}$	$\sigma_t^{2,a3+}$	$\sigma_t^{2,a4+}$	$\sigma_t^{2,a5+}$	$\sigma_t^{2,a6}$	$\sigma_t^{2,\sum_{i=1}^{2} a1}$	$\sigma_t^{2,\sum_{i=2}^{3} a1}$	$\sigma_t^{2,\sum_{i=4}^{5} a1}$	$\sigma_t^{2,\sum_{i=3}^{5} a1}$
1997	7.50	12.97	6.44	5.66	4.81	2.35	1.35	0.25	1.64	3.31	2.11	4.56
1998	7.53	12.89	6.37	5.57	4.73	2.35	1.41	0.25	1.64	3.22	2.11	4.48
1999	7.61	12.84	6.46	5.59	4.83	2.54	1.60	0.30	1.63	3.05	2.24	4.53
2000	7.88	12.39	6.56	5.43	4.91	2.75	1.28	0.20	1.65	2.68	2.55	4.71
2001	8.14	11.82	6.65	5.24	4.93	2.91	0.98	0.12	1.73	2.33	2.80	4.81
2002	8.18	11.94	6.72	5.30	5.01	3.10	1.10	0.12	1.72	2.20	2.98	4.89
2003	8.33	11.88	6.95	5.40	5.20	3.37	1.23	0.11	1.75	2.03	3.25	5.08
2004	8.48	11.38	6.92	5.23	5.11	3.45	1.33	0.14	1.81	1.78	3.31	4.96
2005	8.22	12.23	6.99	5.54	5.27	3.54	1.50	0.21	1.71	2.00	3.34	5.07
2006	8.28	11.50	6.89	5.33	5.10	3.46	1.54	0.26	1.79	1.87	3.19	4.84
2007	8.41	10.93	6.71	5.07	4.90	3.33	1.45	0.22	1.80	1.74	3.11	4.68
2008	8.53	10.57	6.72	4.97	4.87	3.33	1.50	0.23	1.86	1.64	3.10	4.64
2009	8.65	10.43	6.86	5.01	4.95	3.52	1.62	0.25	1.90	1.50	3.27	4.71
2010	9.05	10.51	7.71	5.49	5.49	4.28	2.17	0.38	2.22	1.21	3.90	5.11

Source: authors set

4.1.3 Over-expansionary investment

In the past decade, the growth rate of capital stock has been clearly higher than that of GDP in China. The excessive investment expansion will lead to the decrease of physical capital's marginal production and TFP. Hence, it is necessary to take investment expansion, which implies the political factor into the construction of China's national production function.

As the equation (3.18), $\mathbf{\Delta E_t}$ denotes the impact of investment expansion on TFP. With reference to Feng *et al.* (2012), the measurement is as follow:

$$\mathbf{\Delta E_t = E_t - E_{t-1} \doteq {g_{K_t}}/{g_{Y_t}}} \qquad (4.6)$$

In order to show the investment expansion directly and clearly, authors do the adjustment of $\mathbf{\Delta E_t}$:

$$\mathbf{\Delta E_t^{Exponent} = 100 \cdot \frac{\Delta E_t}{\min(\Delta E_{1998}, \Delta E_{1999}, \dots, \Delta E_{2009})}} \qquad (4.7)$$

Table 4.5: **Over-expansionary investment of China**

	g_{Y_t}	g_{k_t}	ΔE_t	$\Delta E_t^{exponent}$		g_{Y_t}	g_{k_t}	ΔE_t	$\Delta E_t^{exponent}$
1998	0.08	0.11	1.36	157.38	2004	0.10	0.13	1.29	148.98
1999	0.08	0.10	1.38	159.14	2005	0.11	0.13	1.11	128.21
2000	0.08	0.10	1.23	142.03	2006	0.13	0.13	1.01	116.94
2001	0.08	0.10	1.25	144.14	2007	0.14	0.12	0.87	100.00
2002	0.09	0.11	1.23	142.05	2008	0.10	0.13	1.33	153.16
2003	0.10	0.13	1.26	145.34	2009	0.09	0.15	1.60	184.62

Source: China statistical yearbook

4.1.4 Education expenditure

In the calculation of education expenditure, the authors divided education levels as listed: higher education[37], secondary vocational education[38], upper secondary education and compulsory education. The education expenditure consisted of three parts:

1. Fiscal education expenditure C_1 , which can be found at "Government Appropriation for education" in the China Statistical Yearbook[39].
2. Social education expenditure C_2 , which can be found from "Funds from School Runners of Private Schools", "Donations and Fund Raising for Running Schools" and "Other educational Funds" in China Statistical Yearbook.
3. Individual/Household education expenditure C_3 , which contains two parts: tuition and miscellaneous fees, family's education expenditures. The former can be found in the China Statistical Yearbook while the latter cannot be found directly, it was required to divide the total household education expenditure into different levels of education, the measurement is as listed:
   - We obtain the per capita urban household education expenditure from the item "Education" of "Per Capita Annual Consumption Expenditure of Urban Households By Region" in the China Statistical Yearbook, the per capita rural household education expenditure from the item "Education, Culture and Recreation and Services" of "Per Capita Cash Consumption Expenditure of Rural Households by Region".
   - Derive the urban and rural population from "Population and Its Composition" and calculation the total individual/household education expenditure by separately multiplying per capita education expenditure by population of the urban and the rural.
   - According to the percentage of tuition and miscellaneous fees of different education levels (higher education, secondary vocational education, upper secondary education and compulsory education), we divide total education expenditure into different levels.

37 Higher education includes junior college, bachelor, master and doctor.
38 Secondary vocational education includes technical schools, teacher training schools (after 2006, they are called specialized secondary schools), vocational schools (after 2006 it was called vocational high school), general and specialized secondary schools for adults.
39 Education expenditure of upper secondary schools consists 3/7 (approx. 43%) of whole secondary school before 2003.

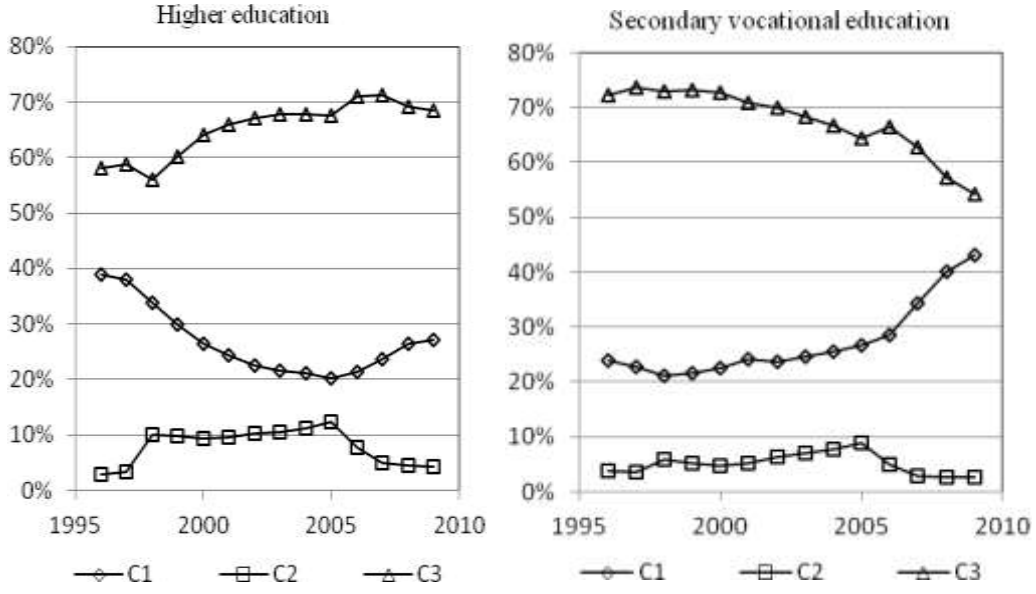
Table 4.6: **Allocation proportion of household education expenditure**

	Tuition and miscellaneous fees (1997 price, hundred million CNY)				Household education expenditure allocation proportion (%)			
	Higher	Vocational secondary	Upper secondary	compulsory	Higher	Vocational secondary	Upper secondary	compulsory
1996	45.30	69.35	24.01	107.92	18.37	28.12	9.74	43.77
1997	57.89	86.05	32.53	127.41	19.05	28.32	10.70	41.93
1998	73.77	92.45	32.14	153.23	20.98	26.30	9.14	43.58
1999	123.44	109.57	44.23	170.85	27.55	24.45	9.87	38.13
2000	192.92	117.61	63.55	188.26	35.51	21.65	8.18	34.65
2001	277.21	117.14	87.17	210.75	40.04	16.92	12.59	30.44
2002	381.13	123.43	112.89	236.82	44.61	14.45	13.22	27.72
2003	480.95	132.96	139.49	260.44	49.11	13.58	10.73	26.59
2004	576.05	134.54	177.38	255.93	50.36	11.76	15.51	22.37
2005	677.76	137.37	204.97	256.56	53.09	10.76	16.06	20.10
2006	706.97	144.72	209.04	164.26	57.71	11.81	17.06	13.41
2007	936.91	184.27	284.15	176.66	59.22	11.65	17.96	11.17
2008	1007.96	186.92	279.11	115.41	63.42	11.76	17.56	7.26
2009	1101.51	198.83	291.19	118.55	64.41	11.63	17.03	6.93

Source: China statistical yearbook

- The next step is to calculate the individual/household education expenditure of different levels C_3 .

By comparing the education expenditure (Table 4.7), it can be found that society and household expenditure share a quite large part. Particularly regarding secondary vocational education and higher education (including higher vocational education), the expenditure of household is higher than government (Figure 4.1). Clearly the result will be incomplete if only analysis of the impact of state financial education expenditure on human capital accumulation is carried out.



Note: C_1 , C_2 , C_3 separately denotes government, society and individual/household education expenditure

Figure 4.1: China's different source of education

Table 4.7 lists education expenditure of government C_1, society C_2 and individual/household C_3:

Table 4.7: **China's education expenditure**

1997 price, hundred million CNY

	Government C_1			Society C_2			Individual/household C_3		
	Higher	Vocational secondary	Upper secondary	Higher	Vocational secondary	Upper secondary	Higher	Vocational secondary	Upper secondary
1996	267	202	126	20	33	35	397	608	211
1997	306	218	140	27	34	43	474	705	266
1998	360	217	141	107	60	65	597	748	260
1999	453	240	162	148	56	78	910	808	326
2000	532	242	185	190	51	93	1285	784	423
2001	621	243	225	247	52	113	1689	714	531
2002	734	239	267	337	63	153	2180	706	646
2003	799	250	302	388	70	179	2513	695	729
2004	863	249	410	456	76	220	2775	648	854
2005	934	264	476	571	88	250	3138	636	949
2006	1038	305	551	375	52	131	3458	708	1022
2007	1224	394	609	258	34	56	3665	721	1112
2008	1424	487	683	243	32	51	3732	692	1033
2009	1619	585	793	259	36	57	4070	735	1076

Source: China statistical yearbook

Meanwhile, not only the total education expenditure but also per student can influence the formation of human capital, so the authors calculated per student education expenditure on the basis of Table 4.7.

Table 4.8: **Per student education expenditure of China**

	Total education expenditure (1997 price, hundred million CNY)			Per capita education expenditure (1997 price, hundred thousand CNY)		
	Higher	Vocational secondary	Upper secondary	Higher	Vocational secondary	Upper secondary
1992			27.25			0.04
1993			86.04			0.13
1994			191.93			0.29
1995	491.16	882.63	287.75	1.69	0.87	0.40
1996	683.86	843.58	371.99	2.26	0.78	0.48
1997	806.65	956.25	448.88	2.54	0.82	0.53
1998	1063.98	1024.42	466.18	3.12	0.84	0.50
1999	1511.32	1104.44	565.93	3.70	0.92	0.54
2000	2007.29	1076.48	701.93	3.61	0.95	0.58
2001	2556.39	1008.26	868.97	3.56	0.95	0.62
2002	3250.15	1008.30	1065.41	3.60	0.90	0.63
2003	3700.03	1015.47	1209.53	3.34	0.83	0.62
2004	4092.79	972.60	1484.91	3.07	0.69	0.67
2005	4642.57	988.27	1674.76	2.97	0.62	0.70
2006	4871.81	1064.89	1704.77	2.80	0.59	0.68
2007	5147.69	1148.83	1776.87	2.73	0.58	0.70
2008	5399.36	1210.89	1767.36	2.67	0.58	0.71
2009	5947.85	1354.85	1926.59	2.77	0.62	0.79

Note: Because of data deficiency, data in shade is estimated by time sequence model regression.

Data source: authors calculate

4.1.5 Human capital accumulation

According to equation (3.5), the human capital increment of employees with i education attainment in the t period relates to the education expenditure of current and past education of i level $\mathbf{Edu_t^i, Edu_{t-1}^i, \dots,}$ and i-1 education level's education expenditure $\mathbf{Edu_{t-\tau_i}^{i-1}, Edu_{t-\tau_i-1}^{i-1}, \dots}$ and so on:

$$\mathbf{\Delta H_t^i = h^{-1}\left(\left(Edu_t^i, Edu_{t-1}^i, \dots Edu_{t-\tau_i+1}^i\right), \left(Edu_{t-\tau_i}^{i-1}, Edu_{t-\tau_i-1}^{i-1}, \dots Edu_{t-\tau_{i-1}+1}^{i-1}\right), \dots\right)} \quad (3.5)$$

Mindful of the fact that new employees have received the compulsory education, the authors assess this aspect of education as the basic part of human capital and focus on the impact of secondary vocational education, upper secondary education and higher education on human capital accumulation. The authors have already calculated per student education expenditure of different education levels by lagging the data.

Besides the lagging, authors take the impact of GDP growth and technology progress into consideration.

- Education expenditure should keep the same growth pace of GDP to ensure the quality of human capital (knowledge and technology stock). Therefore, authors deduct the synchronous growth part of GDP from education expenditure in order to embody the effective increment of expenditure.
- Technology progress can raise the production effectiveness of the education sector and decrease the cost so it also should be included in the adjustment of education expenditure.

Consequently, authors adjust education expenditure with GDP growth rate and technology progress to ensure effective analysis of the education expenditure's input-output effect. The measurement of discount rate is:

Average discount rate of education expenditure

= (1+ average GDP growth rate) / (1+ average technology progress rate) -1 (4.8)

The period of average GDP growth rate is 1992-2009, which is in accordance with the period of education expenditure and its value is 10.3%; the average technology progress rate is measured by the accumulated price index of capital $\mathbf{P_t^{LY}}$ of 1996-2009, which is 3.9%. In this article, the authors choose the period of 1996-2009 instead of 1992-2009 due to China's price reform that took place during 1993-1994. The change of the price system means the price index not only implies technical progress but also "fault age", which means there is nothing that can be compared in terms of price before 1994 and the market price. According to the equation (4.8), the average discount rate of the education expenditure of 1992-2009 is 6.1%.

At this point we calculate the total education expenditure of different education levels by multiplying per capita education expenditure by the number of graduate students and then adjusting them by the average discount rate.

Table 4.9: **Adjusted education expenditure of China**

1997price, hundred million CNY

	Higher	Vocational secondary	Higher + Vocational secondary
1998	1866.02	1902.21	3768.23
1999	2233.95	1967.41	4201.37
2000	2701.68	2039.95	4741.63
2001	3047.37	1866.67	4914.04
2002	3857.73	1609.42	5467.15
2003	5014.55	1428.35	6442.90
2004	5848.26	1328.06	7176.33
2005	6879.13	1287.92	8167.05
2006	7610.19	1229.56	8839.74
2007	8164.48	1205.62	9370.10
2008	8575.66	1214.87	9790.53
2009	8288.28	1250.62	9538.91

Source: authors calculate

4.2 Thailand

4.2.1 Gross domestic product

By investigation, authors find that the time span of GDP is 1990-2010 in the Thailand statistical yearbook but 1980-2010 in the IMF database. After regression analysis, it can be found that there is but little difference between the two sets of data, R-Squared is nearly 100% and regression coefficients are significant at the 99.9% level (Table 4.11). Therefore, since increasing sample size can raise analytical precision, authors choose IMF data as the data basis for modelling.

Table 4.10: **GDP of Thailand**

Current price, billion THB

	Statistical yearbook	IMF		Statistical yearbook	IMF
1980		662	1996	4631	4611
1981		760	1997	4702	4733
1982		842	1998	4693	4626
1983		921	1999	4781	4637
1984		988	2000	5060	4923
1985		1056	2001	5334	5134
1986		1133	2002	5759	5451
1987		1300	2003	6306	5917
1988		1560	2004	6944	6489
1989		1857	2005	7586	7093
1990	2259	2191	2006	8365	7845
1991	2579	2507	2007	9038	8525
1992	2930	2831	2008	9659	9080
1993	3257	3165	2009	9571	9042
1994	3683	3629	2010	10807	10105
1995	4211	4186			

Source: Thailand statistical yearbook and IMF

Table 4.11: **Regression result of two sets of GDP**

Time span		1990-2010
Dep. Var.		Thailand statistical yearbook
c	Estimate	-246
	Std. Err.	55.34

	t value	(-4.46)***
Indep. Var.		IMF
β_1	Estimate	1.09
	Std. Err.	0.0092
	t value	(118.17)***
Residual Std. Err.		95
Sample Size		21
R^2		0.9986
F-statistic		13965
p value		0.0000

Note: "·", "*", "**" and "***"separately denote the significant level90%, 95%, 99% and 99.9%

4.2.2 Physical capital stock

By investigation, time span of gross fixed capital formation is 1990-2010 in the Thailand statistical yearbook. It is difficult to measure capital stock by these data because sample size is too small. Therefore, authors use 1980-2010 World Bank data as substitution and basis of modelling[40].

Table 4.12: **Gross fixed capital formation of Thailand**

Current price, billion THB

	Statistical yearbook	World Bank		Statistical yearbook	World Bank
1980		184	1996	1932	1893
1981		213	1997	1630	1599
1982		227	1998	1041	1035
1983		262	1999	978	966
1984		283	2000	1094	1081
1985		287	2001	1202	1181
1986		292	2002	1264	1243
1987		359	2003	1455	1424
1988		479	2004	1729	1682
1989		643	2005	2110	2050
1990	915	882	2006	2255	2204
1991	1055	1044	2007	2310	2250
1992	1139	1111	2008	2567	2492
1993	1275	1253	2009	2237	2182
1994	1476	1450	2010	2552	2453
1995	1743	1719			

Source: Thailand statistical yearbook and World Bank

Table 4.13: **Regression result of two sets of Gross fixed capital formation**

Time span		1990-2010
Dep. Var.		Thailand statistical yearbook
c	Estimate	-27
	Std. Err.	7.847
	t value	(-3.44)***
Indep. Var.		World Bank

40 Regression (Table 4.13) shows that two sets of data's R-Squared is 0.9996 and coefficients are significant at the 99.9% level.

β_1	Estimate	1.04
	Std. Err.	0.005
	t value	(220)***
Residual Std. Err.		11
Sample Size		21
R^2		0.9996
F-statistic		48486
p value		0.0000

Note: "·", "*", "**" and "***"separately denote the significant level90%, 95%, 99% and 99.9%

Similar to the measurement of China, the authors used the accumulated price index to make price adjustments of the different periods' physical capital formation and measure the heterogeneous capital stock of Thailand. As depreciation data is not available in Thailand, the depreciation rate is set as 6% and depreciation life as 17 years[41]. The results show that investment goods' price index remains stable during 1997-2010 and it rises even higher than the gross price index after 2006. This phenomenon reflects that Thailand's relative technical level has remained unchanged over the past decades. As a consequence there is no need to make quality adjustments when the physical capital formation and stock of Thailand is measured (Table 4.14).

Table 4.14: **Physical capital stock of Thailand**

	p_t^V	p_t^I	$p_t^{I,V}$	Y_t	$I_{B,t}$	K_t
	Index			1997 price, billion THB		
1997	100	100	100	4733	1599	11855
1998	109	88	81	4235	948	12078
1999	105	93	72	4424	921	12263
2000	106	93	63	4634	1018	12530
2001	108	91	53	4734	1089	12848
2002	109	93	45	4986	1137	13194
2003	111	98	39	5341	1286	13660
2004	114	106	36	5679	1472	14275
2005	119	116	36	5940	1717	15086
2006	126	128	36	6246	1755	15888
2007	130	141	39	6561	1731	16622
2008	135	160	47	6729	1847	17423
2009	138	150	51	6571	1586	17933
2010	143	167	60	7082	1719	18539

Source: IMF and World Bank

4.2.3 Labour's Educational attainment

Due to the discontinuity and oversimplification of Thailand's education expenditure (Table 6.4), Model 2 is not applicable in the study of Thailand. Therefore, the authors have carried out the study from the

41 Plenty of empirics set depreciation rate around 6%, such as Hall and Jones (1999), Bils and Klenow (2000), Bloom *et al.* (2002) and so on.

perspective of labours' educational attainment to analyse the effect of education on national output growth.

According to the educational attainment data of the employee in the "Report of the Labour Force Survey", dividing education into 7 levels, a^i denotes education levels, $i = 0, 1, \ldots, 6$ indicating in the following order illiterate, elementary education, lower secondary education, upper secondary education, vocational secondary education (including specialized secondary school and teacher training), junior college and higher education.

Table 4.15: **Thailand's composition of employment by educational attainment**

	a_0	a_1	a_2	a_3	a_4	a_5	a_6
2001	43.4%	22.4%	12.8%	6.5%	3.3%	6.0%	5.5%
2002	42.6%	22.6%	13.0%	6.8%	3.2%	5.9%	5.6%
2003	40.8%	22.5%	13.6%	7.4%	3.3%	6.1%	6.0%
2004	39.0%	22.4%	14.1%	7.9%	3.3%	6.2%	6.6%
2005	38.0%	22.1%	14.1%	8.2%	3.4%	6.4%	7.2%
2006	37.6%	21.8%	14.2%	8.7%	3.3%	6.5%	7.5%
2007	35.4%	22.8%	14.7%	9.2%	3.3%	6.5%	7.7%
2008	33.9%	22.8%	15.2%	9.6%	3.3%	6.6%	8.2%
2009	33.0%	22.6%	15.4%	9.9%	3.4%	6.8%	8.6%
2010	31.4%	22.9%	15.7%	10.4%	3.4%	6.9%	8.9%
2011	30.2%	22.6%	16.0%	10.6%	3.4%	7.2%	9.6%

Source: Report of the Labour Force Survey, National Statistical Office, Ministry of Information and Communication Technology.

According to Thailand's education system (Figure 2.3), authors denote z_{a_i} as schooling years required to finish a^i level of education, m_{a_i} as total schooling years required.

Table 4.16: **Schooling years and total schooling years of Thailand**

Year	a_0	a_1	a_2	a_3	a_4	a_5	a_6
z_{a_i}	0	6	3	3	3	3	4
m_{a_i}	0	6	9	12	12	15	16

Source: authors set

Calculating the average index μ_t and dispersion index σ_t^2 of human capital stock according to equation (3.6) and (3.7) as well as the data in Table 4.17:

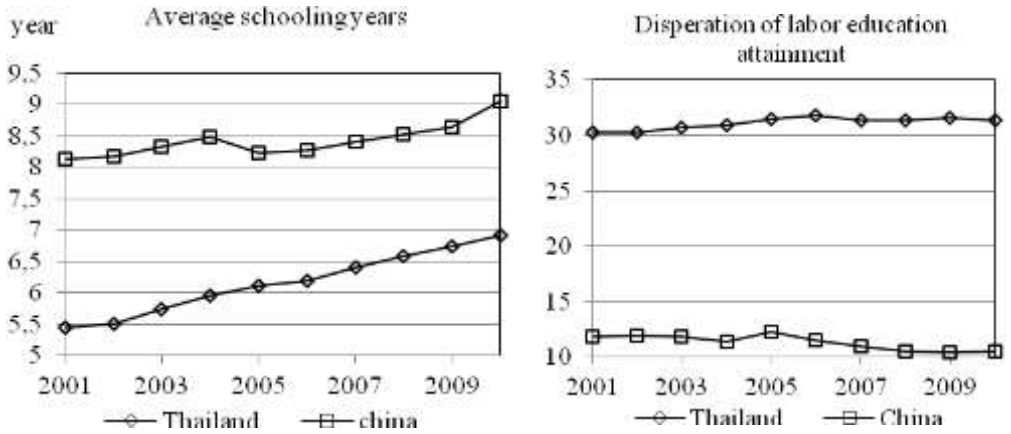


Figure 4.2: China's and Thailand's average and dispersion index of human capital

Table 4.17: **Thailand's average and dispersion index of human capital**

	μ_t	σ_t^2	$\sigma_t^{2,a1+}$	$\sigma_t^{2,a2+}$	$\sigma_t^{2,a3+}$	$\sigma_t^{2,a4+}$	$\sigma_t^{2,a5+}$	$\sigma_t^{2,a6}$
2001	5.44	30.30	17.48	17.41	15.79	13.01	11.57	6.12
2002	5.51	30.27	17.35	17.29	15.71	12.86	11.51	6.20
2003	5.74	30.66	17.24	17.23	15.78	12.88	11.59	6.33
2004	5.95	30.97	17.16	17.16	15.85	12.94	11.73	6.64
2005	6.11	31.53	17.34	17.34	16.16	13.30	12.12	7.06
2006	6.18	31.78	17.40	17.39	16.27	13.34	12.23	7.21
2007	6.40	31.37	16.89	16.86	15.86	12.98	11.94	7.15
2008	6.58	31.41	16.70	16.63	15.74	12.93	11.97	7.27
2009	6.73	31.61	16.64	16.52	15.73	12.98	12.03	7.41
2010	6.92	31.38	16.37	16.17	15.49	12.81	11.92	7.38
2011	7.10	31.53	16.31	16.04	15.46	12.90	12.08	7.61
	$\sigma_t^{2,a1}$	$\sigma_t^{2,\sum_{i=1}^{2} ai}$	$\sigma_t^{2,\sum_{i=2}^{3} ai}$	$\sigma_t^{2,\sum_{i=2}^{t} ai-a3}$	$\sigma_t^{2,\sum_{i=2}^{3} ai}$	$\sigma_t^{2,\sum_{i=2}^{5} ai}$	$\sigma_t^{2,\sum_{i=4}^{5} ai}$	$\sigma_t^{2,a3+a6}$
2001	0.07	1.69	3.06	3.13	4.40	11.57	6.88	8.90
2002	0.05	1.64	2.94	3.00	4.43	11.51	6.67	9.04
2003	0.02	1.47	2.74	2.76	4.35	11.59	6.55	9.23
2004	0.00	1.31	2.53	2.53	4.21	11.73	6.30	9.54
2005	0.00	1.19	2.37	2.37	4.04	12.12	6.24	9.92
2006	0.01	1.13	2.23	2.24	4.06	12.23	6.13	10.14
2007	0.04	1.03	2.03	2.07	3.88	11.94	5.83	10.03
2008	0.08	0.97	1.85	1.93	3.70	11.97	5.66	10.08
2009	0.12	0.91	1.75	1.87	3.53	12.03	5.57	10.15
2010	0.19	0.87	1.57	1.76	3.37	11.92	5.43	10.06
2011	0.27	0.85	1.41	1.68	3.14	12.08	5.30	10.17

Source: authors calculate

Table 4.17 and Figure 4.2 show that:

- Benefiting from the increasing expenditure of elementary education stage (Figure 2.18 during 2001-2011, b), Thailand's average schooling years μ_t is on a steady increase, from 5.6 years to 7.1 years. However, although human capital accumulates continuously, labour's average

schooling years in Thailand still remains low. Taking China as an example (Figure 4.2), the average schooling years was 7.5 in 1997, higher than that of Thailand in 2011. There is still a great deal of space for Thailand to accumulate its human capital.

- Dispersion of Thailand's human capital accumulation is large. The main reason for this is less educated labour takes up a large proportion of employment while those who receive secondary education take up comparatively less.

Table 4.18: **Dispersion index of China's and Thailand's human capital**

	$\sigma^2_{Thailand}$	$\Delta\sigma^2_{Thailand}$	σ^2_{China}	$\Delta\sigma^2_{China}$		$\sigma^2_{Thailand}$	$\Delta\sigma^2_{Thailand}$	σ^2_{China}	$\Delta\sigma^2_{China}$
2001	30.30		11.82		2006	31.78	0.81%	11.50	-5.98%
2002	30.27	-0.08%	11.94	1.04%	2007	31.37	-1.32%	10.93	-4.95%
2003	30.66	1.28%	11.88	-0.53%	2008	31.41	0.13%	10.57	-3.35%
2004	30.97	1.00%	11.38	-4.17%	2009	31.61	0.64%	10.43	-1.31%
2005	31.53	1.81%	12.23	7.45%	Average fluctuation	0.54%		-1.47%	

Source: Table 4.17

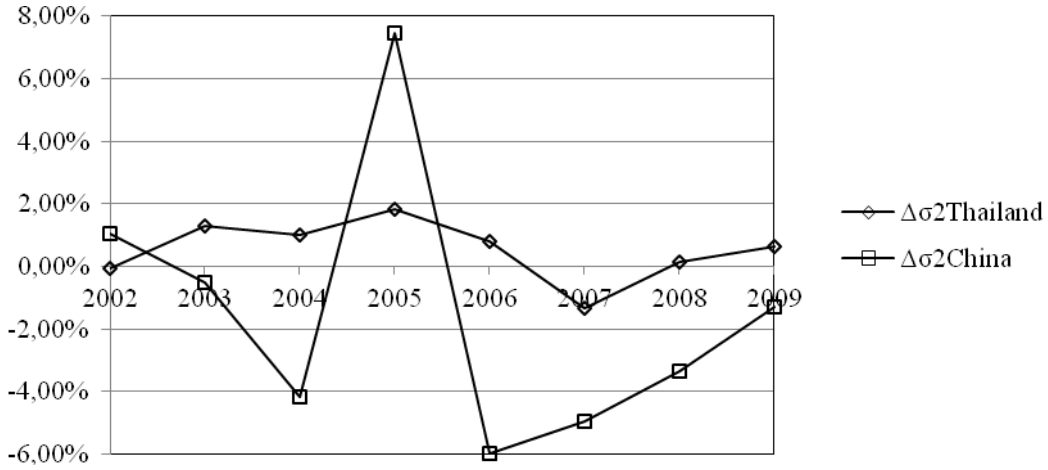


Figure 4.3: Dispersion index of China's and Thailand's human capital

4.3 Vietnam

4.3.1 Gross domestic product

With reference to the GDP data from the general statistical organization during 1990-2010 (Table 4.19 and Figure 2.13), there has been a clear increase in Vietnam's economic growth over the past two decades.

Table 4.19: **GDP of Vietnam**

Billion Dong

	Current year	Current year index 1997=100	1994 price	Constant year index 1997=100	Price index P^Y 1997=100	1997 price
1990	41955	13.38	131968	57.06	23.44	178965

1991	76707	24.46	139634	60.38	40.51	189361
1992	110532	35.24	151782	65.63	53.70	205835
1993	140258	44.72	164043	70.93	63.05	222463
1994	178534	56.93	178534	77.20	73.74	242115
1995	228892	72.98	195567	84.56	86.30	265213
1996	272036	86.74	213833	92.46	93.81	289984
1997	313623	100.00	231264	100.00	100.00	313623
1998	361017	115.11	244596	105.76	108.84	331703
1999	399942	127.52	256272	110.81	115.08	347537
2000	441646	140.82	273666	118.33	119.00	371125
2001	481295	153.46	292535	126.49	121.32	396714
2002	535762	170.83	313247	135.45	126.12	424802
2003	613443	195.60	336242	145.39	134.53	455986
2004	715307	228.08	362435	156.72	145.53	491507
2005	839211	267.59	393031	169.95	157.45	532999
2006	974266	310.65	425373	183.93	168.89	576859
2007	1143715	364.68	461344	199.49	182.81	625640
2008	1485038	473.51	490458	212.08	223.27	665123
2009	1658389	528.78	516566	223.37	236.73	700528
2010	1980914	631.62	551609	238.52	264.81	748051

Source: General Statistical Organization (GSO)

4.3.2 Physical capital stock

As the earliest year of a gross fixed capital formation of Vietnam is 1995, the method above is not applicable. As a result, the authors used estimated capital stock data as the substitution, which can be found in the Global Economic Prospects data base of World Bank (Table 4.20).

Table 4.20: **Physical capital stock of Vietnam**

Billion Dong

	K_t (current years)	K_t (1997 price)	K_t^* (1997 price)
1992	20980	39069	
1993	49419	78384	
1994	89285	121082	
1995	132750	153815	
1996	180135	192020	
1997	229964	229964	229964
1998	284053	260989	274080
1999	335464	291507	327656
2000	390533	328174	378720
2001	450168	371057	431877
2002	516816	409780	474650
2003	590482	438919	492416
2004	670460	460692	514448
2005	756669	480575	546943
2006	850027	503298	584211
2007	972198	531817	628151
2008	1092791	489442	635317
2009	1221403	515939	761704
2010	1363357	514843	871606

Source: General Statistical Organization (GSO) and World Bank

Table 4.21: **Gross fixed capital formation and price index of Vietnam**

	Current year (billion Dongs)	Current year index 1997=100	1994 price (billion Dongs)	Constant year index 1997=100	Price index P^Y 1997=100	p_t^{LY}
1995	58187	69	49715	80	87	
1996	71597	86	56678	91	94	
1997	83734	100	62438	100	100	100
1998	97551	117	70187	112	104	95
1999	102799	123	71294	114	108	89
2000	122101	146	78552	126	116	87
2001	140301	168	86972	139	120	86
2002	166828	199	98160	157	127	86
2003	204608	244	109843	176	139	89
2004	237868	284	121312	194	146	90
2005	275841	329	133141	213	154	88
2006	324949	388	146325	234	166	86
2007	437702	523	181673	291	180	85
2008	513987	614	188647	302	203	77
2009	572526	684	205107	328	208	68
2010	704401	841	227452	364	231	59

Source: General Statistical Organization (GSO)

Likewise with the processing method of China's physical capital, the authors used accumulated price index (Table 4.21) to make the price adjustment of the different periods' physical capital formation and measure the heterogeneous capital stock of Vietnam to obtain the following result:

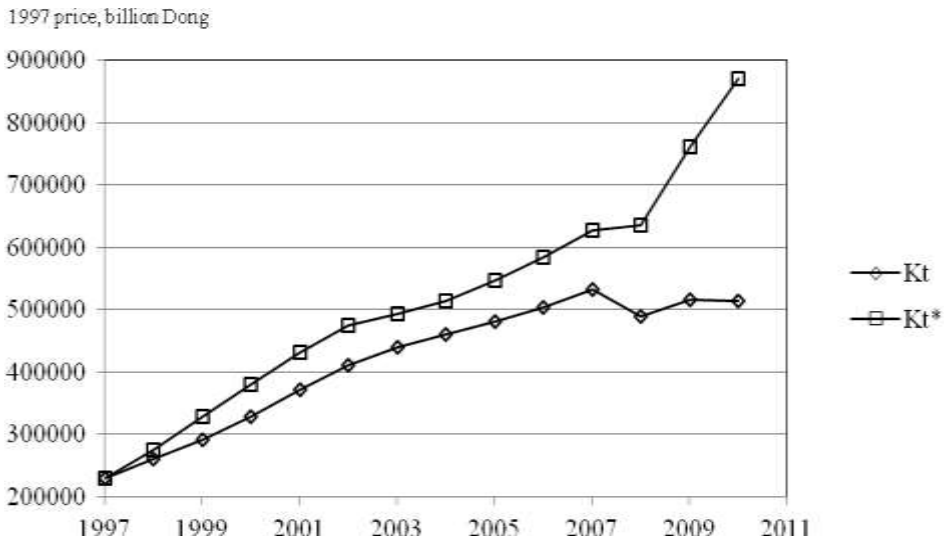


Figure 4.4: Homo- and Heterogeneous capital stock of Vietnam

Figure 4.4 shows that heterogeneous capital stock is greater than the homogeneous one, the divergence has gradually expanded since 2008. It is estimated that with the constant development of economy, technological progress (especially those embodied in physical capital) has risen dramatically

4.3.3 Labour's Educational attainment

Similar to the situation of Thailand, the education expenditure data of Vietnam is also short and discontinuous. Thus, the authors use Model 1 to analyse the impact of Vietnam's education on human capital accumulation and aggregate output.

First, according to the education system of Vietnam (Figure 2.4), education was divided into 7 levels, a^i denotes education levels, $i = 0, 1, \dots, 6$ indicate in the following order: illiteracy, elementary school, lower secondary education, upper secondary education, vocational secondary education (including specialized secondary school and teacher training), vocational college and higher education.

There is a minor difference to Thailand's education system. In Vietnam, elementary education has a duration of 5 years while lower secondary education is 4 years.

Table 4.22: **Schooling years and total schooling years of Vietnam**

Year

	a_0	a_1	a_2	a_3	a_4	a_5	a_6
z_{a_i}	0	5	4	3	3	3	4
m_{a_i}	0	5	9	12	12	15	16

Source: authors set

Table 4.23: **Vietnam's composition of employment by educational attainment**

	a_0	a_1	a_2	a_3	a_4	a_5	a_6
1990	13.5%	34.7%	27.3%	14.5%	5.7%	2.0%	2.3%
1991	13.8%	34.5%	27.1%	14.5%	5.6%	2.1%	2.4%
1992	13.7%	34.5%	27.0%	14.4%	5.5%	2.4%	2.5%
1993	13.9%	34.3%	26.9%	14.3%	5.6%	2.3%	2.7%
1994	13.5%	34.2%	27.3%	14.3%	5.7%	2.2%	2.8%
1995	13.3%	34.0%	27.5%	14.2%	5.8%	2.3%	2.9%
1996	13.6%	33.8%	27.2%	14.0%	6.0%	2.5%	2.9%
1997	14.0%	33.6%	27.0%	14.1%	5.7%	2.6%	3.0%
1998	14.1%	33.7%	26.7%	14.0%	5.5%	2.7%	3.3%
1999	14.0%	33.3%	26.9%	14.0%	5.3%	3.0%	3.5%
2000	13.9%	33.5%	27.5%	13.7%	5.5%	2.2%	3.8%
2001	13.6%	33.7%	27.5%	13.6%	5.6%	2.2%	3.8%
2002	11.1%	33.6%	28.0%	13.6%	7.4%	2.3%	4.0%
2003	13.7%	33.5%	27.6%	13.5%	4.7%	3.1%	3.9%
2004	12.2%	33.6%	27.9%	13.2%	5.6%	3.6%	3.9%
2005	13.9%	33.5%	28.0%	13.0%	5.3%	2.2%	4.1%
2006	15.8%	33.8%	26.9%	13.1%	4.6%	1.7%	4.1%
2007	15.5%	28.9%	31.1%	12.9%	5.3%	1.9%	4.4%
2008	15.2%	29.0%	31.0%	12.9%	5.3%	2.0%	4.6%
2009	16.1%	29.0%	29.9%	13.0%	5.1%	2.2%	4.7%
2010	15.9%	29.1%	29.9%	13.0%	5.0%	2.0%	5.1%

Source: Ministry of labour – invalids and social affairs (MoLISA), General Statistical Organization (GSO)

At this point the authors calculated average index μ_t and dispersion index σ_t^2 of human capital stock according to equation (3.6) and (3.7) as well as data in Table 4.23, the results are in Table 4.24 and Figure 4.5. During the past two decades, the majority of labour has attained lower secondary education, but the dispersion index fluctuates dramatically. This unbalanced phenomenon is caused by the increase in illiterate and highly educated labour. The polarization situation could relate to Vietnam's deficient education input and the social inequality between rich and poor.

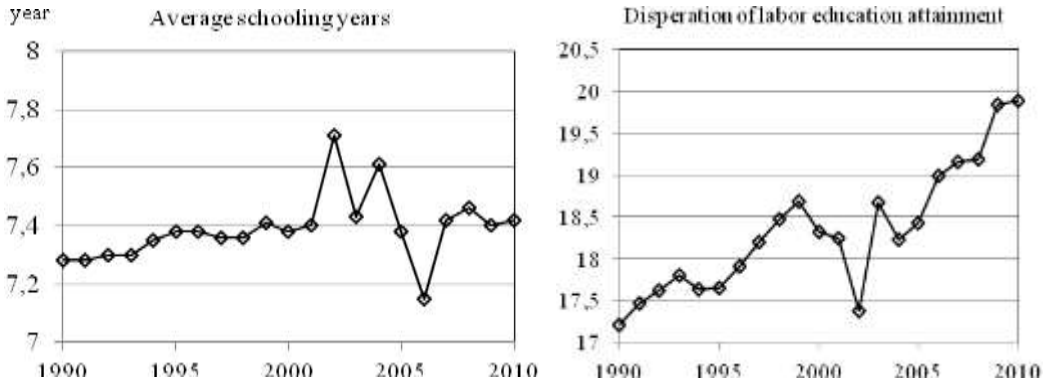


Figure 4.5: Vietnam's average and dispersion index of human capital

Table 4.24: **Vietnam's average and dispersion index of human capital**

	μ_t	σ_t^2	$\sigma_t^{2,a1+}$	$\sigma_t^{2,a2+}$	$\sigma_t^{2,a3+}$	$\sigma_t^{2,a4+}$	$\sigma_t^{2,a5+}$	$\sigma_t^{2,a6}$
1990	7.28	17.21	10.04	8.23	7.43	4.21	2.94	1.75
1991	7.28	17.46	10.16	8.37	7.57	4.33	3.08	1.83
1992	7.30	17.62	10.31	8.48	7.70	4.53	3.31	1.89
1993	7.30	17.80	10.39	8.58	7.80	4.64	3.41	2.04
1994	7.35	17.63	10.35	8.47	7.72	4.62	3.39	2.10
1995	7.38	17.65	10.40	8.47	7.75	4.72	3.49	2.15
1996	7.38	17.91	10.51	8.60	7.88	4.89	3.61	2.16
1997	7.36	18.20	10.63	8.76	8.03	4.99	3.76	2.24
1998	7.36	18.47	10.83	8.95	8.23	5.22	4.04	2.46
1999	7.41	18.68	10.99	9.05	8.37	5.42	4.31	2.58
2000	7.38	18.32	10.77	8.87	8.15	5.23	4.06	2.78
2001	7.40	18.24	10.79	8.84	8.14	5.26	4.08	2.81
2002	7.71	17.37	10.78	8.32	7.85	5.34	3.98	2.75
2003	7.43	18.66	11.10	9.11	8.44	5.62	4.64	2.86
2004	7.61	18.23	11.16	8.87	8.33	5.79	4.71	2.74
2005	7.38	18.43	10.87	8.98	8.24	5.46	4.33	3.05
2006	7.15	18.98	10.91	9.36	8.43	5.35	4.26	3.21
2007	7.42	19.15	10.62	8.94	8.16	5.45	4.33	3.24
2008	7.46	19.19	10.73	8.98	8.24	5.58	4.49	3.35
2009	7.40	19.83	11.02	9.36	8.59	5.83	4.75	3.48
2010	7.42	19.88	11.13	9.42	8.67	5.95	4.90	3.75
	$\sigma_t^{2,a1}$	$\sigma_t^{2,\sum_{i=1}^{2} ai}$	$\sigma_t^{2,\sum_{i=1}^{3} ai}$	$\sigma_t^{2,\sum_{i=2}^{3} ai}$	$\sigma_t^{2,\sum_{i=2}^{4} a1-a3}$	$\sigma_t^{2,\sum_{i=2}^{5} ai}$	$\sigma_t^{2,\sum_{i=4}^{5} ai}$	$\sigma_t^{2,a3+a6}$

1990	1.81	2.61	5.84	4.03	2.07	2.94	2.46	4.97
1991	1.79	2.59	5.83	4.04	2.06	3.08	2.50	5.06
1992	1.83	2.61	5.78	3.95	1.99	3.31	2.64	5.07
1993	1.82	2.59	5.75	3.93	2.01	3.41	2.60	5.20
1994	1.88	2.63	5.73	3.85	1.98	3.39	2.52	5.20
1995	1.93	2.65	5.68	3.74	1.95	3.49	2.57	5.18
1996	1.91	2.63	5.62	3.71	2.00	3.61	2.74	5.15
1997	1.87	2.59	5.64	3.77	1.96	3.76	2.75	5.28
1998	1.88	2.60	5.61	3.73	1.90	4.04	2.76	5.48
1999	1.94	2.62	5.56	3.63	1.79	4.31	2.84	5.53
2000	1.90	2.62	5.54	3.64	1.89	4.06	2.45	5.70
2001	1.94	2.65	5.52	3.58	1.89	4.08	2.45	5.68
2002	2.46	2.93	5.44	2.98	1.83	3.98	2.59	5.26
2003	1.98	2.66	5.48	3.50	1.66	4.64	2.76	5.68
2004	2.29	2.83	5.37	3.08	1.62	4.71	3.04	5.29
2005	1.89	2.63	5.41	3.52	1.87	4.33	2.41	5.83
2006	1.56	2.48	5.57	4.01	2.01	4.26	2.13	6.30
2007	1.69	2.47	5.18	3.49	1.89	4.33	2.21	5.95
2008	1.75	2.49	5.15	3.39	1.83	4.49	2.23	6.01
2009	1.66	2.43	5.19	3.53	1.85	4.75	2.35	6.24
2010	1.71	2.45	5.18	3.47	1.79	4.90	2.20	6.48

Source: authors calculate

4.4 Lao PDR

Due to Lao's data deficiency, it is difficult to carry out extensive research. Listed here is some information collected on Lao PDR.

4.4.1 Gross domestic product

As the GDP data of Lao PDR is discontinuous, the authors have used IMF GDP data as a substitute[42]. Lao's GDP was discovered to show a rapid growth rate over the past two decades, especially after 2002, it retains at 7% and above (Table 4.26).

Table 4.25: **GDP of Lao PDR**

Billion Kip

	GDP - NSC	GDP - IMF					
	Current year	Current year	Current year	Current year	Current year	Current year	Current year
1990	613	643	28	8779	64.16	43.40	1482
1991		758	33	9131	66.72	49.17	1541
1992		886	38	9770	71.39	53.74	1649
1993		998	43	10343	75.58	57.17	1746
1994		1163	50	11187	81.75	61.59	1889
1995	1430	1490	64	11975	87.51	73.68	2022

[42] Regression (Table 4.25) shows that two sets of data's R-Squared is 0.9979 and coefficients are significant at the 99.9% level

1996		1812	78	12800	93.54	83.85	2161
1997		2310	100	13684	100.00	100.00	2310
1998		4286	186	14284	104.38	177.74	2411
1999		9972	432	14874	108.70	397.12	2511
2000	13669	12918	559	15815	115.57	483.83	2670
2001	15702	14854	643	16546	120.91	531.78	2793
2002	18401	17682	765	17682	129.21	592.35	2985
2003	22511	21287	921	18780	137.24	671.43	3170
2004	26590	25152	1089	20099	146.87	741.27	3393
2005	30594	28948	1253	21459	156.81	799.09	3623
2006	35407	35981	1558	23314	170.37	914.20	3936
2007	40467	40467	1752	25142	183.73	953.42	4244
2008	46215	46215	2000	27099	198.03	1010.19	4575
2009	47562	47567	2059	29156	213.06	966.39	4922

Source: Lao department of statistics[43], IMF

Table 4.26: **GDP growth of Lao PDR**

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
GDP Growth rate	1482	1541	1649	1746	1889	2022	2161	2310	2411	2511
		4%	7%	6%	8%	7%	7%	7%	4%	4%
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
GDP Growth rate	2670	2793	2985	3170	3393	3623	3936	4244	4575	4922
	6%	5%	7%	6%	7%	7%	9%	8%	8%	8%

Source: IMF

Table 4.27: **Regression result of two sets of GDP**

Time span		2000-2009
Dep. Var.		Lao department of statistics "GDP"
c	Estimate	1626
	Std. Err.	495
	t value	(3.28)**
Indep. Var.		IMF"GDP"
β_1	Estimate	0.96
	Std. Err.	0.02
	t value	(61.46)***
Residual Std. Err.		604
Sample Size		10
R^2		0.9979
F-statistic		3777
p value		0.0000

Note: "·", "*", "**" and "***"separately denote the significant level90%, 95%, 99% and 99.9%

43 Source of Laos GDP:1990-2006 http://www.nsc.gov.la/Selected_Statistics.htm;2007-2010:Department of Statistics, Ministry of Planning and Investment.

4.4.2 Physical capital stock

As the gross fixed capital formation of Lao PDR is deficient, the authors referred to the study method of Vietnam, using capital stock data of the World Bank as a substitute. The accumulated price index of capital $p_t^{I,Y}$ decreases sharply during 1997-2010 even approaching zero (Table 4.28). This demonstrates that Lao PDR has clearly experienced technical progress over the past decades and it could be relevant to its low economic development level.

Table 4.28: **Gross fixed capital formation of Lao PDR**

	Current year	Current year index 1997=100	2005 price	Constant year index 1997=100	Current price	investment goods' price index p_t^I 1997=100	$p_t^{I,Y}$
				Million. USD	Million. Kip		
1984	108.57	8.94	153.82	62.61	86400	14.27	
1985	166.67	13.72	143.14	58.26	80400	23.54	
1986	123.16	10.14	142.96	58.19	80300	17.42	
1987	110.78	9.12	137.44	55.95	77200	16.30	
1988	80.86	6.66	118.04	48.05	66300	13.85	
1989	601.97	49.55	143.12	58.26	80390	85.05	
1990	946.97	77.94	168.21	68.47	94479	113.83	
1991	1129.75	92.98	179.27	72.97	100695	127.42	
1992	1279.36	105.30	190.34	77.48	106911	135.91	
1993	1450.72	119.40	201.41	81.98	113127	145.64	
1994	1619.17	133.26	212.48	86.49	119344	154.09	
1995	1596.87	131.43	223.54	90.99	125560	144.44	
1996	1528.67	125.82	234.61	95.50	131776	131.75	
1997	1215.01	100.00	245.68	100.00	137992	100.00	100.00
1998	501.42	41.270	256.74	104.50	144208	39.49	22.22
1999	250.18	20.59	267.81	109.01	150424	18.89	1.06
2000	241.15	19.85	278.88	113.51	156640	17.48	0.04
2001	249.27	20.52	299.13	121.76	168018	16.85	0.00
2002	320.89	26.41	394.24	160.47	221439	16.46	0.00
2003	359.44	29.58	399.00	162.41	224112	18.22	0.00
2004	569.03	46.83	576.05	234.47	323555	19.97	0.00
2005	637.77	52.49	637.77	259.60	358221	20.22	0.00
2006	893.60	73.55	755.53	307.53	424368	23.92	0.00
2007	1385.75	114.05	1032.26	420.17	579800	27.14	0.00
2008	1643.83	135.29	1023.16	416.47	574692	32.49	0.00
2009	1812.71	149.19	1125.34	458.06	632084	32.57	0.00
2010	1906.93	156.95	1037.00	422.10	582462	37.18	0.00

Source: World Bank

4.4.3 Education background

Lao PDR's labour educational attainment data is not available at present and its education expenditure is also insufficient, thus the authors could not carry out any further studies in the absence of such necessary data. A list has been provided of some education information gathered by process of investigation.

Table 4.29: **Students in school of different education levels**

Thousand person

	Elementary	Lower secondary	Upper secondary	Vocational secondary	Junior college	Higher
2001	828	196	89	15	10	10
2002	853	214	102	18	15	11
2003	857	229	119	22	19	13
2004	885	240	135	22	20	18
2005	891	243	145	28	26	24
2006	892	243	148	29	30	31
2007	892	249	152	26	40	38
2008	901	255	155	21	54	38
2009	909	265	157	17	59	54
2010	916	335	98	18	50	67

Source: authors investigate

Table 4.30: Education expenditure of Lao PDR

Current year, million USD

	Elementary	Lower secondary	Upper secondary	Vocational secondary	Junior college	Higher
2001		1727.74		4530.09	482.02	
2002	90493.55	17555.05	15654.86	32629.10	7357.28	22590.57
2003	105542.18	6230.10	12204.56	40973.03	7553.18	17500.00
2004	180967.09	25069.19	**7223.45**	13362.71	1490.19	17000.00
2005	169577.25	34078.60	42058.86	50554.26	6115.55	**237810.00**
2006	404509.60	**118255.45**	52875.62	66860.25	8091.55	**56493.83**
2007	312049.02	51109.27	62003.44	66755.43	5379.44	**64509.33**
2008	273021.35	99070.32	106778.83	31024.82	3888.74	**77401.83**
2009	283052.29	**118112.47**	122677.21	59599.54	5844.36	**259833.32**
2010	**18722.34**	13726.92	**5694.04**	**164231.07**	2053.07	**82973.69**

Bold data in Table fluctuate sharply and because of limited data source, it difficult to confirm their precision.

Source: authors investigate

5 Regression

5.1 China

5.1.1 Total output effect of education beyond junior high school

To obtain an overall assessment of the total output effect of education beyond junior high school, the authors has assumed ΔH_t^{3+4} as the general human capital of secondary vocational and higher general/vocational education without considering their heterogeneity. Accordingly, the econometric function inferred from equation (3.18) is:

$$\Delta Y_t = \alpha \cdot \Delta K_t^* + \beta \cdot \Delta E_t + \gamma_{3+4} \cdot \Delta H_t^{3+4} + \varepsilon_t \qquad (5.1)$$

According to the result in Table 5.1 regression 1, the total output effect of secondary vocational and higher general/vocational education can be reflected by production as follows:

$$\Delta Y_t = 22200 + 0.11\ \Delta K_t^* - 137.03 \Delta E_t + 0.83\ \Delta H_t^{3+4} \qquad (5.2)$$

The result shows that: the output elasticity of general human capital measured by the sum of secondary vocational and higher general/vocational education expenditure is positive (0.83) and it is significant at the 95% level. As the other regression coefficients are significant at the 99.9% level and R-Squared is 0.9903, it can be concluded that equation (5.2) can effectively describe China's national output growth over the past decades, secondary vocational and higher general/vocational education clearly bear a significant positive output effect.

5.1.2 Respective output effects of education beyond junior high school

To measure the respective output effects of each education level beyond junior high school, the authors subdivided general human capital into two levels.

- Higher general/vocational education

Assuming the human capital increment of secondary vocational education ΔH_t^3 remains stable, ΔH_t^4 is the human capital accumulation of higher general/vocational education, simplify equation (3.18):

$$\Delta Y_t = \alpha \cdot \Delta K_t^* + \beta \cdot \Delta E_t + \gamma_4 \cdot \Delta H_t^4 + \varepsilon_t \qquad (5.3)$$

Table 5.1: **Regressions on China's national production function**

		Regression 1	Regression 2	Regression 3	Regression 4
Time span		1998-2009			
Dep. Var.		ΔY_t	ΔY_t	ΔY_t	ΔY_t
c	Estimate	22200	23970	34400	31070

	Std. Err.	(4050)***	(2975)***	(1500)***	(1855)***
	t value	5.48	8.06	22.94	16.75
Indep. Var.1		ΔK_t^*	ΔK_t^*	ΔK_t^*	ΔK_t^*
α	Estimate	0.11	0.11	0.13	0.154
	Std. Err.	(0.020)***	(0.017)***	(0.009)***	(0.007)***
	t value	5.44	6.34	15.12	21.39
Indep. Var.2		ΔE_t	ΔE_t	ΔE_t	ΔE_t
β	Estimate	-137.03	-136.82	-148.79	-174.85
	Std. Err.	(19.263)***	(17.233)***	(11.012)***	(13.103)***
	t value	-7.11	-7.94	-13.51	-13.35
Indep. Var.3				ΔH_t^3	
γ_3	Estimate			-3.77	
	Std. Err.			(1.022)**	
	t value			-3.69	
Indep. Var.4			ΔH_t^4		
γ_4	Estimate		0.75		
	Std. Err.		(0.268)*		
	t value		2.71		
Indep. Var.5		ΔH_t^{3+4}			
γ_{3+4}	Estimate	0.83			
	Std. Err.	(0.353)*			
	t value	2.36			
Residual Std. Err.		743.6	698.6	588.8	912.8
Sample Size		12	12	12	12
R^2		0.9903	0.9914	0.9939	0.9835
R_{ij}^2 (Multicollinearity test)		R_{12}^2 0.0466 R_{14}^2 0.7356 R_{24}^2 0.0542	R_{12}^2 0.0466 R_{14}^2 0.7169 R_{24}^2 0.0575	R_{12}^2 0.0466 R_{13}^2 0.5269 R_{23}^2 0.0750	R_{12}^2 0.0466
F-statistic		271.8	308.3	435.1	268.7
p value		0.0000	0.0000	0.0000	0.0000

Note: "·", "*", "**" and "***"separately denote the significant level 90%, 95%, 99% and 99.9%

The result is shown in Table 5.1 regression 2 and the econometric function is as follows:

$$\Delta Y_t = 23970 + 0.11 \Delta K_t^* - 136.82 \Delta E_t + 0.75 \Delta H_t^4 \quad (5.4)$$

Its R-Squared is 0.9914.

By comparing the results of regression 1 and 2, it can be found that the output elasticity of ΔK_t^* and ΔE_t is nearly the same and the coefficient of higher general/vocational education is significantly positive (0.75) but less than that of ΔH_t^{3+4} (0.83) in equation (5.2), the extra part could arise from secondary vocational education.

- Secondary vocational education

With reference to the analysis of higher general/vocational education, the regression equation of secondary vocational education is as follows:

$$\Delta Y_t = \alpha \cdot \Delta K_t^* + \beta \cdot \Delta E_t + \gamma_3 \cdot \Delta H_t^3 + \varepsilon_t \qquad (5.5)$$

The result is shown in Table 5.1 regression 3 and the econometric function is as follows:

$$\Delta Y_t = 34400 + 0.13\ \Delta K_t^* - 148.79 \Delta E_t - 3.77\ \Delta H_t^3 \qquad (5.6)$$

Its R-Squared is 0.9939.

The regression coefficient of secondary vocational education is significantly negative, which is inconsistent with the above analysis conclusion and earlier research work (Fu and Xu, 2005; Li and Lin, 2007).

The authors attribute this to the fact that: secondary vocational education input does not rise significantly and the per student education expenditure trend went down in the past decade (Table 4.8). If we take the depression of human capital (knowledge and technology update) into consideration, deficient education expenditure does not contribute to human capital accumulation and it cannot make up for the depression of human capital, which makes ΔH_t^3 decrease. Meanwhile, as the aggregate output of China is on the rise, the decline of secondary vocational education expenditure will cause a negative correlation between the two of them.

Furthermore, if human capital has a negative impact on aggregate output, its carrier (labour) cannot be employed in the labour market. The comparison between equation (5.2) and (5.4) also shows that secondary vocational education bears a positive output effect. Therefore, equation (5.6) implies that: inadequate input in secondary vocational education is a handicap to China's economic development.

5.1.3 Estimated error

To testify whether the national production function (5.2) and (5.4) are effective in reflecting the real economic operation, the authors measured the estimated error of three production functions that include physical capital stock and general and respective human capital (Figure 5.1).

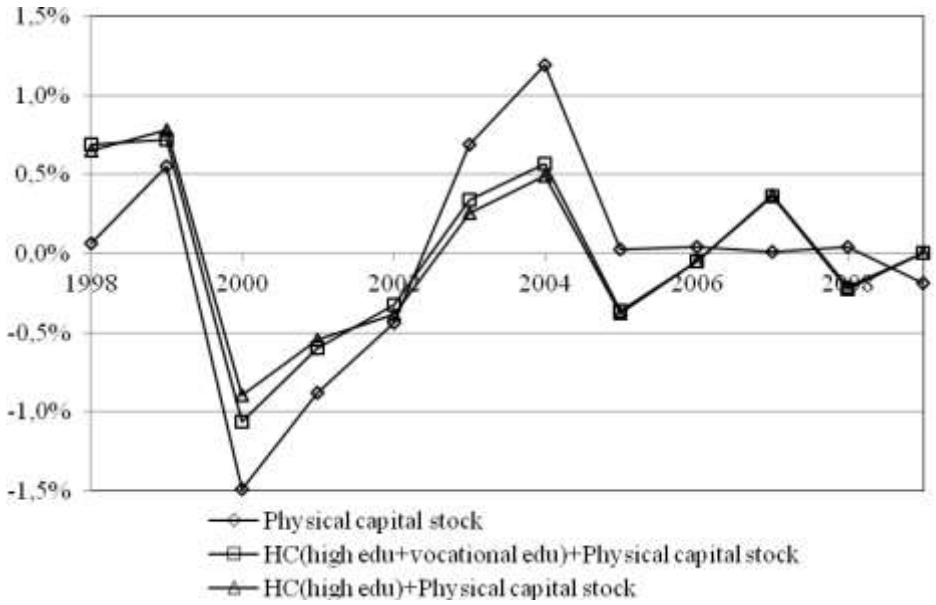


Figure 5.1: Estimated error of China's national production function

Figure 5.1 shows that the GDP estimated error is in the range of $\pm 1.5\%$, which indicates that the national production function can reflect China's real economic operation effectively. The error of equation (5.2) as well as equation (5.4) is less than the equation which only contains physical capital. We can conclude that human capital has a positive impact on GDP and the effect of secondary vocational education on human capital accumulation also cannot be neglected.

5.2 Thailand

5.2.1 Aggregate national production function

As discussed above, it is not applicable to use the accumulated price index to make a price adjustment of a different periods' physical capital formation and measure the heterogeneous capital stock of Thailand. Thus the authors have made the adjustment of equation (3.8) and construct Thailand's national production function.

$$\mathbf{lnY_t = C + \beta_1 \cdot lnK_t + \beta_2 \cdot lnL_t + \beta_3 \cdot lnh_t + \varepsilon_t} \qquad (5.7)$$

In accordance with the view that labour's educational attainment remained stable in Thailand over the past decades, the authors used average schooling years as the proxy of human capital. The result in Table 5.3 regression 1 shows that if the regression equation includes all production factors, R-Squared is 0.9865 but regression coefficients particularly those of physical capital and human capital is non-significant. This phenomenon may be caused by variables multicollinearity.

Testing results (Table 5.3 regression 2-4) prove the high correlation between physical capital, pure

labour and human capital, which means one of them can be the explanatory variable in the construction of the national production function. As this research endeavours to analyse education's output effect, the authors chose human capital as the explanatory variable and adjusted the regression equation is as follows:

$$\ln Y_t = C + \beta_1 \cdot \ln \mu_t + \varepsilon_t \qquad (5.8)$$

The regression result (Table 5.3 regression 5) shows that the R-Squared of the adjusted production function (5.8) is 0.9609 and the coefficients are significant at the 99.9% level. But the R-Squared of regression 5 is lower than that of regression 1, which means there remains another explanatory variable.

By analysing Thailand's economic indicators, it was found that last century's Southeast Asian financial crisis and the 2008 international financial crisis have all had a great impact on its economy growth (Figure 5.2). Hence, it is necessary to add a dummy into the equation (5.8) to describe Thailand's economic environment.

$$\ln Y_t = C + \beta_1 \cdot \ln \mu_t + \beta_1 \cdot Dummy + \varepsilon_t \qquad (5.9)$$

The value of the dummy depends on the annual growth rate of Thailand's GDP and the authors set the value as 1 when GDP growth rate is positive and 0 when it is negative (Table 5.2).

Table 5.2: **Dummy value**

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
GDP growth rate	2.17%	5.32%	7.13%	6.32%	4.60%	5.14%	5.05%	2.56%	-2.35%	7.78%
Dummy	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00

Source: IMF and authors set

The result in Table 5.3 regression 6 shows that R-Square of equation (5.9) (0.9849) is higher than that of equation (5.8) and all the explanatory variables are significant. Therefore, equation (5.8) can be used as the national production function of Thailand.

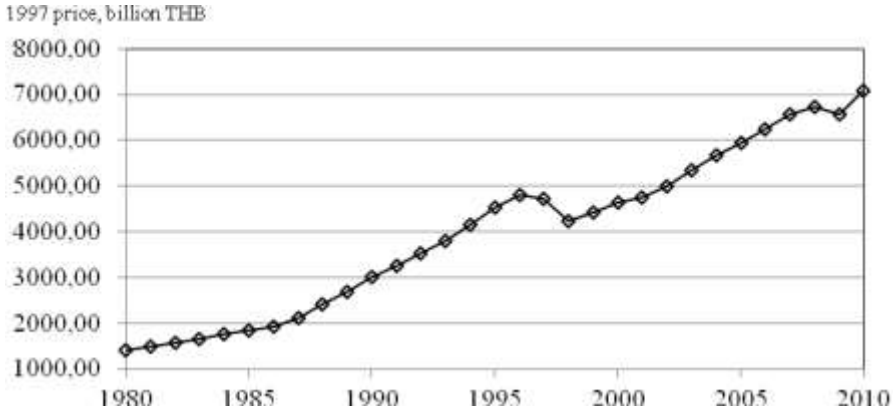
$$\ln Y_t = 5.44 + 1.75 \cdot \ln \mu_t + 0.07 \cdot Dummy \qquad (5.10)$$

Table 5.3: **Regressions on Thailand's aggregate national production function**

		Regression 1	Regression 2	Regression 3	Regression 4	Regression 5	Regression 6
Time span		2001-2010					
Dep. Var.		$\ln Y_t$	$\ln K_t$	$\ln L_t$	$\ln K_t$	$\ln Y_t$	$\ln Y_t$
c	Estimate	-21.01	-30.65	9.82	6.74	5.72	5.44
	Std. Err.	7.970	4.030	0.066	0.124	0.212	0.163
	t value	$(-2.64)^{*}$	$(-7.61)^{***}$	$(149.63)^{***}$	$(54.3)^{***}$	$(26.96)^{***}$	$(33.28)^{***}$
Indep. Var.1		$\ln K_t$	$\ln L_t$	$\ln \mu_t$	$\ln \mu_t$	$\ln \mu_t$	$\ln \mu_t$

β_1	Estimate	0.27	3.82	0.39	1.60	1.64	1.75
	Std. Err.	0.410	0.382	0.036	0.068	0.117	0.085
	t value	(0.65)	(10.00)***	(10.84)***	(23.37)***	(14.02)***	(20.63)***
Indep. Var.2		$\ln L_t$					Dummy
β_2	Estimate	2.54					0.07
	Std. Err.	0.776					0.022
	t value	(3.27)*					(3.34)*
Indep. Var.3		$\ln \mu_t$					
$\beta 3$	Estimate	0.22					
	Std. Err.	0.712					
	t value	(0.30)					
Residual Std. Err.		0.020	0.382	0.009	0.017	0.029	0.019
Sample Size		10	10	10	10	10	10
R^2		0.9865	0.9259	0.9363	0.9856	0.9609	0.9849
F-statistic		146	99.99	117.5	546.1	196.5	228.8
p value		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Note: "·", "*", "**" and "***"separately denote the significant level 90%, 95%, 99% and 99.9%



Source: IMF

Figure 5.2: GDP of Thailand

5.2.2 Per capita national production function

The regression result of equation (5.7) shows that pure labour has a great impact on Thailand's aggregate output. Thus, on the basis of equation (3.9), the authors constructed the per capita national production function of Thailand.

$$\ln y_t = \beta_1 \cdot \ln k_t + \beta_2 \cdot \ln \mu_t + \varepsilon_t \qquad (5.11)$$

Its R-Squared is 0.9655 (Table 5.4 regression 1) but the regression coefficients are not significant, it may be caused by multicollinearity between the explanatory variables (Table 5.4 regression 2).
Similar to the situation of the aggregate national production function, there is a high correlation between per capita physical capital and human capital. Therefore, the authors chose human capital as the

explanatory variable and the adjusted equation is as follows:

$$\ln y_t = C + \beta_1 \cdot \ln \mu_t + \varepsilon_t \qquad (5.12)$$

Table 5.4: **Regressions on Thailand's per capita national production function**

		Regression 1	Regression 2	Regression 3	Regression 4
Time span		2001-2010			
Dep. Var.		$\ln y_t$	$\ln k_t$	$\ln y_t$	$\ln y_t$
c	Estimate	-4.93	-3.06	-4.03	-4.21
	Std. Err.	1.289	0.132	0.151	0.133
	t value	(-3.83)**	(-23.18)***	(-26.67)***	(-31.69)***
Indep. Var.1		$\ln k_t$	$\ln \mu_t$	$\ln \mu_t$	$\ln \mu_t$
β_1	Estimate	-0.29	1.19	1.20	1.28
	Std. Err.	0.418	0.073	0.083	0.069
	t value	(0.50)	(16.43)***	(14.44)***	(18.48)***
Indep. Var.2		$\ln \mu_t$			Dummy
$\beta 3$	Estimate	1.55			0.05
	Std. Err.	0.507			0.018
	t value	(3.07)*			(2.64)*
Residual Std. Err.		0.021	0.018	0.021	0.016
Sample Size		10	10	10	10
R^2		0.9655	0.9712	0.9631	0.9815
F-statistic		98	269.8	208.6	185.5
p value		0.0000	0.0000	0.0000	0.0000

Note: "·", "*", "**" and "***"separately denote the significant level 90%, 95%, 99% and 99.9%

The regression result is in Table 5.4 regression 3. The R-Square of equation (5.12) is 0.9631 and the coefficients are significant at the 99.9% level. With reference to equation (5.9), the economic environment variable dummy is added into equation (5.12):

$$\ln y_t = \text{add } C + \beta_1 \cdot \ln \mu_t + \beta_2 \cdot \text{Dummy} + \varepsilon_t \qquad (5.13)$$

The R-Square of equation (5.13) (0.9815) is higher than that of equation (5.12) (Table 5.4 regression 4), all explanatory variables are significant. Therefore, Thailand's per capital national production function with average schooling years as proxy of human capita is as follows:

$$\ln y_t = -4.21 + 1.28 \cdot \ln \mu_t + 0.05 \cdot \text{Dummy} \qquad (5.14)$$

Equation (5.14) indicates that human capital (with average schooling years as proxy, most of the share of labour has finished elementary education) has a significant positive impact on Thailand's aggregate output. Furthermore this phenomenon may relate to the labour intensive production mode.

5.2.3 *Estimated error*

To testify whether equation (5.10) and (5.14) are effective in reflecting the real economic operation, the authors compared the estimated GDP of two equations and the real GDP. (Table 5.5 and Figure 5.3):

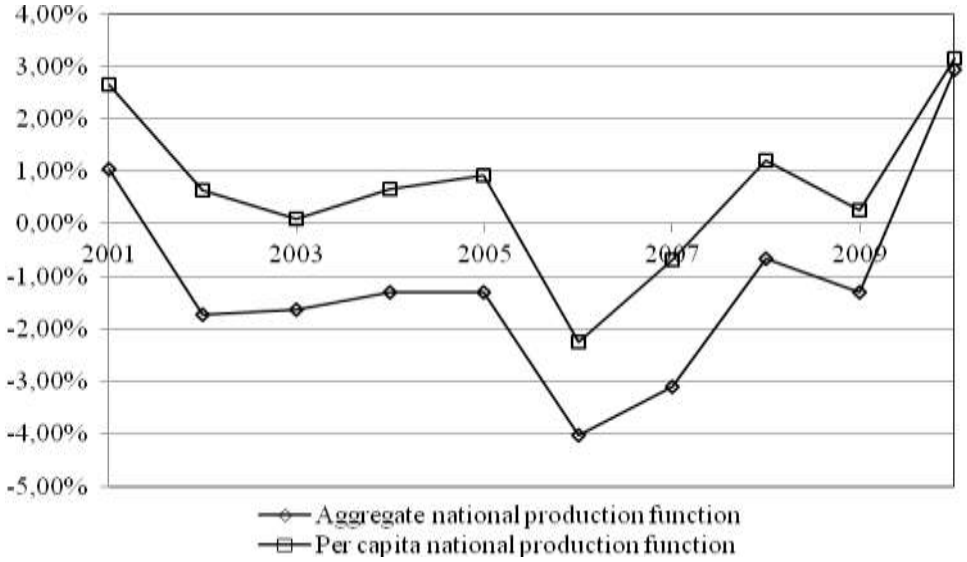


Figure 5.3: Estimated error of Thailand's national production function

Table 5.5: **Estimated error of Thailand's national production function**

$\ln Y_t = 5.44 + 1.75 \cdot \ln \mu_t + 0.07 \cdot Dummy$

	Y_t	L_t	$\ln \mu_t$	Dummy	Estimated		Difference	
	1997 price billion THB	Thousand person	Logarithm	Natural number	$\ln Y_t$	Y_t	Absolute value	Relative value
2001	4734	35654	1.69	1.00	8.47	4783	48.80	1.03%
2002	4986	36178	1.71	1.00	8.50	4899	-86.72	-1.74%
2003	5341	36619	1.75	1.00	8.57	5254	-86.98	-1.63%
2004	5679	37342	1.78	1.00	8.63	5605	-73.40	-1.29%
2005	5940	37902	1.81	1.00	8.68	5863	-77.19	-1.30%
2006	6246	37977	1.82	1.00	8.70	5994	-251.41	-4.03%
2007	6561	38821	1.86	1.00	8.76	6358	-203.23	-3.10%
2008	6729	39120	1.88	1.00	8.81	6684	-45.28	-0.67%
2009	6571	38638	1.91	0.00	8.78	6485	-85.92	-1.31%
2010	7082	39384	1.93	1.00	8.89	7289	207.63	2.93%

$\ln y_t = -4.21 + 1.28 \cdot \ln \mu_t + 0.05 \cdot Dummy$

	Y_t	L_t	$\ln \mu_t$	Dummy	Estimated		Difference	
	1997 price billion THB	Thousand person	Logarithm	Natural number	$\ln Y_t$	Y_t	Absolute value	Relative value
2001	4734	35654	1.69	1.00	-1.99	4859.57	125.44	2.65%
2002	4986	36178	1.71	1.00	-1.98	5018.30	32.43	0.65%
2003	5341	36619	1.75	1.00	-1.92	5346.31	4.93	0.09%
2004	5679	37342	1.78	1.00	-1.88	5715.93	37.23	0.66%
2005	5940	379023	1.81	1.00	-1.84	5995.41	55.36	0.93%

2006	6246	37977	1.82	1.00	-1.83	6105.39	-140.17	-2.24%
2007	6561	38821	1.86	1.00	-1.78	6515.71	-45.17	-0.69%
2008	6729	39120	1.88	1.00	-1.75	6810.38	81.57	1.21%
2009	6579	38638	1.91	0.00	-1.77	6587.62	16.72	0.25%
2010	7082	39384	1.93	1.00	-1.68	7305.56	223.74	3.16%

Source: Thailand statistical yearbook

The result indicates that the estimated error of aggregate and per capita national production function is in the range of $\pm 4\%$ and both of them can effectively reflect the economic operation of Thailand over the past decade.

5.3 Vietnam

5.3.1 Aggregate national production function

First, authors use average schooling years as the proxy of human capital and made the following adjustment of equation (3.8):

$$\ln Y_t = \beta_1 \cdot \ln K_t^* + \beta_2 \cdot \ln L_t + \beta_3 \cdot \ln \mu_t + \varepsilon_t \qquad (5.15)$$

According to the result in Table 5.6 regression 1, R-Squared of the regression equation which includes physical capital, pure labour and human capital is 0.9865 but the regression coefficients of physical capital and human capital is negative. This phenomenon may be caused by multicollinearity of variables. Testing results (Table 5.5 regression 2-4) proved the high correlation between physical capital and pure labour, but there is no significant correlation between labour's average schooling years and other production factors. In as much as the average index of human capital remained stable over the past decade (7.4 years) while dispersion index changed sharply, the authors used the dispersion of dramatically fluctuated education levels as the proxy of Vietnam's human capital.
The adjusted regression equation is as follows:

$$\ln Y_t = C + \beta_1 \cdot \ln L_t + \beta_2 \cdot \ln \sigma_t^{2,ai} + \varepsilon_t \qquad (5.16)$$

During 1990-1010, the proportion of labour that received lower secondary education and higher education changed sharply (Table 4.25). Therefore, the authors chose the dispersion of lower secondary education attainment $\sigma_t^{2,a2}$, higher education attainment $\sigma_t^{2,a6}$ and both of them as the proxy of human captial.

$$\ln Y_t = C + \beta_1 \cdot \ln L_t + \beta_2 \cdot \ln \sigma_t^{2,a2} + \varepsilon_t \qquad (5.17)$$

$$\ln Y_t = C + \beta_1 \cdot \ln L_t + \beta_2 \cdot \ln \sigma_t^{2,a6} + \varepsilon_t \qquad (5.18)$$

$$\ln Y_t = C + \beta_1 \cdot \ln L_t + \beta_2 \cdot \ln \sigma_t^{2,ai} + \beta_3 \cdot \ln \sigma_t^{2,a6} + \varepsilon_t \qquad (5.19)$$

The regression result (Table 5.6 regression 5-7) shows that the coefficients are most significant when the proxy is the dispersion of lower secondary education attainment and its R-Squared is 0.9989. Thus, the national production function of Vietnam is as follows:

$$\ln Y_t = -13.52 + 2.51 \cdot \ln L_t + 0.06 \cdot \ln \sigma_t^{2,a2} \qquad (5.20)$$

Vietnam's national production function indicates that the output effect of pure labour and human capital (lower secondary education) is significant. The reason for this could be that Vietnam is still at an early stage in industrialization, development level is low and the proportion of labour intensive industries is high.

Table 5.6: **Regressions on Thailand's aggregate national production function**

		Regression 1	Regression 2	Regression 3	Regression 4	Regression 5	Regression 6	Regression 7
Time span		1997-2010						
Dep. Var.		$\ln Y_t$	$\ln K_t^*$	$\ln L_t$	$\ln K_t^*$	$\ln Y_t$	$\ln Y_t$	$\ln Y_t$
c	Estimate	-14.29	-20.55	11.81	13.85	-13.52	-13.38	-14.33
	Std. Err.	0.799	2.375	4.155	13.588	0.281	1.237	0.935
	t value	(-17.89)***	(-8.65)***	(2.84)*	(1.02)	(-38.20)***	(-10.82)***	(-15.32)***
Indep. Var.1		$\ln K_t^*$	$\ln L_t$	$\ln \mu_t$	$\ln \mu_t$	$\ln L_t$	$\ln L_t$	$\ln L_t$
β_1	Estimate	-0.07	3.17	-0.59	-0.38	2.51	2.49	2.59
	Std. Err.	0.029	0.224	2.073	6.779	0.026	0.126	0.096
	t value	(-2.49)*	(14.16)***	(-0.29)	(-0.057)	(95.55)***	(19.69)***	(26.96)***
Indep. Var.2		$\ln L_t$				$\ln \sigma_t^{2,a2}$	$\ln \sigma_t^{2,a6}$	$\ln \sigma_t^{2,a2}$
β_2	Estimate	2.75				0.06	0.04	0.07
	Std. Err.	0.095				0.018	0.103	0.021
	t value	(29.03)***				(3.28)**	(0.35)	(3.34)**
Indep. Var.3		$\ln \mu_t$						$\ln \sigma_t^{2,a6}$
β_3	Estimate	-0.46						-0.07
	Std. Err.	0.162						0.081
	t value	(-2.86)*						(-0.90)
Residual Std. Err.		0.009	0.093	0.120	0.392	0.011	0.015	0.011
Sample Size		14	14	14	14	14	14	14
R^2		0.9993	0.9436	0.0068	0.0002	0.9989	0.9979	0.999
F-statistic		4566	200.6	0.082	0.003	5034	2568	3298
p value		0.0000	0.0000	0.7793	0.9557	0.0000	0.0000	0.0000

Note: "·", "*", "**" and "***"separately denote the significant level 90%, 95%, 99% and 99.9%

5.3.2 Per capita national production function

Similar to Thailand's analysis, the authors constructed the per capita national production function of Vietnam on the basis of equation (3.9):

$$\ln y_t = \beta_1 \cdot \ln k_t^* + \beta_2 \cdot \ln \mu_t + \varepsilon_t \qquad (5.21)$$

Its R-Squared is 0.8733 (Table 5.7 regression 1) and the regression coefficients is not significant. As there exists no multicollinearity between the explanatory variables (Table 5.7 regression 2), the reason for poor coefficient quality can only be attributed to the wrong proxy of human capital. Regarding the stability of labour's average schooling years, it is not an appropriate human capital proxy. Therefore, with reference to the data processing method above, the authors chose the dispersion of lower secondary education attainment $\sigma_t^{2,a2}$, higher education attainment $\sigma_t^{2,a6}$ and both of them as the proxy of human capital.

$$\ln y_t = \beta_1 \cdot \ln k_t^* + \beta_2 \cdot \ln \sigma_t^{2,a2} + \varepsilon_t \qquad (5.22)$$

$$\ln y_t = \beta_1 \cdot \ln k_t^* + \beta_2 \cdot \ln \sigma_t^{2,a6} + \varepsilon_t \qquad (5.23)$$

$$\ln y_t = \beta_1 \cdot \ln k_t^* + \beta_2 \cdot \ln \sigma_t^{2,a2} + \beta_3 \cdot \ln \sigma_t^{2,a6} + \varepsilon_t \qquad (5.24)$$

The regression results are in Table 5.7 regression 2-4.

The R-Squared of equation (5.22)-(5.24) are all greater than 0.89 but the significance of explanatory variables coefficients is not high, especially that of human capital is non-significant or significant at no more than 90% level. Thus equation (5.22)-(5.24) is inappropriate in approximating Vietnam's national production function.

Table 5.7: **Regressions on Vietnam's per capita national production function**

		Regression 1	Regression 2	Regression 3	Regression 4
Time span		1997-2010			
Dep. Var.		$\ln y_t$	$\ln y_t$	$\ln y_t$	$\ln y_t$
c	Estimate	4.03	1.08	1.13	1.13
	Std. Err.	2.357	0.168	0.150	0.157
	t value	(1.71)	(6.45)***	(7.57)***	(7.22)***
Indep. Var.1		$\ln k_t^*$	$\ln k_t^*$	$\ln k_t^*$	$\ln k_t^*$
β_1	Estimate	0.61	0.59	0.09	0.07
	Std. Err.	0.071	0.064	0.179	0.309
	t value	(8.63)***	(9.21)***	(0.52)	(0.22)
Indep. Var.2		$\ln \mu_t$	$\ln \sigma_t^{2,a2}$	$\ln \sigma_t^{2,a6}$	$\ln \sigma_t^{2,a2}$
β3	Estimate	-1.54	0.23	1.02	-0.02
	Std. Err.	1.175	0.105	0.336	0.171
	t value	(-1.31)	(2.14)	(3.04)*	(-0.11)
Indep. Var.3					$\ln \sigma_t^{2,a6}$
β3	Estimate				1.08
	Std. Err.				0.621
	t value				(1.73)
Residual Std. Err.		0.068	0.061	0.054	0.056
Sample Size		14	14	14	14

R^2	0.8733	0.8967	0.9205	0.9206
F-statistic	37.9	47.77	63.69	38.65
p value	0.0000	0.0000	0.0000	0.0000

Note: "·", "*", "**" and "***"separately denote the significant level 90%, 95%, 99% and 99.9%

5.3.3 Estimated error

As only aggregate national production can effectively reflect Vietnam's economic operation, the following is merely a measurement of the estimated error of equation (5.26).

Table 5.8: **Estimated error of Vietnam's national production function**

	Y_t	L_t	$\ln\sigma_t^{2,a2}$	Estimated		Difference	
	1997 price billion Dong	Thousand person	Logarithm	$\ln Y_t$	Y_t	Absolute value	Relative value
1997	313623	34493	-0.32	12.69	323477	9853.59	3.14%
1998	331703	35233	-0.33	12.74	340815	9112.54	2.75%
1999	347537	35976	-0.39	12.79	357942	10404.52	2.99%
2000	371125	37075	-0.33	12.87	387359	16233.93	4.37%
2001	396714	38180	-0.35	12.94	416427	19712.76	4.97%
2002	424802	39276	-0.76	12.99	436412	11610.17	2.73%
2003	455986	40404	-0.39	13.08	479024	23037.50	5.05%
2004	491507	41579	-0.62	13.14	507654	16146.56	3.29%
2005	532999	42775	-0.30	13.23	555508	22509.15	4.22%
2006	576859	43980	-0.08	13.31	603775	26915.61	4.67%
2007	625640	45208	-0.25	13.37	640372	14731.64	2.35%
2008	665123	46461	-0.31	13.43	683456	18333.11	2.76%
2009	700528	47744	-0.26	13.51	733860	33331.22	4.76%
2010	748051	49049	-0.29	13.57	783650	35599.28	4.76%

Source: World Bank, General statistical organization (GSO)

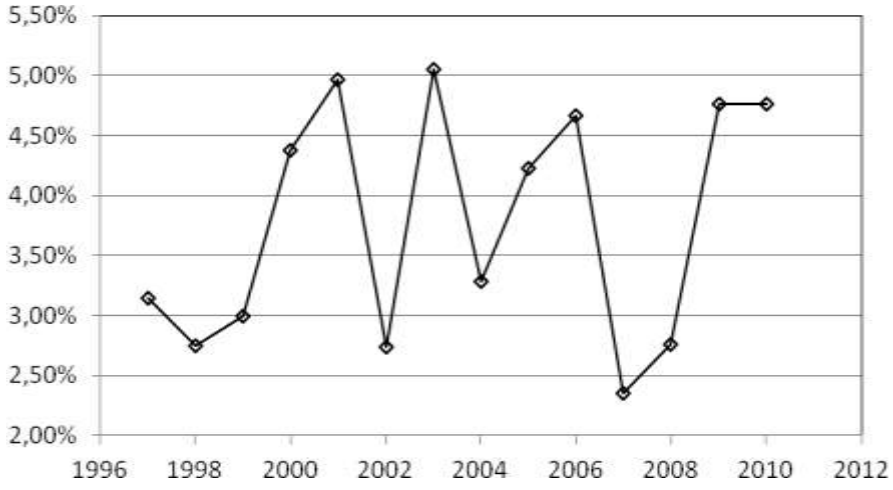


Figure 5.4: Estimated error of Vietnam's national production function

The result indicates that the estimated error of the aggregate national production function is in the range of 2%-5%, and can effectively reflect the economic operation of Vietnam over the past decade.

6 Comparative Statics

6.1 China

From three regressions of Table 5.1, it can be concluded that investment expansion ΔE_t has a negative impact on aggregate output growth ΔY_t. From this we can deduct that the quick accumulation of physical capital did not raise the TFP. Moreover, at the China's present stage, if we continue focusing on physical capital while ignoring human capital accumulation, the production efficiency of physical capital will further decrease. To carry out the quantitative analysis of these two kinds of production factors, the authors measured the marginal output effect of two factors.

6.1.1 Output effect of unit physical capital investment

Based on the supposition that human capital is beyond consideration, the relation between capital increment, investment expansion and GDP is as follows:

$$\Delta Y_t = C + \alpha \cdot \Delta K_t^* + \beta \cdot \Delta E_t + \varepsilon_t \qquad (6.1)$$

The regression result is in Table5.1 regression 4.

Ceteris paribus, measure the output effect of unit physical capital investment according to the following equation (calculating at 1997 constant):

$$\frac{\Delta Y_t}{\Delta K_t^*} = \alpha \cdot \frac{P_t^I \overline{P}_t^Y}{\frac{P_{1997}^I}{P_{1997}^Y}} \qquad (6.2)$$

The result is in “Return on unit physical capital investment” of Table 6.1.

6.1.2 Output effect of unit human capital investment

Ceteris paribus, by using the results in Table 5.1 regression 1 and 3 as well as equation (6.3):

$$\frac{\Delta Y_t}{\Delta H_t^i} = \beta^i \cdot \frac{P_t^I \overline{P}_t^Y}{\frac{P_{1997}^I}{P_{1997}^Y}} \qquad (6.3)$$

We can calculate the unit output effect of human capital emerges from higher general/vocational education and general human capital emerges from higher and secondary vocational education. The results are in “Return on unit general human capital investment” and “Return on unit higher human capital investment” of Table 6.1.

Table 6.1: **Output effect of China’s physical capital and human capital**

	Return on unit physical capital investment	Return on unit general human capital investment	Return on unit higher human capital investment

	ΔK_t^*	ΔK_t^*	ΔY_t	$\frac{\Delta Y_t}{\Delta K_t^*}$	ΔH_t^{3+4}	ΔH_t^{3+4}	ΔY_t	$\frac{\Delta Y_t}{\Delta H_t^{3+4}}$	ΔH_t^4	ΔH_t^4	ΔY_t	$\frac{\Delta Y_t}{\Delta H_t^4}$
	Current year	1997 price		Ratio	Current year	1997 price		Ratio	Current year	1997 price		Ratio
1998	1.00	1.01	0.15	0.15	1.00	0.93	0.83	0.89	1.00	1.07	0.73	0.68
1999		1.02	0.15	0.15		1.15	0.83	0.72		1.15	0.73	0.63
2000		1.03	0.15	0.15		1.23	0.83	0.67		1.23	0.73	0.59
2001		1.02	0.15	0.15		1.32	0.83	0.63		1.32	0.73	0.55
2002		1.01	0.15	0.15		1.42	0.83	0.59		1.42	0.73	0.51
2003		0.99	0.15	0.16		1.52	0.83	0.55		1.52	0.73	0.48
2004		0.96	0.15	0.16		1.63	0.83	0.51		1.63	0.73	0.44
2005		0.91	0.15	0.17		1.75	0.83	0.47		1.75	0.73	0.41
2006		0.84	0.15	0.18		1.88	0.83	0.44		1.88	0.73	0.39
2007		0.75	0.15	0.2		2.02	0.83	0.41		2.02	0.73	0.36
2008		0.68	0.15	0.23		2.16	0.83	0.38		2.16	0.73	0.34
2009		0.61	0.15	0.25		2.32	0.83	0.36		2.32	0.73	0.31

Source: authors calculate

After measuring the different output effect of factors, it can be concluded that:

- Output effect of unit human capital is higher than that of physical capital;
- Output effect of unit general human capital (including secondary vocational education and higher education) is greater than that of higher human capital.

Clearly, secondary vocational education has a positive impact on China's economic growth.

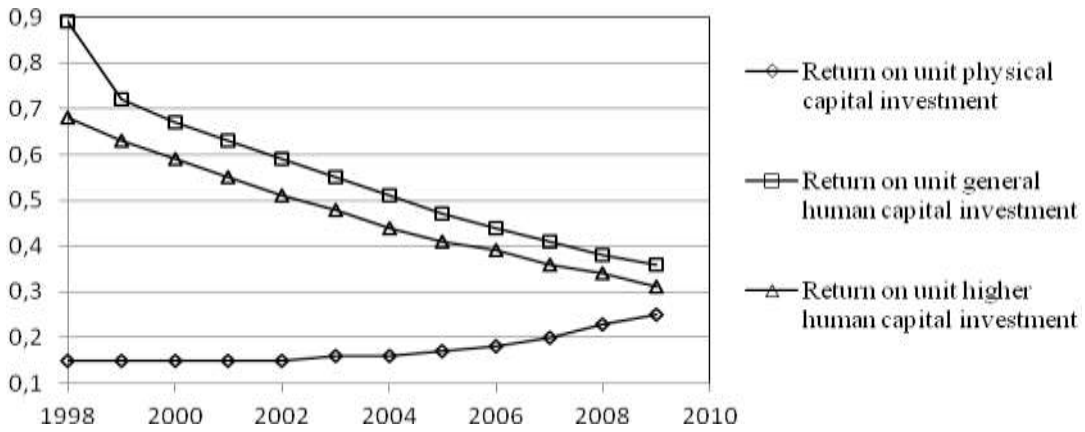


Figure 6.1 Output effect of Chain's physical capital and human capital

6.2 Thailand

Analysis above indicates that human capital has a significantly positive impact on Thailand's national output growth while physical capital's output effect is small. Therefore, in this instance all that is measured is the marginal product effect of the former.

The mechanism of how human capital investment impacts on aggregate output is as follows: The

investment in institutions of educational level a_i increases the number of graduate student $X_t^{a_i}$ (inside the education system), then it raises the proportion of employees with educational level a_i among all (in the labour market), and consequently improves human capital quality.

$$\frac{\partial Y_t}{\partial I_{B,t}} = \frac{\partial Y_t}{\partial \mu_t} \cdot \frac{\partial \mu_t}{\partial p_t^{a_i}} \cdot \frac{\partial p_t^{a_i}}{\partial X_t^{a_i}} \cdot \frac{\partial X_t^{a_i}}{\partial I_{B,t}} \qquad (6.4)$$

In which,

- The relationship between $X_t^{a_i}$ and $I_{B,t}$ satisfies:

$$X_t^{a_i} = \frac{I_{B,t}}{\sum_{j=1}^{z_{a_i}} C_t^{a_i} \cdot (1+r)^j} \qquad (6.5)$$

in which $C_t^{a_i}$ represents the average education expenditure per student of level a_i, r for the real interest rate, which reflects the opportunity cost of human capital investment. For the sake of simplification, authors set r as 3.5%[44]. Based on equation (6.10), we get:

$$\frac{\partial X_t^{a_i}}{\partial I_{B,t}} = \frac{1}{\sum_{j=1}^{z_{a_i}} C_t^{a_i} \cdot (1+r)^j} \qquad (6.6)$$

- In the labour market, the percentage of employees with a_i education level among all L_t is defined as $p_t^{a_i} = \left(L_t^{a_i} + X_t^{a_i}\right) / L_t$. Cetris paribus, we get:

$$\frac{\partial p_t^{a_i}}{\partial X_t^{a_i}} = \frac{1}{L_t} \qquad (6.7)$$

- $\partial \mu_t / \partial p_t^{a_i}$ stands for the marginal effect of $p_t^{a_i}$'s changes on human capital average index μ_t which can be derived from equation (3.6) that:

$$\frac{\partial \mu_t}{\partial p_t^{a_i}} = m^{a_i} \qquad (6.8)$$

- $\partial Y_t / \partial \mu_t$ denotes the marginal product effect of human capital quality change, as shown in equation (6.9).

44 Authors get the average real interest rate during 2001-2008 from IMF.

$$(\partial Y_i t)/(\partial \mu_{\downarrow} t) = 1.75(Y_i t/\mu_{\downarrow} t, \qquad (\partial Y_i t)/(\partial \mu_i t): Y_{\downarrow} t/\mu_{\downarrow} t = 1.75 \qquad (6.9)$$

So equation (6.9) is rewritten as

$$\frac{\partial Y_t}{\partial I_{B,t}} = \frac{1.75\ (Y_t \cdot m^{a_i}}{\mu_t \cdot L_t \cdot \Sigma_{j=1}^{z_{a_i}} C_t^{a_i} \cdot (1+r)^j} \qquad (6.10)$$

As the education expenditure of elementary and secondary schools is combined during 2005-2008 (henceforth E-S education), the authors do the regression of 1997-2004 data for the purpose of dividing it into specific education levels (Table 6.2).

Table 6.2: **Regression on primary and E-S education expenditure**

Time span		1997-2004
Dep. Var.		Elementary education
c	Estimate	23358
	Std. Err.	11070
	t value	(2.11)·
Indep. Var.		E-S education
β_1	Estimate	0.48
	Std. Err.	0.070
	t value	(6.79)***
Residual Std. Err.		2193
Sample Size		8
R^2		0.8847
F-statistic		46.04
p value		0.0005

Note: "·", "*", "**" and "***"separately denote the significant level 90%, 95%, 99% and 99.9%

According to regression result in Table 6.2, we can obtain the relationship between elementary and E-S education expenditure:

Elementary education expenditure=0.48*E-S education expenditure +23358 (6.11)

Then authors calculated primary and secondary education expenditure during 2005-2008 according to equation (6.11) and the results are in Table 6.3.

The total education expenditure is just one important factor that impacts on education quality, the number of students in school is also another significant factor. Therefore, per student education expenditure is a proper index for measuring the effect of education investment on national output growth.

Table 6.3: **Education expenditure of Thailand**

Current year, billion THB

	Elementary	Secondary	E-S	Elementary	Secondary	Higher
1997	96425	55880	152305	96425	55880	38093
1998	96380	57988	154368	96380	57988	40927
1999	90898	50326	141224	90898	50326	36472
2000	96064	51843	147907	96064	51843	35289
2001	98465	52460	150926	98465	52460	32762
2002	97923	53806	151729	97923	53806	32008
2003	98228	64770	162998	98228	64770	33348

2004	111836	67885	179721	111836	67885	33480
2005	184455		184455	111896	72559	40308
2006	203246		203246	120916	82330	48152
2007	245489		245489	141193	104296	58444
2008	251786		251786	144215	107571	67267

Note: Because of data deficiency, data in shade is estimated by time sequence model regression.

Source: Ministry of education (MOE)

Table 6.4: **Average per student education expenditure of Thailand**

	Education expenditure			Students in School				Average education expenditure per student		
	1997 price, million THB			Thousand person				1997 price, THB/person/year		
	E	S	H	E	S		H	E	S	H
					Lower	Upper				
1997	96425	55880	38093							
1998	88229	53084	37466							
1999	86713	48009	34793							
2000	90424	48799	33217							
2001	90805	48379	30213	19550	14496	10404	7245	4645	1943	4170
2002	89573	49218	29279	19617	14503	10550	7727	4566	1965	3789
2003	88667	58465	30102	18997	14464	10358	8564	4668	2355	3515
2004	97864	59403	29297	18385	16309	11256	9333	5323	2155	3139
2005	93709	60765	33757	18162	16642	11124	9694	5160	2189	3482
2006	96265	65545	38335	17864	16690	11355	10791	5389	2337	3553
2007	108660	80265	44978	17889	16496	11496	10450	6074	2867	4304
2008	106866	79712	49846	17810	16211	11576	10273	6000	2869	4852

Note: E stands for elementary education, S for secondary education while H for higher education

Source: Ministry of education (MOE)

According to data in Table 6.4, the authors measured the marginal product effect of different education levels during 2001-2008: Primary education, secondary education (including lower, upper and vocational secondary education) and higher education (including general and vocational higher education) (Table 6.5).

Table 6.5: **Thailand's marginal product effect of human capital investment**

	2001	2002	2003	2004	2005	2006	2007	2008	Average
Elementary	8.14	8.48	8.44	7.43	7.70	7.64	6.74	6.75	7.67
Secondary	19.47	19.72	16.72	18.36	18.16	17.62	14.27	14.11	17.30
Higher	5.26	6.00	6.85	8.00	7.43	7.64	6.48	5.85	6.69

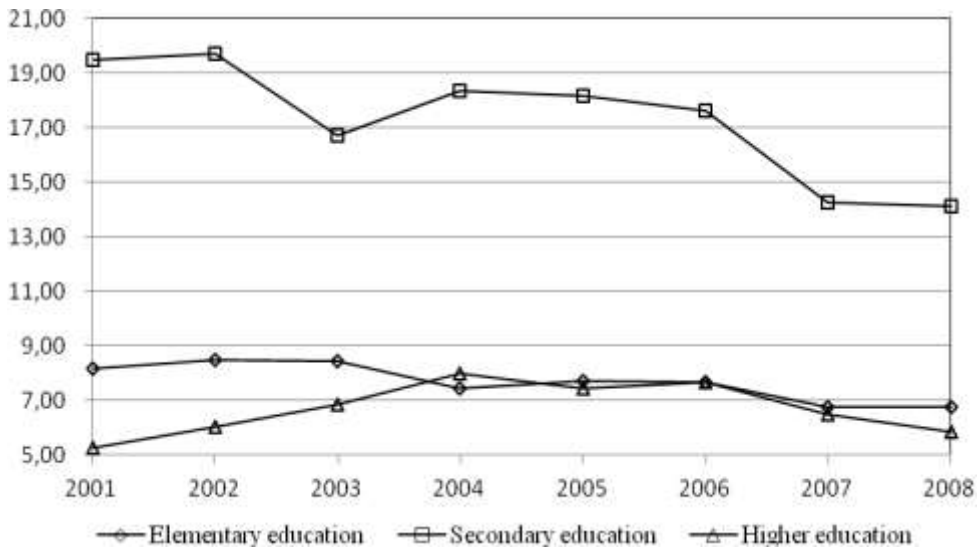


Figure 6.2: Thailand's marginal product effect of human capital investment

It can be inferred from Table 6.5 and Figure 6.2 that:

- According to the average value during 2001-2008, marginal education investment can improve to at least 6.69 unit of Thailand's GDP.
- Different education levels have various output effects, those from highest to lowest are as follows: secondary education (including lower, upper and vocational secondary education), higher education (including higher vocational education) and elementary. The marginal product effect of secondary education is 2.25 times than that of elementary education.

6.3 Vietnam

Due to Vietnam's education expenditure data deficiency, the authors chose fiscal education input rather than the whole society education example (like China) as the data basis for measuring the marginal product effect of human capital. Differing with Thailand, Vietnam's proxy of human capital is the dispersion of specific education attainment labour. Thus the authors had to measure the marginal product effect of $\mathbf{p_t^{a_1}}$ on dispersion index $\sigma^{2,a_2}{}_t$. According to equation (3.7) we can obtain that:

$$\frac{\partial \sigma^{2,a_2}{}_t}{\partial p_t^{a_i}} = (m^{a_1} - \mu_t)^2 \qquad (6.12)$$

$\partial Y_t / \partial \sigma^{2,a_2}{}_t$ indicates the marginal product effect of human capital investment on GDP.

$$(\partial Y_t)/(\partial [\![\sigma^t(2,a_2)]\!]_t) = 0.06(Y_t/[\![\sigma^t(2,a_2)]\!]_t, \qquad (\partial Y_t)/(\partial [\![\sigma^t(2,a_2)]\!]_t): Y_t/[\![\sigma^t(2,a_2)]\!]_t = 0.06 \qquad (6.13)$$

So equation (6.4) is rewritten as

$$\frac{\partial Y_t}{\partial I_{B,t}} = \frac{0.06\ (Y_t \cdot (m^{a_i} - \mu_t)^2}{\sigma^{2,a_2}{}_t \cdot L_t \cdot \Sigma_{j=1}^{z_{a_i}} C_t^{a_i} \cdot (1+r)^j} \qquad (6.14)$$

r is set as 5.3%[45] The education expenditure of Vietnam is in Table 6.8.

Table 6.6: **Education expenditure of Vietnam**

1997 price, billion. Dong

	Elementary	Lower secondary	Higher secondary	Vocational secondary	Junior college	Higher education
1996	2397	1420	753	317	400	969
1997	3118	1906	855	375	464	1159
1999	6001	3566	1305	349	439	1312
2000	7678	4680	1819	430	550	1520
2001	6380	3962	2149	641	627	1798
2002	7057	4770	2367	729	651	2026
2004	10081	7230	3170	1258	752	3294
2006	17105	11833	5663	3671	1434	4881

Source: Department of Planning and Finance, MoET; GSO

Per student education expenditure calculated by data in Table 6.6 is as follows:

Table 6.7: **Average per student education expenditure of Vietnam**

	Student in school						Average education expenditure per student					
	Thousand person						1997price, thousand. Dong					
	E	LS	UP	SV	JC	H	E	LS	UP	SV	JC	H
1996	10353	4840	1156	163	116	236	247	313	695	2078	3673	4371
1997	10384	5205	1382	163	125	358	300	366	619	2299	3724	3241
1999	10034	5695	1957	119	143	421	520	544	579	2548	2660	2705
2000	9741	5864	2171	126	255	900	662	671	704	2865	1810	1420
2001	9315	6259	2301	147	271	974	565	522	770	3607	1906	1521
2002	8816	6430	2454	176	389	1021	635	588	765	3277	1326	1574
2004	7745	6617	2761	230	467	1320	894	751	789	3758	1108	1715
2006	7029	6152	3075	306	516	1666	1441	1139	1090	7115	1646	1734

Note: E stands for elementary education, LS for lower secondary education, US for upper secondary education, SV for secondary vocational education, JC for junior college while H for higher education

Source: Ministry of education and training (MoET)

According to the regression result above, only lower secondary education has a significantly positive output effect. Thus the authors were only required to measure its marginal product effect during 1996-2006 (data is discontinuous). The results are in Table 6.8 and Figure 6.3.

Table 6.8: **Vietnam's marginal product effect of human capital investment**

	1996	1997	1999	2000	2001	2002	2004	2006
Lower secondary education	0.468	0.427	0.306	0.252	0.336	0.305	0.262	0.199

[45] Authors get the average real interest rate during 1996-2006 from IMF.

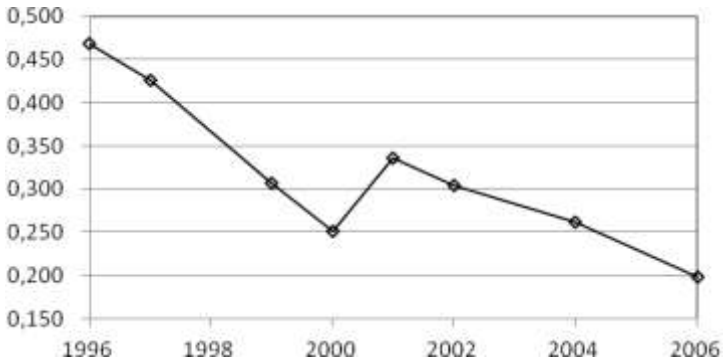


Figure 6.3: Vietnam's marginal product effect of human capital investment

Average value during 2001-2008 shows that the marginal lower secondary education investment can at least improve 0.319 unit of Vietnam's GDP.

7 Conclusions

By analysing education inputs and its contribution to the improvement of labours' educational attainment situation, the authors constructed two models from the perspective of labours' educational attainment and education expenditure to study the human capital accumulation and output effects of education particularly in regard to vocational education in China, Thailand and Vietnam.

7.1 China

- Time lag has to be taken into consideration when we use education expenditure as the proxy of human capital and measure its output effect. Meanwhile, the education expenditure ought to be discounted by the GDP growth rate and technical progress rate. The result indicates that with education expenditure adjustment, the model constructed is practicable and valid in explaining China's economic growth from 1998 to 2009.
- The result in Table 5.1 regression 4 shows that 98.4% GDP growth can be explained by physical capital and over-expansionary investment, which indicates that physical capital investment is still a key driver of China's economic growth at present. But over-expansionary investment has a significant negative impact on TFP. This means there is inappropriate allocation between physical capital and human capital, overdependence on physical capital investment for the purpose of enlarging production scale will have negative structure effect. Furthermore, Figure 6.1 shows that the output effect of human capital investment out-weighs that of physical capital investment. Thus it is suggested that China has to increase its education expenditure and optimize the allocation of limited resources between physical capital and human capital.
- According to the results in Table 6.1, the output effect of general human capital stemming from higher education (including higher vocational education) and secondary vocational education is greater than that of higher education (including higher vocational education). As most upper secondary school students go on to future studies after graduation while secondary vocational school graduates join the workplace immediately, it can be deduced that the production elasticity of employees with secondary vocational education is positive and has important impacts on China's human capital accumulation as well as economic growth.

7.2 Thailand

- Aggregate and per capita national production function indicates that human capital accumulation makes a significant contribution to Thailand's gross domestic product. As there is a high correlation between pure labour input and human capital stock (Table 5.3 regression 3), the former should have a significant output effect during 2001-2010.
- According to the phenomenon revealing investment goods' price index increasing annually, it can be inferred that Thailand's technical level, especially the part embodied in physical capital accumulation made no obvious improvement over the past decade. Meanwhile, regression results

(Table 5.3 regression 4) demonstrate a significant linear positive correlation between Thailand's physical capital accumulation and pure labour input during 2001-2010, indicating that Thailand's labour and physical capital configuration hardly changed at all during the same period. All of the above clearly demonstrate the authors' judgment regarding Thailand's slow technical progress.

- External economic environment change has had a great influence on Thailand's aggregate output. Over the past two decades, two large-scale financial crises (that of Southeast Asia one and the 2008 global crisis) crippled its economic growth, indicating that Thailand's economic scale is too small to cope with such external shocks.
- Although Thailand's labour education attainment rose steadily during 2001-2011, its human capital stock remains at a low level. The greater part of labour only received elementary education and the proportion of those illiterate or who drop out from elementary schools remains high. The major cause of this is Thailand's labour intensive production mode. Comparative statics show that the marginal output effect of secondary education is the highest. Therefore, combined with Thailand's industrial structural and developmental level, the need to increase the training of skilled workers who have completed secondary general/vocational education is of dire urgency.

7.3 Vietnam

- Vietnam is still at an early stage of industrialization. In the late 80's and early 90's, primary industry accounted for the biggest proportion of GDP while secondary industry the lowest. After 20 years of development, secondary industry has become Vietnam's leading industry and tertiary industry takes second place, reflecting its industrial upgrading.
- By constructing the national production function, it can be found that pure labour and human capital accumulated by lower secondary education have the greatest impact on Vietnam's aggregate output. It indicates that Vietnam badly needs a vast amount of labour with basic operational ability. It also predicts the importance of secondary education, particularly secondary vocational education in the future. Obeying the rule of economic development and industrial structural change, constructing the appropriate talent training policy is the most vital way in which to promote Vietnam's economic development and enhance its development potential.
- During 1990 to 2010, labour's average schooling year stabilized at around 7.4 years. On the one hand, the proportion of less educated labour including illiteracy is on the rise. On the other, the proportion of high-quality labour that have received higher education has also increased. As a result, the gap in labour's educational background enlarges the distribution variance of labour's educational attainment. This phenomenon may be caused by the extended gap between rich and poor. Meanwhile, the relative reduction of labour force at intermediate level is not conducive to the process of industrialization and may well restrict Vietnam's economic growth potential. Therefore, how to adjust the education structure rationally and increase the investment in secondary vocational education is an exigent problem that must be solved in Vietnam.

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