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Paper presented at *Being Sustainable – Competitiveness for Business and Industry 2002 Conference*, Thammasat University, Bangkok.

September 2002

Abstract

We investigate the sources of Thai economic growth over the period 1972:1-2000:4 using both growth accounting and level accounting approaches, allowing explicitly for the contribution of human capital accumulation. The accumulation of human capital in Thailand is measured by the average years of schooling in population age 25-64, and we assess its relative contribution alongside physical capital accumulation and labour force growth. The rate of growth of human capital increased significantly in the period 1972:1-2000:4. We find that, after incorporating human capital, the Solow growth residual is positive and significant during the pre crisis period 1972-1996. Disaggregating our analysis over five year periods reveals a productivity slowdown with negative contribution from capital, labour, and human capital during the period 1997-2000. We conclude that both productivity growth and factor accumulation are significant in accounting for Thai growth performance during the pre and post crisis period.

Key Words: TPF, Human Capital, Growth and Level Accounting, Thailand

1. Introduction

From 1972-2000 the Total Factor Productivity (TFP) measure for Thailand is found to be at an average rate of 1 percent a year. This translates into about 33 percent contribution to output growth over the same period. Thailand's average annual output growth over this period was about 6.3 percent. This compares favourably with the experience of other SE Asian economies, such as South Korea, Singapore and Hong Kong. The extraordinary growth performances of these economies, as well as their sources and sustainability, have been the subject of some debate. The debate, initiated by Young (1992, 1995) and Krugman (1994) on the sources of growth in East Asian economies, has spurred a growing literature on this subject. The main premise of Young's conclusions is that there has been no miracle behind East Asian growth, as high growth rates in these economies were fuelled essentially by factor accumulation rather than total factor productivity growth[1]. Kim and Lau (1994) reach essentially the same conclusions for Singapore, Hong Kong, South Korea and China. Krugman (1994), relying on Young (1992, 1995) and Kim and Lau (1994) studies, contends that the so-called "East Asian Miracle" is a myth as output growth for SE Asian counties has been driven mainly by mobilisation of resources rather than by technological change.

This paper aims to contribute to this debate by investigating the sources of Thailand's growth over the period 1972-2000, using both growth accounting and levels accounting frameworks. High rates of investment in human and physical capital are often identified as major contributors to East Asian growth. The South East Asian economies (Singapore, Hong Kong, South Korea and Taiwan) have consistently invested a larger share of output than compared to other developing countries—nearly 50 per cent higher in 1990. As for human capital, in 1990 their primary enrolment rate was 25 per cent higher and their infant mortality rate 50 per cent lower than the average for all developing countries (Thomas and Wang 1993). However, this leaves the question of why such investments in human and physical capital have contributed to East Asian growth, while other countries, such as the Soviet Union with similar rages of investment have not achieved such miracle growth rates. We do not seek to address this

[1] Young (1992) performs detailed growth accounting calculations for Singapore and Hong Kong, and subsequently Young (1995) updates his results for these countries as well as performs similar calculations for Korea and Taiwan.

specific question (see Krugman, 1994), but we focus on an important aspect of the debate: namely the contribution of total factor productivity (TFP) growth in Thailand. By performing detailed growth accounting calculations for Thailand, in line with Young's (1992) analysis of Hong Kong and Singapore, and Young's (1995) similar calculations for Korea and Taiwan, we estimate the rate of TFP growth. Following Kim and Lau (1994), we incorporate a measure of human capital stock as an additional input in the underlying production function, to represent the quality of labour, and attempt to shed light on the relative importance of factor accumulation (physical capital, human capital and labour) versus the growth of TFP.

Our results indicate that the aggregate picture for Thailand is broadly in line with conclusions reached by Young (1992, 1995), Kim and Lau (1994), and more recently by Singh and Trieu (1999) who conduct a similar study for Japan, South Korea and Taiwan. Thus, supporting Krugman's (1994) view, we argue that output growth in Thailand has been driven mainly by mobilisation of resources, although in the absence of human capital accumulation there remains a significant role for productivity growth. However, in terms of TFPG, Thailand's position lies somewhere between the high-TFPG countries such as Hong Kong, Taiwan and South Korea and the comparatively low-TFPG countries like Indonesia, Malaysia, and the Philippines (Susankarn and Tinakorn, 1998). This might suggest a limited role for technological change in any case, although there remains the outstanding question of investigating variations in TFPG for Thailand over the long period of study (1972-2000) that we investigate. In fact, our results for 1997-2000 suggest that TFP growth is negative, indicating that productivity slowdown may have been a factor contributing to the Thai recession over this post-crisis period.

In section 2 we provide a short summary of the background work to motivate our analysis. Section 3 provides a theoretical discussion of factors determining TFP growth. Section 4 presents the growth accounting framework that is used in the calculation of our results. Section 5 discusses the issues in the measurement of human capital and explains how we construct the human capital series. Section 6 briefly outlines the development of Thai education and the recent trend in Thailand's human capital stock. Section 7 presents the results, also analysed further in section 8. Section 9 extends our framework to levels accounting, and section 10 concludes with some ideas on further work.

2. Background Literature

In the last decade, there have be substantial advances in theories of endogenous growth. This "new" growth theory allows for investment in education, changes in the labour force, and technological change to be determined within the economy, rather than set by unexplained external forces. These theories emphasise the role of economic policy in affecting the long-run growth. For instance any economic policy, which changes the economy's tendency to invest in education, training or technology, will enhance growth. Such policies would involve change in taxes and subsidies for research and development (R&D)[2]. Thus, the regulation of imported technology and foreign goods can potentially create long-run growth implications (see, e.g. Grossman and Helpman 1992, Romer 1990).

Most empirical studies testing various aspect of the new growth theory typically employ regression methods using cross-country data, often covering a large cross-section of countries (see e.g. Barro, 1991). However, there are also many studies employing growth accounting methods to identify TFP growth, and we discuss just a small sample here relating to SE Asia; see Felipe (1999) who provides a critical survey of the literature. In this section, we briefly discuss: Young (1992 and 1995), Kim and Lau (1994), Fischer (1993), Marti (1996), Collins and Bosworth (1997), Singh and Trieu (1999), Hayami and Ogasawara (1999) and Sonobe and Otsuka (2001). The methodology followed in most of these studies is growth accounting using a translog production function[3]. All studies with the exception of Sonebe and Otsuka (2001) measure TFP growth as a whole, and so are unable to decompose the latter into efficiency change and technological progress. Again, with exceptions noted below, most of these studies show that output growth in East Asia since the 1960s can be

[2] The role of R&D and TFP growth in Japan, South Korea, and Taiwan are examined in Trieu (1995) and in Trieu and Singh (1996).

[3] With the exception of Kim and Lau (1994), all employ the assumption of constant returns to scale and perfect competition.

accounted for chiefly by input growth in physical capital or human capital or labour input, leaving little left over to be attributed to technological change.

Young (1992) employs growth accounting to measure the contributions of input factors and productivity to the economic growth of Singapore and Hong Kong over the period 1966-90. He attributes Singapore's growth entirely to the growth in the labour force and the accumulation of capital. He concluded that the average value of the Solow residual for Singapore was zero, if not negative, for the previous thirty years. The TFP contribution to output between 1974 and 1989 was about –0.004% to 6% without allowing for heterogeneity in inputs, or –8% from 1970 to 1990 with differentiated inputs. Capital accumulation explained essentially all of the increase in output per worker during this period. Negative TFP contribution was also found in the manufacturing sector (Young 1995). In the case of Hong Kong, Young found some support for productivity growth although increases in input factors at 50% to 70% were responsible for a major part of the growth process. Young (1995) extended his earlier work to include the economies of South Korea and Taiwan as well. He found positive rates of productivity growth for 1960 to 1990. For Korea, the annual contribution of TFP for the overall economy for the period 1966 to 1990 was 16.5% of overall growth. For the manufacturing sector, it accounted for 20% of overall growth of the sector.

Kim and Lau (1994) extended Young's (1992) work to include, apart from Hong Kong and Singapore, South Korea and Taiwan. They take an alternative approach to Young by applying the concept of a meta-production, and while their methodology has some advantages, including not imposing constant return to scale, it involves lumping together the four East Asian "tigers".

Young (1995) used an alternative estimation method to calculate TFP growth for Hong Kong and Singapore. He regressed the output growth rate per worker on a constant and the growth of capital per worker for the period 1970 to 1985 using cross-country data constructed from the Penn World Tables (Summers and Heston, 1988). The capital stock was constructed by the perpetual inventory method with the accumulating investment flows for 1960 to 1969 as benchmark, and 6% depreciation rate. These results were consistent with his previous 1992 study, in that TFP growth in Hong Kong was high but almost nonexistent in Singapore.

Fischer (1993) employs the growth accounting method to estimate three sets of TFP calculations, each with a different weight on labour and capital inputs, using data from the Penn World Tables. He obtains a negative TFP growth rate for Singapore. Marti (1996), also using the Penn World data set, examines Young's (1995) results over an extended period and obtains a positive TFP growth rate for Singapore.

Singh and Trieu (1999) obtain growth accounting results for Japan, South Korea and Taiwan and finds a positive and significant role for technological change in these countries. They find that Japan had the highest TFP contribution to output growth over the period 1965 to 1990, at 44% of the output growth, and Korea not far behind with 42% TFP contribution to output growth. Collins and Bosworth (1997) also obtain positive results of TFP growth for East Asian economies, but conclude that their results are not extraordinary compared to that of other regions. Further, they conclude that factor accumulation was more important to output growth over the period 1965 to 1990.

Based on Young (1992) and Kim and Lau (1994), Krugman (1994) provides a controversial interpretation that there has been no miracle behind East Asia's growth but only simple capital accumulation and mobilisation of resources, and argues that these countries would not be able to sustain their economic growth. Instead, they might end up like the former Soviet Union, which also experienced rapid input-driven economic growth some five decades ago. In this context we should note that the studies of growth accounting for the Chinese economy by Chow (1993), Borensztein and Ostry (1996) and Hu and Khan (1997) suggest that the absence of human capital can overestimate the contribution of TFP to economic growth. After incorporating human capital, they found that the growth of total factor productivity played a positive but less significant role as the inclusion of the added input has the effect of reducing the impact of TFP. The results of the growth accounting exercise reported below confirm this picture for Thailand.

An extension to this work is to conduct levels rather than growth accounting, following the approach of Mankiw, Romer and Weil (1992) and others (e.g. Hall and Jones (1999)). This is a relatively straightforward extension also undertaken below and is intended to check whether the results of growth accounting hold in so far as the importance of productivity is concerned.

3. Factors Contributing to Economic Growth

There are many aspects of economic growth, however, the crucial one is the increase in the real value of output produced by a unit of labour input. As an example, the value of output per hour worked in the US has roughly doubled in the period 1950 to 1991. Such increases in productivity can be attributed mainly to increases in the amount of capital used per hour worked as well as to technological progress.

The capital stock of an economy includes all the buildings, structures, and machinery used, in combination with labour time. It is obvious that each unit of labour can bring about more output as the capital stock per hour worked increases. But this is not the only and not necessarily the most important factor underlying economic growth. Technological progress is the key to offering future populations the potential for improved standards of living. Technical change enables firms to combine inputs in a novel manner to produce existing products more cheaply and to develop new products to meet consumer needs. Economists and other social scientists are in broad agreement that technological change is the most important contributor to economic growth in the modern era. Based on Robert Solow's and Moses Abramovitz's ground-breaking work more than 40 years ago, economists have estimated that more than half of the United States' long-run growth is attributable to technological change (Solow, 1957, Abramovitz, 1956).

Technological progress causes a given increase in the capital stock per hour worked to generate output more effectively. Conversely, it makes possible the attainment of any given increase in national output with a small increase in capital stock per hour worked. This increase in output per hour worked due to technological progress is called an increase in total factor productivity (TFP).

3.1 TFP Growth and Technological Change

The neoclassical growth model serves as the framework for TFP computation, TFP growth is generally attributed to technological change, and there has always been a concern that the actual conditions of an economy may be at variance with the neoclassical assumptions. In particular, it has been felt that the neoclassical assumption of perfect factor mobility and equality of marginal product and factor returns across sectors is rather stringent. The feeling towards the assumption of constant returns to scale in all sectors has also been the same (Islam 1999).

However, Jorgenson (1988) emphasises that measured growth of neoclassical inputs can explain more of output growth and can be viewed as departures from neoclassical assumptions. He deals extensively with aggregation issues and in particular shows that the existence of the aggregate production function requires the value added function and the capital and labour input functions for each sector to be identical to corresponding functions at the aggregate level. Identical sector production functions in turn imply identical input and output prices. Jorgenson (1988) computes growth rates of output and input with and without allowing for these price differences across sectors and finds the results to differ, particularly for shorter periods. He interprets resulting differences as a contribution to aggregate productivity growth of reallocation of value added, capital input, and labour input among sectors. Jorgenson's computation shows that over a relatively shorter period, the contribution of reallocation of factors to growth is significant.

Another work addressing this issue in the context of international TFP of a small sample of developed countries is Maddision (1987). Apart from the standard neoclassical sources of growth, namely labour and capital, Maddison considers a long list of other sources of growth, e.g. structural effect, foreign trade effect, economies of scale effect, etc. He shows that allowing for such non-neoclassical sources of growth has an important effect on international TFP comparisons. A country's relative position changes depending on whether or not these other effects are taken into account. This is because countries differ with regard to the degree of departure from the neoclassical assumptions, and correspondingly, with regard to the importance of these sources of growth. Therefore, the main purpose was to obtain a broad indication about the importance of various sources of growth, neoclassical as well as structural.

3.2 Determinants of TFP Growth

There are three possible determinants of technological change that can be identified from the growth literature: inventions, economies of scale and learning by doing (Hall and Jones, 1997, Aghion and Howitt, 1999, and Young, 1993).

1. The invention of new products raises productivity indirectly by shifting labour and capital from old uses to new ones that are presumably of higher value, thus increasing the overall value of output. Invention activities are in general related to R&D expenditures and the average education level of the working population. However, whether international differences in R&D expenditures can help explain international difference in per capita GDP growth remains an open issue. Some empirical studies support the relationship while others dispute it. The contribution of education to TFP growth is much better established. (see Jones, 2000).

2. A second important determinant of TFP growth is economies of scale, i.e. falling unit costs at higher levels of production. Economies of scale can exist when the size or capacity of production facilities increases, or because of specialisation. Specialisation can raise TFP because less time is lost due to workers switching from one task to another, or because some workers may be better at some tasks than other workers are. The efficiency gain from specialisation of tasks within a firm extends to the specialisation of production across firms as well: if production is organised so that a large number of firms produce very specialised products, the productivity of labour and capital will be higher. The degree of specialisation depends on the size of the market. The economic integration of geographically dispersed market is perhaps the most significant channel through which economies of scale contribute to the growth of TFP. When regions that did not previously trade with each other begin to do so, market size for producers in both regions expands, making it possible for more and more firms to profitably adopt bigger plant and if profitable specialise.

3. The third source of TFP growth is learning on the job or learning by doing. As individuals working together in a factory gain experience in the production of a new producing a given volume of output. Consequently, TFP increases simply as a result of experience. However, while TFP growth from learning effects may be substantial, it

may ultimately stop. This does not mean that TFP growth as a result of learning by doing will after some time cease for the economy as a whole, though, since new products and new processes are added every year, there may be fresh opportunities for learning effects to increase TFP.

4. The Growth Accounting Framework

Total Factor Productivity (TFP) shows the relationship between a composite input and the output, calculated as a ratio of output and input. Productivity increases when the growth in output is greater than the growth in input, or when the rate of growth of output minus the rate of growth of the composite input is positive. Economic growth can be obtained either by increasing inputs or by improving factor productivity. Productivity growth occurs when a higher output can be attained with a given amount of input, or a certain level of output can be attained with smaller amounts of factor input. This productivity growth is obviously preferable to growth due to increase in factor inputs, since the latter might be subject to diminishing marginal returns. For a country with available natural resources as Thailand, an improvement in efficiency is distinctly more significant than for countries abundant in natural resources, and thus improvement in efficiency is especially important for Thai economies' growth. In the remainder of this section, we describe in detail our methodology for estimating TFP growth.

4.1 Total Factor Productivity and its measurement

Productivity is an indicator of the efficiency with which inputs in a production process are used to produce output. However, growth in a neo-classical framework stems from two sources: factor accumulation and productivity (TFP) growth. The key point of the debate at hand is the relative importance of each of these two components. A convenient way to conceptualise the notion of TFP is to start with a production function. We start with the aggregate production that tells us that output Y will be at some particular time t a function of the economy's stock of capital K, its labour L, and also of the total factor productivity, A as in Solow (1957). The aggregate production function can this be represented as

$$Y = F(L, K; t) \quad (1)$$

where Y denotes output, L labour, K capital, t time to allow for technical change. It is commonly assumed that technological change is disembodied and factor-neutral so that the technology indicator, A, can be separated from input factors as

$$Y = A(t)F(L, K) \quad (2)$$

The contribution of productivity gains in economic growth can best be described in the context of a growth accounting equation. Differentiating equation (2) with respect to time and dividing the resulting equation by Y, Solow (1957) obtains,

$$Y / Y = \dot{A} / A + A * \partial f / \partial K * \dot{K} / Y + A * \partial f / \partial L * \dot{L} / Y \quad (3)$$

where dots indicate time derivatives. Now, under perfect competition in the factor markets, so that the returns to capital (w_k) and labour (w_l) are the respective shares:

$$w_k = (\partial Y / \partial K)(K / Y);$$
$$w_l = (\partial Y / \partial L)(L / Y)$$

Substituting w_k and w_l into (3) gives the result

$$\dot{Y} / Y = \dot{A} / A + w_k * \dot{K} / K + w_l * \dot{L} / L \quad (4)$$

Now, let F be homogeneous of degree one, *i.e.* $Y / L = y, K / L = k, w_l = 1 - w_k$

Note that $\dot{y} / y = \dot{Y} / Y - \dot{L} / L; \dot{k} / k = \dot{K} / K - \dot{L} / L$

Then (4.4) becomes

$$\dot{y} / y = \dot{A} / A + w_k * \dot{k} / k \quad (5)$$

Equations (4) and (5) have been used widely in growth accounting; (4) allows us to separate out TFP growth ($\dot{A}/A$) from changes in the contributions of labour and capital, and (5) is the same calculation in terms of productivity of labour ($y = Y/L$). This is the Solow aggregate model, which assumes neutral technical change. In further development of the Solow model, Jorgenson, Gollop and Fraumeni (1987) use a translog production function to get a more precise estimate of TFP growth. This is done by disaggregating capital into various components, such as machinery and plant, construction, inventory, etc, and labour based on skilled, un-skilled, age and gender. Thus, the Translog production function allows disaggregate analysis. In the Young (1992) framework, TFP growth is measured using a translog production function, and is defined as the difference between output growth and the weighted growth of inputs. Output growth is modelled as a translog function of inputs, hence the growth rates of inputs are weighted on the basis of their share in the total value of output. Importantly, in the translog function both growth in the quantity and quality of inputs is taken into account. This requires a detailed breakdown of different types of labour for example, according to the schooling levels and age, and of different types of capital.

This methodology allows us to analyse the sources of growth in real factor inputs between quantity and quality of factor inputs[4]. One of the more relevant questions is to know the contribution of the improvements in the design of new capital embodiment and the contribution of disembodied technical progress to economic growth. We consider that all inputs are different, one hour of work by an unskilled worker is not the same as one hour by a skilled worker. In common with the literature on quality changes, we assign a significant role to embodied technical change as a determinant of the prices of investment goods. This approach implies that technical progress can be attributed to capital. This is done by estimating the service flow from different vintages of capital. That is, technological improvements in the design of investment goods embodied technical change, may be a significant source of productivity change. One consequence of the embodiment hypothesis is that new capital is more productive than

[4] The earliest growth accounts only took into consideration the physical quantities of the two main factors of production, capital and labour input.

older capital (Hulten (1992)). This methodology considers that there are large differences in the marginal productivity of the different types of labour and capital. The Translog indices aid the decomposition of the growth rates into quantity and quality growth rates. The importance of this distinction is that we assume that the introduction of new, more efficient capital goods and more qualified human capital is an important source of productivity change.

It is clear that there has been much technological change in the production of new equipment and the not all capital has the same quality. The production of capital goods becomes increasingly efficient with the passage of time. The failure to measure capital efficiency units has the effect of suppressing the quality effects into the conventional TFP residual.

Early growth accounting included in the residual not only pure disembodied innovation, but also the innovation embodied in capital good (capital quality), human capital accumulation (labour quality) and improvements in markets (resource allocation). Understanding the changes in the quality of capital is very useful to study the importance of technology transfer in the catching-up process by developing countries. For instance, if growth rates can be explained by improvements in the quality of capital, then the success of Thailand in this period must also be due to the adoption of new machinery. Conversely, if productivity improvement is relatively independent of factors of production, one must underline the importance of disembodied technical change that productivity (not due to more and better machines). In summary, growth accounting essentially divides output growth into a component that can be explained by some quality adjusted input growth, and a 'Solow residual' which captures changes in productivity.

4.4.2. Translog Production Function.

The methodology is based on a constant returns to scale Translog production function, which gives the theoretical justification for the use of factor shares to weight of growth rates[5].

[5] See Young (1992).

$$\ln Y = \alpha_0 + \alpha_K \ln K + \alpha_L \ln L + \alpha_t t + 0.5\beta_{KK}(\ln K)^2 + \beta_{KL}(\ln K \ln L) + \beta_{Kt} \ln K * t + 0.5\beta_{LL}(\ln L)^2 + \beta_{Lt} \ln L * t + 0.5\beta_{tt} t^2 \quad (6)$$

where Y is output, K, L, and t denote capital input, labour input and time, and where under the assumption of constant returns to scale, the parameters satisfy the restriction:

$$\alpha_K + \alpha_L = 1, \beta_{KK} + \beta_{KL} = 0, \beta_{KL} + \beta_{LL} = 0$$

The necessary conditions for producer equilibrium are given by equalities between the value shares and the elasticities of output with respect to the corresponding inputs. Under constant returns to scale the value shares for capital and labour sum to unity:

$$\theta_K = \partial \ln Y(K, L, t) / \partial \ln K = \alpha_K + \beta_{KK} \ln K + \beta_{KL} \ln L + \beta_{Kt} t$$
$$\theta_L = \partial \ln Y(K, L, t) / \partial \ln L = \alpha_L + \beta_{KL} \ln K + \beta_{LL} \ln L + \beta_{Lt} t$$

We can define the rate of productivity growth, say θ_t, as the growth of output with respect to time, holding capital input and labour input constant:

$$\theta_t = \partial \ln Y(K, L, t) / \partial \ln t = \alpha_t + \beta_{Kt} \ln K + \beta_{Lt} \ln L + \beta_{tt} t$$

If we consider data at any two discrete points of time, say t and $t-1$, the average rate of technical change can be expressed as the difference between successive logarithms of output less a weighted average of the differences between successive logarithms of capital and labour input with weights given by average value shares:

$$\ln Y(t) - \ln Y(t-1) = \bar{\theta}_K \left[\ln K(t) - \ln K(t-1)\right] + \bar{\theta}_L \left[\ln L(t) - \ln L(t-1)\right] + TFP_{(t-1,t)} \quad (7)$$

where

$$\bar{\theta}_K = 0.5\left[\theta_K(t) + \theta_K(t-1)\right]$$

$$\bar{\theta}_L = 0.5[\theta_L(t) + \theta_L(t-1)]$$

If aggregate capital and labour inputs are translog functions of their components, we can express the difference between successive logarithms of aggregate capital and labour inputs in the form:

$$\ln K(t) - \ln K(t-1) = \sum_i \bar{\theta}_{Ki}[\ln K_i(t) - \ln K_i(t-1)] \tag{8}$$

$$\ln L(t) - \ln L(t-1) = \sum_j \bar{\theta}_{Lj}[\ln L_j(t) - \ln L_j(t-1)] \tag{9}$$

where

$$\bar{\theta}_{Ki} = \frac{[\theta_{Ki}(t) + \theta_{Ki}(t-1)]}{2} \qquad \text{(i=1,2,…n)}$$

$$\bar{\theta}_{Lj} = \frac{[\theta_{Lj}(t) + \theta_{Lj}(t-1)]}{2} \qquad \text{(j=1,2,…n)}$$

$\bar{\theta}_{ij}$ denotes the elasticity of each aggregate input with respect to each of its component sub-inputs, assuming perfect competition, the share of each sub-input in total payments to its aggregate factor. These indexes adjust for improvements in the quality of aggregate capital and labour input by, to a first-order approximation, weighting the growth of each sub-input by its average marginal product.

4.3 Human Capital Adjusted TFP

Over the last five decades there has been a radical change in Thailand's economic landscape as the country moved from a primarily agricultural to a non-agricultural society. Currently, Thailand is moving towards a more knowledge-based economy. Hence information technology skills and various managerial skills are important and much needed. However, these types of skills are not readily available, even though the overall educational level, especially secondary education, has shown impressive achievements with the proportion of employees in secondary education increasing from 8 percent in 1979 to almost 30 percent in 1999 (UNDP 1999), although this is relatively low compared to other SE Asian counties (see Figure 1 below). However, it is clear that structural changes associated with industrialisation require different kinds of skills, and a shift of labour from the agricultural sector to the industrial and service sectors also demands corresponding changes in skills. This suggests that the quality of labour is important in accounting for growth although the relatively low level of educational attainment and skill base in Thailand is unlikely to guarantee a sufficient supply of skilled labour needed for faster growth.

Our analysis based on these ideas will draw upon recent theories of endogenous growth suggesting a positive effect of human capital on economic growth, although empirical evidence on this issue has been mixed. In the context of growth accounting, this also suggests additional determinants of growth beyond the basic factors of production. To keep the analysis simple, we adopt the Cobb-Douglas production function:

$$Y_t = A_t K_t^{1-\alpha} (L_t H_t)^{\alpha} \tag{10}$$

where Y_t equals real GDP, K_t equals the total physical capital stock, L_t equals the number of workers (employed persons), H_t is average schooling years of population of age 15+ group or age 25+ group and represents human capital stock. Thus, (L_t H_t) is a skill-adjusted measure of labour input, and A_t equals an index of total factor productivity. Taking logs and differentiating totally both sides of equation (10) with respect to time yields:

$$y_t = a_t + (1-\alpha)\hat{k}_t + \alpha(\hat{l}_t + \hat{h}_t) \tag{11}$$

and rewriting (4.11) gives the following:

$$a_t = y_t - (1-\alpha)\hat{k}_t - \alpha(\hat{l}_t + \hat{h}_t) \quad (12)$$

where a_t is the growth of human capital adjusted TFP, and y_t is the growth of real output. $\hat{k}$, the growth of real capital, $\hat{l}$, the growth of labour and $\hat{h}$, the growth of educational attainment. Equation (12) thus represents the growth rate of TFP as the growth rate of output minus a weighted average of the growth rates of physical capital and skill-augmented labour. Under the assumption of perfect competition and constant returns to scale, these weights are the shares of the two inputs in aggregate output. In addition, the production function parameters are central to the decomposition of output growth into contributions from physical capital, labour and productivity. However, if these sources of bias are somehow successfully removed, the remaining portion of output growth unexplained by the weighted average of the rate of input growth is the measure of real TFP growth, and would be attributed to productivity or technological change.

4.5. Measurement of Human Capital

According to Barro and Lee (1993), there are three suggested ways to measures the human capital: (i) school enrolment ratios, (ii) adult literacy ratios, and (iii) educational attainement. Schooling enrolment ratios are widely available across countries but, as a measure of the stock of human capital, this measure is deficient for developing countries since it does not account for the fact that many parents are not able to send their children to school. The adult literacy rate has frequently been used in empirical studies, because it measures a stock of human capital for the adult population, whereas the school enrolment ratios measure the flow of education. However, this measure is less widely available because the underlying information typically comes from general population censuses and surveys, activities that usually occur only once per decade. Educational attainment, favoured by Barro and Lee (1993, 2000), provide information on the average number of years of education attained for a specified population group, such as the labour force or persons aged 25 and over.

In this study we have obtained data on educational attainment from Barro-Lee (1993, 2000) and The World Bank (2001), covering the period 1972-2000. These two databases reflect the major alternative approaches to estimating education attainment. The first method, as illustrated by the World Bank study, relies on school enrolment data, which are quite widely available. The approach is similar to that used to construct measures of the physical capital stock, past investments are used to build up a stock of educational skills in the current working population. It requires keeping track of the educational attainment of each age cohort as it accesses through the ages of school attendance and enters into the labour force and as it retires or dies. The researchers had access to school enrolment data extending back into the 1930s. The alternative approach, used by Barro-Lee, use census reports of the educational level of the population age 25 and over as the primary information source. Thus, it can be viewed as developing direct estimates of the stock of education at various points in time and interpolating between them.

Using a perpetual inventory method (PIM), Barro and Lee (2000) construct a measure of human capital stock. Their data set comprises at least one observation for 142 countries, of which 107 have complete information at five-year intervals from 1960 to 2000. The percentage of the population who have successfully completed a given level of schooling (secondary, tertiary, or post-primary schooling) is a straightforward way to show the population's attainment of skills and knowledge associated with a particular level of education[6]. With these data they can construct measures of average years of schooling at all levels for each country, which is taken as the human capital stock series.

Finding a relationship between gains in educational attainment and economic growth is due to the frequent use in the empirical studies of "years of schooling" to measure the change in labour quality. Barro and Lee applied an exponent of 0.5 to the measure of year of schooling (s) to compute an index of labour (H):

[6] In particular, however, each cycle of education has significant variation in duration across countries. They also take account of this variation by using information on the typical duration of each level of schooling within countries.

$$H_{i1} = s_i^{0.5} \tag{13}$$

This approach still implies very large gains in quality for countries that begin with a very low level of educational attainment. Essentially, those with no schooling are being assigned a zero weight in the index of labour quality. Instead, it is necessary to construct a measure that explicitly incorporates relative wage rates to aggregate the skills of workers at different levels of educational attainment. Of course, this type of detailed data is not available for more than a few countries, even then it can be distorted if education is used as a simple screening device to separate workers whose skills differ for other reasons. However, those few studies that have examined the structure of relative wage rates by education find surprisingly little variation across countries[7]. Thus they have used Denison's studies to construct a single set of weights that they apply to the proportions of the population at different educational level (P_j). The measures are standardised at 1.0 for those who have completed the primary level of education. The relevant wage weights are 0.7 for no schooling, 1.4 for completion of the secondary level, and 2.0 for completion of the third level. Weights for intervening levels of education by interpolation:

$$H_{i2} = \sum_j w_j * P_{ij} \tag{14}$$

where P_j equals the proportion of the working age population in the j^{th} education level. Data are reported as years of average schooling at each level. The constructed index is based on a comparable relationship that translates year of schooling at each level. We have a preference for the Barro-Lee data because it seems more in accord with expectations; and Barro-Lee approach should provide high quality results for the developing countries like Thailand.

6. Human Capital Stock of Thailand

6.1. Development of Thailand's Education

[7] See Denison (1967) and World Development Report (1995).

In Thailand, education begins with kindergarten (ages 3-6) and continues with primary (age 6-12) and secondary education (age 12-18), which includes junior and senior secondary schools, specialised secondary schools, vocational schools, and technical training schools. Higher education, which includes universities and colleges as well as postgraduate programmes, requires 4-5 years for a Bachelor degree, 7-8 years for a Masters degree, and 10-11 years for a Ph.D.

Around 50 per cent of Thai's population were without formal schooling after World War II (1973-1945) and the Civil War (1945-1949). In the 1950s, there was a widespread movement to eradicate illiteracy. In the 1960s, the implementation of an obligatory mandatory nine-year education policy began. This policy called for six years in primary school and three years in junior secondary school. While the implementation of this policy has been consistent in urban areas, it did not materialise in rural regions in terms of financial assistance. The enrolment growth at the primary level is slow compared to other levels because the coverage at this level was already extensive for a long time. Slower growth in enrolment in primary education also stems from the decline in birth rate since 1970s and a reduction in dropout and repetition rate that reduced the proportion of students in the primary school age range. By the mid 1990s, Thailand achieved virtually universal enrolment in primary education, but the quality vary a great deal. Only two-thirds of primary school students currently complete their entire primary cycle. In some remote and poor regions, completion rate were also as low as 45 per cent.

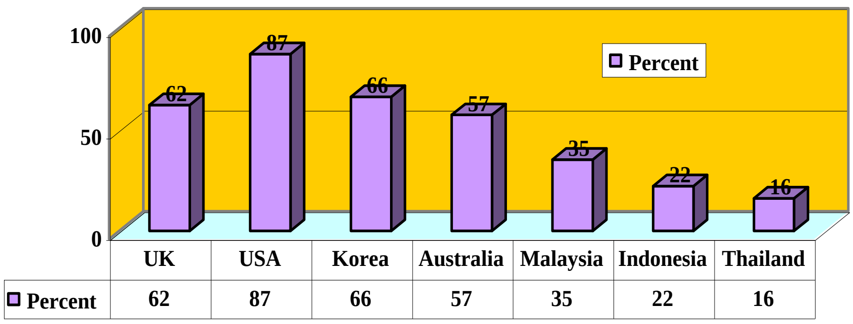
At secondary level, gross enrolment rates rose progressively but both enrolment rates and growth at this and the tertiary level remained low, relative to those of other Asian countries. Although government policies created better educational opportunities for working class and peasants, famine and social conflict in the early 1960s thwarted that momentum. Regular enrolment was restored in 1970s, but Thailand had already lagged behind Korea, Malaysia, Indonesia, and other countries (see Figure 1 below). At the tertiary level, however, coverage is also low. Thailand does lag behind other countries regarding some dimension of educational progress. For instance, its rate of enrolment particularly in higher education is about average among all Asian countries and the rates found in some low-income countries.

6.2. Trends in Thailand's Human Capital Stock

As argued above, improving the quality of human capital is the most promising strategy for sustainable economic growth in Thailand. The Government has shown its commitment to the strategy of human capital development by improving the quality of education and providing educational access to more of the nation's school-age children. (as part of Thailand's ninth five-year plan, 2002-2006). Over the past decade, a substantial budget share has been allocated to the education sector. In recent years, spending on education has equalled nearly 20 percent of the total government budget and about 4 percent of GDP, comparable to the allocations in many high-income countries, including Japan and the USA. Despite the 1997 crisis, which has necessitated budget tightening, the education's share of the Thai total budget has continued to be higher than the share of any other sector. The National Educational Act of 1999 demonstrates the Government's commitment to education by promising 12 years of quality education for all Thai children, free of charge, by 2004.

However, despite having achieved nearly universal enrolment in primary education and high adult literacy rates, Thailand has, until very recently, lagged behind other countries at comparable income levels in terms of secondary education development. As can be seen from Figure 1, only 16 percent of Thailand's adult population between the age of 25 and 64 have completed secondary education. This is one of the lowest levels in East Asia and far below the level of most developing countries.

Figure 4.1 Percentages of population (25-64 years) completing secondary education in selected countries, 1999



Source: OECD Education at a Glance, OECD Indicators, 2001

However, the situation in Thailand began to change rapidly in the mid-1990s, as Thailand's gross secondary enrolment ratio increased by half, rising from 40 percent in 1993 to nearly 70 percent in 2000 (ONEC statistics). Moreover, secondary education attainment is likely to increase significantly when the full impact of the National Education Act of 1999 takes place. This suggests that human capital is likely to be an important determinant of further economic development in Thailand.

7. Data and Results

We report below the results of Solow's growth accounting exercise undertaken for Thailand, using the translog function method as employed by Young (1992). The analysis focuses on data for output i.e. real GDP and three aggregate inputs, physical capital, labour and a measure of human capital. Real GDP is reported in the International Financial Statistics (IMF) at constant prices with 1995 chosen as the base year.

The National Economic and Social Development Board (NESDB) of Thailand compiled its capital stock series for the first time, covering the period of 1970-1996. In the case of Thailand, capital stock is composed of three major parts. These are buildings and structures, machinery and equipment, and cultivated land development. In Thailand, perpetual inventory method (PIM) was conducted to obtain the benchmark figures of capital stock and related data. The basic concept of PIM is to accumulate gross fixed capital formation from the first year to the current year minus the value of capital retirement. The result is gross capital stock. To derive net capital stock, the accumulated depreciation over the same period has to be subtracted from the total value of the gross capital stock[8]. This is equivalent to the net capital stock in the previous year plus gross investment in the current year minus annual depreciation.

In the case of labour, the Labour Force Survey (LFS) has been undertaken by the National Statistical Office since 1963. The survey started in 1971, two rounds of the survey for the whole kingdom had been conducted each year, the first round enumeration was held during January-March coinciding with the non-agricultural season and the second round during July-September coinciding with the agricultural season. From 1984-1997, the survey has conducted three rounds a year, the fourth round of the survey for the whole kingdom has been conducted additionally during October-December. Since then, the LFS has been undertaken four times a year; the first round is February, the second in May, the third round and the fourth rounds in August and November respectively. We chose the second round LFS because the timing is considered fairly consistent. Ideally, a series of the average employment is calculated between the dry and the rainy seasons. However, there would be a downward bias in the TFP for the agriculture sector and an upward bias for the non-agricultural sector.

As a measure of human capital, we use the initial-year level of average years of the secondary schooling attainment constructed by Barro and Lee (2000) as a proxy of human capital. Table 1 below displays results in five-year averages as well as for the entire period 1972-2000, using the aggregate measures capital and labour, excluding human capital[9]. The five-year averages smooth out annual effects but the result may still indicate substantial variations in TFP growth (TFPG hereafter) between the five-year spans, given nearly three decades of annual data.

Table 1: Percentage contribution of labour, capital and TFP				

[8] Depreciation is simply calculated using the straight-line method. Values of scrap in each item of all asset types are assumed 1 per cent of its value at purchasing time. Depreciation is equivalent to value of assets, subtracted by scrap, divided by expected economic lifetime. In general, lifetime is recorded at 45-50 years for building and structure and at 10-15 years for machinery and equipment. No lifetime is estimate for dam and road.

[9] Hence, the results are based on the use of equation (4.6) above.

		Growth of		Average	Average		Percentage contribution of	
Time period	**Output**	**Labour**	**Capital**	**Capital share**	**Labour share**	**Labour**	**Capital**	**TFP**
72-76	0.273	0.132	-0.083	0.429	0.571	0.277	-0.13	0.853
76-80	0.292	0.201	0.082	0.480	0.520	0.358	0.136	0.506
80-84	0.22	0.144	0.283	0.473	0.527	0.344	0.61	0.046
84-88	0.314	0.125	0.311	0.516	0.484	0.193	0.511	0.296
88-92	0.318	0.095	0.476	0.484	0.516	0.129	0.604	0.267
92-96	0.319	-0.005	0.381	0.477	0.523	-0.008	0.57	0.438
96-00	-0.051	0.024	0.247	0.484	0.516	-0.239	-2.343	3.582
72-00	1.748	0.716	1.698	0.473	0.527	0.214	0.459	0.327

Table 1 suggests TFPG has been consistently high, in excess of 20%, showing a productivity slowdown during the period 1996-2000 (by 358%), the decline in output growth during this period is also partly attributed to the negative contribution of capital during the period of the Thai financial crisis. Over the entire period 1972-2000, it can be noted that productivity, capital and labour contributed, respectively, about 21%, 46% and 33% to output growth. Hence, it appears that Thailand’s economic growth is 67% input driven and 33% productivity driven over this period.

Table 2. Output per worker (attributable to TFP), Gtfp = [GY - GL] - capital share [GK - GL] and output per worker (capital accumulation).

Time period			**Average**					
	[GY- GL]	**[GK - GL]**	**Capital share**	**real [GK - GL]**	**Gtfp**	**Output per worker (attributable to TFP)**	**Output per worker (capital accumulation)**	
72-76	0.141	-0.215	0.4288	-0.092	0.233	1.65	-0.65	
76-80	0.091	-0.119	0.4802	-0.057	0.148	1.63	-0.63	
80-84	0.076	0.139	0.473	0.066	0.010	0.13	0.87	
84-88	0.189	0.186	0.516	0.096	0.093	0.49	0.51	
88-92	0.223	0.381	0.4842	0.184	0.039	0.17	0.83	
92-96	0.324	0.386	0.477	0.184	0.140	0.43	0.57	
96-00	-0.075	0.223	0.4838	0.108	-0.183	2.44	-1.44	
72-00	1.032	0.982	0.473	0.464	0.568	0.55	0.45	

Note: GY denote growth of out put, GL denote growth of labour, GK denote growth of capital, Gtfp denote growth of total facto productivity.

Table 2 shows the same calculations in per capita terms, in order to indicate the contribution of output due to capital accumulation, as also shown by Young (1992).[10] Over the period 1972-2000, the results indicate TFPG (adjusted for labour force growth) at 57% but per capita output growth attributed to capital accumulation at 45%. Note that the rapid capital decline over the period 1996-2000 translates to a decline in per capita output growth attribute to capital by over 100%.

Table 3 shows the TFP calculations after including human capital as an additional variable in growth accounting equation, human capital being represented by secondary educational attainment levels for age groups 25+.[11] The results show that skill-adjusted labour input growth does lead to reduction in the TFP residual, as predicted, except for the time periods 1980-84 and 1996-2000. In the former case, a relatively high percentage of human capital leads to a negative TFP, but in the later case the percentage contribution of human capital to output growth is actually negative, implying a productivity slowdown as output growth is negative over this period. On average, over the entire period 1972-2000 these effects cancel out, suggesting that output growth is 86% input-driven, but still a significant 14% total factor productivity driven.

Table 3. TFP calculations with Human Capital.

		Growth of				Percentage contribution of		
Time period	**Output**	**Capital**	**Labour**	**Human Capital**	**Capital**	**Labour**	**Human Capital**	**TFP**
72-76	0.273	0.132	-0.083	0.014	0.207	-0.174	0.029	0.937
76-80	0.292	0.201	0.082	0.049	0.331	0.146	0.087	0.436
80-84	0.22	0.144	0.283	0.195	0.31	0.678	0.466	-0.454
84-88	0.314	0.125	0.311	0.111	0.205	0.479	0.172	0.143
88-92	0.381	0.095	0.176	0.072	0.121	0.238	0.097	0.544
92-96	0.319	-0.005	0.381	0.053	-0.007	0.625	0.087	0.296
96-00	-0.05	0.024	0.247	0.050	-0.228	-2.500	-0.510	4.238
72-00	1.748	0.716	1.698	0.544	0.194	0.507	0.163	0.137

Table 4 shows analogous calculations as reported in Table 2 but with human capital included in the production function. In computing these values we have used data for educational attainment at 25+. The results suggest that of the per capita output

[10] Here, the results are based on the use of equation (4.7) above.
[11] The results are based on the use of equation (4.11) or (4.12) and using the same data set for physical capital and labour.

growth over the period 1972-2000, 146 per cent attributed to capital accumulation, leaving -46% to be attributed to TFP growth. Thus, adjusting for capital/labour ratio with human capital-augmented labour contributes to a reduction of the Solow residual as expected.

Table 4. Growth of output per worker attributable to Capital Accumulation and TFP (with Human Capital).

Time period	GY-(GL+GH)	GK-(GL+GH)	Average share of augmented capital	Real GK-(GL+GH)	Gtfp	Output per worker (Capital Accumulation)	Output per worker (attributable to TFP)
72-76	0.342	0.201	0.4288	0.086	0.256	0.252	0.748
76-80	0.161	0.07	0.4802	0.034	0.127	0.209	0.791
80-84	-0.258	-0.334	0.473	-0.158	-0.100	0.612	0.388
84-88	-0.108	-0.297	0.516	-0.153	0.045	1.419	-0.419
88-92	0.133	-0.153	0.4842	-0.074	0.207	-0.557	1.557
92-96	-0.115	-0.439	0.477	-0.209	0.094	1.821	-0.821
96-00	-0.348	-0.273	0.4838	-0.132	-0.216	0.380	0.620
72-00	-0.494	-1.526	0.473	-0.722	0.228	1.461	-0.461

8. An analysis of the findings

Research by Young (1992, 1995), Kim and Lau (1994) and Krugman (1994) have generated considerable controversy surrounding the rapid growth of the East Asian Economies, arguing that factor accumulation has been responsible for a major part of the economic growth. Our results are broadly consistent with this view, although productivity growth is also arguably an important factor.

In Thailand, during the early period of our study (1972-76), productivity accounted for over 80% of output growth although in the subsequent periods (1976-80 and 1980-84) this contribution is much lower. This reduction has come about as a result of a higher capital accumulation and, to some extent, higher labour force growth although the latter has subsequently declined. Higher capital accumulation was supported by a high savings rate as well as import-substituting industrialisation strategy, which prompted the importation of capital goods. The increase in the labour force initially came from a growing population as well as a rising labour force participation rate, both of which have subsequently declined, thus reversing the trend in labour force growth in subsequent years.

In the early part of the 1980s, the growth of capital stock was lower than GDP growth, the effect of which has meant that the productivity contribution to output growth has been particularly high during the period 1984-88, as output growth rose faster than capital accumulation while labour force growth declined over this period. In subsequent periods, much of the output growth is explained by rapid capital accumulation (possibly a result of the shift to export-led growth) and some productivity growth as labour force continued to decline. This is evident from Table 4.2, showing a much higher contribution of capital accumulation in per capita output growth over the periods 1988-96 compared to other time periods. By contrast, over the period 1996-2000, output growth actually registers a decline, but this period of the Thai financial crisis has also resulted in much greater reduction in the growth of capital stock, implying that just over 100% of the decline in output growth is attributed to a decline in capital accumulation, the remainder being due mainly to a slowdown in productivity. The inclusion of human capital slightly reduces the proportion of this contribution (and consequently increases the proportion of the productivity contribution) in the decline of output growth. Excluding human capital, nearly 45% is the net contribution of productivity growth to more than 100% growth of per capita output during the period 1972-2000 (Table 4.2). Adjusting for human capital-augmented labour, the net contribution of productivity over the same period is -46% as noted earlier.

9. A View from levels accounting

The above exercise can be compared with levels accounting where output per capita is decomposed into capital-output (rather than the capital-labour) ratio, human capital per worker, and productivity. This follows the approach of Mankiw, Romer and Weil (1992) and others (e.g. Hall and Jones (1999)). This is relatively straightforward extension of the Solow residual approach and is intended to check whether the results of growth accounting have undermined the importance of productivity (Hall and Jones (1999)). Incorporating human capital in a Cobb-Douglas production function, we follow Hall and Jones (1999) by proceeding as follows:

$$Y_t = K_t^{\alpha}(A_t H_t)^{1-\alpha} \tag{13}$$

where Y_t and K_t are same as in equation (10) above, where A_t is “a labour-augmenting measure of productivity”. H_t, human capital-augmented labour is defined as

$$H_t = e^{(E_t)} L_t \tag{14}$$

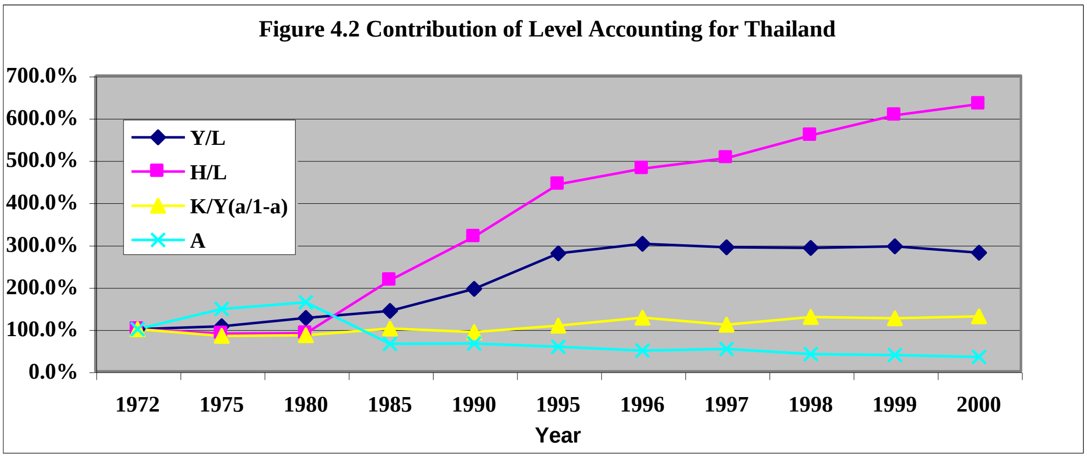
where E_t indicates average years of schooling (of the Thai total employment in year *t).* E_t was used as a measure of human capital in the earlier stage. Rewrite equation (13) in per capita terms as

$$y_t = (K_t / y_t)^{\alpha/1-\alpha} .h_t .A_t \tag{15}$$

where $h \equiv$ H/L is human capital per worker.

Table 5. Level Accounting for Thailand.										**1972=100**			
						Contribution of					**Contribution of**		
Year	**Y**	**L**	**K**	**H**	**Y/L**	**H/L**	**K/Y^α/(1-α)**	**A**		**Y/L**	**H/L**	**K/Y^α/(1-α)**	**A**
1972	712.49	16618.6	2644.35	34.467	0.04605	0.00214	2.24783	9.58740		1.00000	1.00000	1.00000	1.00000
1975	892.06	18818.7	2349.23	34.813	0.04906	0.00191	1.81485	14.11915		1.06542	0.89606	0.80738	1.47268
1980	1306.71	22507.7	2693.11	43.38	0.05806	0.00193	1.92381	15.65767		1.26070	0.90196	0.85585	1.63315
1985	1704.03	25837	3920.71	119.104	0.06595	0.00461	2.28562	6.25961		1.43218	2.15731	1.01681	0.65290
1990	2781.53	30940.1	6403.79	210.608	0.08990	0.00681	2.08866	6.32327		1.95220	3.18552	0.92919	0.65954
1995	4194.6	32575	10692.8	307.968	0.12877	0.00945	2.43977	5.58259		2.79621	4.42434	1.08539	0.58228
1996	4487.66	32232.3	11496.7	330.298	0.13923	0.01025	2.86434	4.74339		3.02337	4.79560	1.27427	0.49475
1997	4486.25	33162.3	12589.3	357.808	0.13528	0.01079	2.47862	5.05851		2.93766	5.04932	1.10267	0.52762
1998	4319.66	32138	13591.1	383.752	0.13441	0.01194	2.89306	3.89082		2.91873	5.58804	1.28705	0.40583
1999	4376.26	32087.1	13644.8	415.713	0.13639	0.01296	2.83293	3.71598		2.96166	6.06305	1.26029	0.38759
2000	4264.84	33001	14711.9	445.856	0.12923	0.01351	2.92098	3.27476		2.80633	6.32259	1.29946	0.34157

The levels accounting approach based on equation (15) thus decomposes output per capita into capital-output ratio, educational attainment (the human capital ratio), and productivity. In calculating the effects of these factors, we use the same values for the capital and labour share of output (α, $1-\alpha$) as in the growth accounting approach, assuming perfect competition in the factor markets and constant returns to scale.[12]



Note: Y/L denote Output per worker, H/L denote human capital per worker, K/Y(a/1-a) denote decomposes output per capita into capital-output ratio, A denote TFP.

Table 5 and Figure 2 present the results based on equation (15) for some selected years. The contribution of TFP is notably high in the earlier years and deteriorates steadily, as we noted in the growth accounting case (see Table 4). This of course is due in part to the rise in the human capital ratio over the period, which represents a significant factor in explaining labour productivity of the Thai economy.

10. Conclusion and Implications

This paper investigates the changes in the sources of economic growth during the period 1972-2000 by undertaking both a growth accounting exercise and level accounting approach, incorporating human capital. The accumulation of human capital in Thailand as measured by the average years of schooling attainment in population age 25-64, and it contributes significantly to growth. The rate of growth of human capital increased significantly in the period 1972-2000. After incorporating human capital, the growth of total factor productivity still plays a positive and significant role during the

[12] Thus α varies in each period, but results based on a common value of α = 1/3 does not significantly alter the conclusion. In fact, as our calculation of the factor shares exceeds 1/3, the estimates of the Solow residual are lower than would be the case otherwise.

pre crisis period (1972-1996), in contrast to the negative contribution from capital, labour, and human capital during the period 1997-2000 (see Table 3). Thus, we conclude that productivity growth and factor accumulation are significant in accounting for Thai growth performance during the pre and post crisis period[13].

In summary, the aggregate picture for Thailand is broadly in line with conclusions reached by Young (1992) for Singapore and Hong Kong, Kim and Lau (1994) for Singapore, Hong Kong, South Korea and China, and more recently Singh and Trieu (1999) for Japan, South Korea and Taiwan. As Krugman argues, output growth for SE Asian counties has been driven mainly by mobilisation of resources rather than by technological change, and our results are not inconsistent with this view although we do find a Solow residual that is still high even after incorporating human capital in our analysis. In fact, a significantly large residual for the period 1997-2000 seems to indicate that productivity slowdown may have been a factor in contributing to the Thai recession over this period. However, there remains the outstanding question of investigating the importance of other factors. More importantly, there might be a role for openness and technology transfer in the form of FDI in promoting efficiency of production in the earlier decades. In particular, there may be complementarities between human capital, FDI, domestic investment and openness that need to be explored further, given the recent study by Borensztein et al. (1998) who find, in a cross-country context, a strong positive association between FDI and the level of educational attainment (our proxy for human capital) suggesting that the effect of FDI is dependent on the level of human capital available in the host economy. These issues are investigated in another paper (Tanna and Topaiboul, 2004).

[13] Financial crisis in Asia happened in the mid of 1997.

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