

Study of Economic Growth in Thai Economy

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Abstract

This empirical investigation seeks to detect empirical explanations for the behavior of the Thai economy and its production input efficiency within the process of economic development for last three decades. The notion of estimated parameters used is the elasticity or productivity, which has estimated through the econometric estimation of Cobb-Douglas production function. After conducting various statistical test, AR(1) model incorporating some input factors production function is superior to ARCH-type specifications for growth of Thai economy. A significant AR coefficient demonstrates the martingale process that suggests a long memory in any change in the annual gross domestic output. A second aspect of this study is to argue against the traditional belief that the estimated parameters of production inputs are time-varying process. The empirical findings from a state space model suggest evidence that they vary through time. They also shed elucidate the sensitivity of input factor efficiency following the sharp fallout in the 1997 financial crisis. The current absorptive capability of technological transfer from foreign countries via indirect channels seems to be significantly improved. A third finding is that the framework of inflation targeting has not gain trustworthiness to the marketplace and Thai economy has increasingly relied on capital investment. Time-varying parameter method also provides evidence of two reversal direction of inflation uncertainty on economic growth from negative to positive effect.

1.Introduction

Interest in maximizing the growth rate of the economy has recently grown, especially in such developing countries as Thailand. However, the achievement of accelerated growth may be unsustainable in the long term as the result of the unique characteristics of each economy and uncontrollable exogenous factors such as globalization, and technological and institutional innovations. Thus, sustainability must join high growth to form a double strategic challenge for policy makers. Completed understanding of developed economic growth models and progresses toward the determinants of economic success will be some more insightful aspects to policy makers in answering questions about the sustainable growth and assuring the subsistence needs of population. To facilitate area of interest in those of understanding, this paper offers a threefold contribution to the empirical growth literatures that are: investigating characteristics and dynamic behavior of economic growth of Thailand, testing for the powerful ARCH-type model with

the Cobb-Douglas production function to estimate growth in Thailand, and exploration the time-varying efficiency of output determinants.

Factor productivity and efficiency are widely indicators of sustainable economic growth because they point to structural changes and innovations in production processes. For this reason, most of recent researches¹ have concentrated on investigating the determinants of economic growth not in terms of the accumulation of traditional production factors, capital and labor, but rather in stimulating factor productivity. Several theoretical models and econometric techniques have been applied to explain the growth rate of GDP. Many studies² have recently attempted to explain phenomenon of input productivity, including total factor productivity (TFP) or miscellaneous material productivity (MMP), providing the dominant source of output growth by various methods through production or cost functions.

Even though recent studies³ of the sources of economic growth have become widespread, they largely agree in their properties, empirical applications, and conclusions. Any new growth theories or models must therefore evolve from earlier works. This paper specifically aims to enrich the explanations of economic growth by applying the powerful ARCH-type model with the Cobb-Douglas production function. Chancharoenchai et al. (2008) provide evidence in favor of simple AR model for annual growth of Thai economy, but the accurate model is still inclusive due to the significant rejection of ARCH effect tests while ARCH estimators seem to be spurious. Fang et al. (2007), at the same time, detect significant heteroskedestic process in variance for the output growth in Germany, Italy, the U.K. and the U.S. They also point to an interesting conclusion remark that the structural change in both output growth and its volatility should not be neglected by researchers.

Previous research also widely reports that the productivity trends in economic and unspecified factors of production change over time as the result of development processes such as globalization and technological innovation, making factor input use more productive. That implicit assumption is inherent in the use of the state space modeling technique, one of several applications of the Kalman filter methodology. The unique feature of the Kalman filter methodology is it allows for the presence of unobserved components in an economic model and can therefore be used to reflect business and production process conditions, or the existence of globalization and innovation to the trend of factor productivity. The second objective in this paper is consequently to analyze the stability of parameters of factor determinants as estimated using a state space model.

The remainder of this research is organized as follows. The next section broadly contains the theoretical and empirical background, and the relevant literatures, while the section 3 briefly describes the data characteristics and the aspect of empirical methodologies. The section on empirical findings is divided into two main parts: which are, first part presents summary statistics, and second part explains empirical results. The final section is a brief summary and concluding remarks.

2. Review of Relevant Literature

The revival of interest in growth theory with the development of framework associating growth models had opened new avenues of research and initiated several debates among economists over the sources of growth and growth regression (Romer, (1996), Crespo (2005), Tinakorn and Sussangkarn (1994), Borensztein, Gregorio and Lee (1998), Chancharoenchai et al. (2008), and among others). The major approach is to model the process of growth and to identify and measure its important components. Many researchers have built upon the work of Solow (1957) to widely discuss common problems of sources of output growth rates associated the accumulation of factor inputs and of the growth of total factor productivity.

One may observe an alternative path of analyzing determine of economic growth in form of the updated

neoclassical endogenous growth models Romer (1986) and Lucas (1988) initially introduced an endogenous growth theory that focused on explaining Solow's residual⁴, instead of factor accumulation and total factor productivity (TFP) growth. Their theory generally considered the effects of numerous variables such as human capital, trade, technological change, and the different mechanisms of technological diffusion and absorption capacity. Technology here is considered as an endogenous variable that could spill over from one (typically developed) to another (typically less developed) country through the trade of goods. The findings indicate that the technological innovation and the quality of factors are important explanations of both TFP growth and the absorption capacity of foreign technology.

An alternative school to the neoclassical model accentuates the impact of economic growth upon local economy productivity. According to Grossman and Helpman (1991), the use of imported products incorporates both ideas and foreign R&D. Barro and Sala i Martin (1992) propose that the level of the technology can differ across states or countries. The technical knowledge would also diffuse slowly from one whose technology is more advanced to lower regions. This underlying variation in technology causes variation in both capital and output per worker. Because of the flow of knowledge forms of the technology, if there is free mobility of capital across regions, income per capita will grow faster in the follower(s). This would mean that international trade or multinational corporations may facilitate the diffusion of knowledge.

Because of rising arguments over open trade regimes and rapid expansion in foreign direct investment (FDI) throughout the world economy, the growth repercussions of trade liberalization upon the domestic economy, as a main gateway of global knowledge transmissions, have captured the attention of numerous economists. After opening up to international trade and capital flows, countries could access global knowledge spillover via a number of channels, notably FDI⁵. However, Damijan et al. (2003) and Chanchaoenchai et al. (2008), for instance, failed to find evidence on positive spillover effects of FDI for domestic firms. A development policy of promoting FDI would therefore be indefensible on welfare grounds. Even though there is an enrichment of this area of interest, the results are still ambiguous with various approaches⁶.

A third light of argument, Keller (1996), and López-Acevedo (2002) has proposed a relationship between technology and skill demand. Their empirical results suggest that demand for highly skilled workers increases after the adoption of technology; and that complementary investments in works' training may help realizing the productivity potential of technology. This would mean that technology adoption could lead an economic growth only if workers had adequately technological absorbing capacity. This third school thus highlighted the importance of efficiency as a source of variation in TFP other than technological progress. Incorporating the education or skill level of labor into a theory of development to explore its contribution to economic growth becomes worthwhile. Moreover, the new growth theory purposes a stock of knowledge as another contributor to economic growth. Generally, the stock of knowledge is proxied by R&D investment or payment. Addison (2003) modeled the growth in a common (Cobb-Douglas) production function to estimate TFP of 29 countries (13 rich and 16 poor) on the assumption that all countries in the sample had the same production function. This paper also attempts to test whether TFP, production growth less of labor and capital growth, was a function of growth in product variety and R&D employment.

In addition, it is also possible that some portion of the inflation rate will be anticipated by economic agents and capital markets. A higher degree of price volatility increases to the uncertainty of inflation which, in turn, increases uncertainty about the future of risky investments and wealth creation. Shen (1998) points out that, changes in the size of the risk premium, which reflect perceived inflation uncertainty, can reveal to monetary policymakers how credible their policy actions are in the marketplace. Shen also finds in the case of UK monetary policy that the introduction of inflation targeting does not immediately reduce inflation uncertainty in the marketplace; a finding consistent with the general view that inflation targeting takes time to gain credibility with the public. The present study will therefore reveal the size of the cost of this uncertainty and the credibility of policymakers in the marketplace as a proxy for

macroeconomic stability.

Given the inclusiveness of empirical research on various issues related to the behavior of economic growth, many areas of study remain fertile for further research. The conflicting results on the exact relationship among the economic growth rate, the main production inputs, and other macroeconomic variables are worth exploring first. The present research will model three main inputs, the quality of those inputs, macroeconomic stability and other macroeconomic factors to explain the growth rate of output in the Thai economy over the period 1979 to 2007. An autoregressive conditional heteroskedasticity model (ARCH) will be used to successfully capture time variant in factor productivity or to allow TFP to change through time. However, this estimated technique can well be employed only if output growth performs heteroskedastic process in its second moment. Otherwise, the least square estimation would be an alternative method to estimate output growth.

The traditional ARCH method was originally proposed by Engle (1982) to allow a conventional regression specification for the mean function with a variance permitted to change stochastically over a particular sample period. The ARCH was generalized by Bollerslev (1986) into the so-called GARCH by introducing the lagged value of conditional variances into its own function. Engle et al. (1987) further extended the GARCH model by allowing the conditional mean to be a formulation of the conditional variance⁷. The use of ARCH-family models to analyze time-varying volatility in financial data series has become so widespread that there currently exists a large body of literature documenting their properties and empirical applications⁸ but not so far in economic growth. It is therefore worthwhile to contribute to previous investigations of economic growth by employing an ARCH-family model.

Accordingly, Chancharoenchai et al. (2008) find that the simple AR(1) specification is more proper than AR(1)-GARCH(1,1) specification for economic growth over the sample period 1979-2005 in Thailand because of the less robustness and spuriousness of predictive power. However, the white tests still detects the heteroskedastic process in growth of Thai economy and model incorporated ARCH improves value of log likelihood function. With this reason, the ARCH feature should not be neglected and be re-justified. They also obtained the uncertainty of inflation series by forecasting inflation through the ARCH-type models. The traditional ARCH method is originally proposed by Engle (1983), which allows a conventional regression specification for the mean function, with a variance permitted to change stochastically over the particular sample period. The conditional variance of inflation from the ARCH-type methods is reasonably adopted as a proxy for inflation uncertainty in this study. Using the ARCH-type technique the conditional mean (output growth) and variance (unobserved portion) can be estimated jointly using conventionally specified models for economic variables.

Additionally, the efficiency of production factors is also explored in this study using time-varying parameter regression. The unique power of the Kalman filter methodology is that it allows for the presence of unobserved components in an economic model, and can therefore be used to reflect business conditions, or the existence of fads and their influence on the economic growth process. Anderson and Moore (1971) give the comprehensive exposition of the Kalman filter method. Richards (2000) and Crespo (2005) examine characteristic of unobserved components in the time series of total factor productivity and estimate changes in the efficiency of explanatory variables. The estimation is conducted by the simplest approach, state space model, with the state of the system representing the various unobserved components⁹. Consequently, the last objective in this paper is to investigate the time-varying coefficients regarding to growth of output using the state space model.

3. Methodologies of Analysis

3.1 Data description

The data set in this study consists of annually figures for all series data from 1977 to 2007 used in this study.

Because the main output data and input factors are from the national income account, which is revised based on 1988 prices and the new series starts to release at 1970, the data cannot go back further in order to avoid the inconsistent data. Another important reason of choosing the starting period at the late 1970 regards to the availability of the labor force data. From the available labor data, this study is therefore started at the year 1977. The annual output (GDP) and capital stock (K) data are taken from National Economic and Social Development of Thailand, which are denominated in real term or at a constant price. The agricultural use of land (N) and labor data are obtained from Office of Agricultural Economics and National Statistics Office of Thailand, respectively. Numbers of labor in industrial and agricultural sector using to calculate the ratio of industrial labor and agricultural labor (RL) as proxy of human capital or labor quality are come from National Statistics Office. Domestic R&D funds (R&D), a main source of knowledge accumulation, captures the innovative and absorptive capacity of economy and is gathered from Bureau of the Budget Thailand. Import of capital goods (IMC) and foreign direct investment (FDI) are used to represent the technological diffusion in the direct and indirect channel, which are gathered from Ministry of Commerce Thailand and Bank of Thailand, respectively. Finally, the Thai Government Bond as interest rate (INT) is proxied for the monetary policy or examined the impact of actions by the national central bank and the banking system.

In order to examine the impact of macroeconomic instability by the cost of inflation uncertainty and the credibility of policymakers in the marketplace, the uncertainty of inflation series data as a proxy of this instability is obtained from the forecast of inflation through the ARCH-type models. It is briefly explained in the following section. The inflation rate (INF) is measured by the percentage change in the consumer price index (CPI) which is taken from National Economic and Social Development of Thailand. While the narrow money supply (M1), used to represent the money supply, and the Thai Government Bond are drawn from the International Financial Statistic (IFS).

3.2 Empirical methodologies of analysis

3.2.1 ARMA and ARCH-type models

Production Function:

For simplifying, the Cobb-Douglas form is the most widely used form of production function because it provides a relatively accurate description of the economy and is very easy to work with algebraically. This study therefore assumes a Cobb-Douglas production function. In order to account for factors that determine economic productivity, the standard Cobb-Douglas equation of production function must be taken into logarithmic linear form.

Before estimating the impact of conditional variance of annual output, h_t , the mean equation for output data series must first be specified in either way, naïve or ARMA specification. If an output series does not appear to be serially correlated with the errors, the naïve no change mean equation is employed as

$$LY_t = \phi + e_t \quad (2)$$

Other ways, if the output exhibit a serial correlation, an ARMA(m,n) specification is then employed as a mean equation:

$$LY_t = \phi + \sum_{i=1}^m \alpha_i LY_{t-i} + \sum_{i=1}^n \beta_i e_{t-i} + e_t \quad (3)$$

where ϕ , α and β are the parameters to be estimated where errors e_t are not autocorrelated with zero mean. Even thought errors e are serially uncorrelated with zero mean, they are not necessarily homoskedastic process or white noise process (inconstant variance h_t). Using ordinary least square specify the most appropriate specification (naïve or ARMA) of the production function in order to obtain the squares of the fitted error. The testing for possible existence of no conditional heteroskedasticity is then constructed by regressing the squared residuals on their constant past lags:

$$e_t^2 = \gamma_0 + \sum_{i=1}^k \gamma_i e_{t-i}^2 \tag{4}$$

and the procedure to derive test statistics for γ parameters under the null hypothesis of no conditional heteroskedasticity is all γ parameters indifferent from zero; $H_0 = \gamma_1 = \gamma_2 = \dots = \gamma_k = 0$. The test statistics for such a hypothesis are *F*-test and Lagrange multiplier test statistic (nR^2) with an asymptotic χ^2 distribution. If there are no ARCH or GARCH effects, all γ parameters should be zero, and, hence, the traditional least squared is said to be more proper. If at least one of the estimated coefficients from Equation (4) is significantly different from zero, the ARCH error process is then assumed. In other word, the unspecified portion of output growth exhibits time variant that can well be captured by ARCH-family in which of circumvent the use of two-step estimators.

A brief review of the ARCH-family, for example, The GARCH models take the higher-order moving average term into the conditional variance that is introduced by Bollerslev (1986). It is the generalized ARCH model or the GARCH errors. The GARCH(p,q) specification defines the conditional variance of annual output to be of the form:

$$h_t = a_0 + \sum_{i=1}^q a_i e_{t-i}^2 + \sum_{i=1}^p b_i h_{t-i} \quad \text{where } a_i, b_i \geq 0 \tag{5}$$

and a and b are parameters to be estimated. For $p=0$, Equation (5) becomes the ARCH(q) process as developed by Engle (1982), and for $p=q=0$ the variance of annual output is nothing but a white noise process with zero mean and constant variance. The output is then well estimated by ordinary least square model.

To address the predictability of potential factors of Thai economy, as describe earlier, are included into the basic Cobb-Douglas equation. If an output series exhibits significantly serial autocorrelation, an ARMA(m,n) specification is adopted as a mean equation for output growth series. The estimating equation can be rewritten as following:

$$\text{Ln}Y_t = \phi + \sum_{i=1}^m \alpha_i Y_{t-i} + \beta_K \text{Ln}K_t + \beta_L \text{Ln}L_t + \beta_N \text{Ln}N_t + \sum_{i=0}^T \beta_D D_{t-i} + \sum_{i=1}^n \delta_i e_{t-i} + e_t \tag{6}$$

Letting $\text{Ln}Y_t$, $\text{Ln}K_t$, $\text{Ln}L_t$, and $\text{Ln}N_t$ denote the logarithms of the annual gross domestic product, capital stock, labor and land, respectively. D_t is a vector that contains the relevant variables of six economic factors that are also in the logarithmic form, include: (i) RL, ratio of industrial labor and agricultural labor, (ii) R&D, domestic R&D funds, (iii) INT, Thai Government Bond, (iv) UINF, inflation uncertainty, (v) IMC, import of capital goods, and (vi) FDI, foreign direct investment. The ϕ , β_K , β_L , β_N and β_D are parameters to be estimated. The estimated parameters theoretically measure the elasticity of output with respect to considered factors of production, which, in turn, indicate the productivity of respective factors. It must note that the testing for possible existence of heteroskedasticity of error, obtained from Equation (6) must also be constructed in the same procedure as disused above. If it is detected an ARCH effect, the conditional variance equation is then applied as in the form Equation (5).

Inflation Rate:

According to Ouellette and Paquet (1999) and among other, the ARCH-type model is adopted to estimate the conditional expected inflation rate underlying the time-varying conditional variance of the Thai inflation using the time series data¹⁰. The main reason of regressing is to obtain the series of inflation uncertainty data. The conditional mean equation is formulated as

$$\Pi = \Pi_t^e + \varepsilon_t \tag{7}$$

$$\Pi_t^e = E(\Pi_t | \Omega_{t-1}) = Z_t' \omega, \tag{8}$$

where Π_t is the inflation rate and Π_t^e is the expected inflation rate. The ε_t is the error terms or unexpected inflation rate component and Z_{t-1} is the information available to economic agents at time $t-1$, which is a subset of Ω_{t-1} , i.e. $Z_{t-1} \in \Omega_{t-1}$. Additionally, the error terms ε_t are serially uncorrelated with the zero mean, but they are not necessarily featured as homoskedastic, i.e. $\varepsilon_t \sim N(0, h_t)$. Letting Z_t is a vector that contains the local macroeconomic variables, namely the narrow money supply (M1), the Thai Government Bond (INT), the gross domestic product of Thailand, GDP, and the lagged inflation rate, they will be examined to carry out various specification tests for the ARCH-type model of the inflation rate. With Equation (7) and (8) the conditional mean equation can be rewritten as

$$\Pi = \omega + \sum_{i=1}^T \omega_i Z_{t-i} + \varepsilon_t \quad (9)$$

Since the investigation on annual inflation rate are employed the same methodology as the output, which is fully described above, the empirical regression of conditional variance on inflation rate is not discussed in this part. It is must be noted that this conditional variance h_t as shown in Equation (5) is taken as a proxy for inflation uncertainty. If estimated residuals obtained from regressing inflation, Equation (9), exhibit a white noise process, the inflation uncertainty is nothing but its unexplained portion or ε_t term.

3.2.2 State space models

However, there is one important restriction that remains: the effect of economic growth determinants, that presence the efficiency of factors, are held constant. With this restriction, the estimators could possibly bias the effect of explanatory factors to be either over or under valuation. Capturing the serial effect of estimators, the state space modeling technique can thus be employed in one of two ways. This model provides a flexible approach to time series analysis, especially for simplifying likelihood estimation and accounting missing values. Unfortunately, because of a limitatin of observation number, each of coefficient of economic growth determinants could be solely applied as a state coefficient, while others are assumed to be constant overtime. To express the time-vrying parameter regression, capital stock, for example in this case, is assumed to exhibit time variant process. The production function as early shown in Equation (6) with ARMA(m, n) specification with a random walk process of β_{K_t} can be then formulated as the following system of equations:

$$\text{Ln}Y_t = \phi + \sum_{i=1}^m \alpha_i Y_{t-i} + \beta_K \text{Ln}K_t + \beta_L \text{Ln}L_t + \beta_N \text{Ln}N_t + \sum_{i=0}^T \beta_D D_{t-i} + \sum_{i=1}^n \delta_i \varepsilon_{t-i} + \varepsilon_t \quad (10)$$

$$\beta_{K_t} = \beta_{K(t-1)} + \eta_t \quad (11)$$

where the efficiency of the capital stock, β_{K_t} , is assumed to follow a random walk process as shown in Equation (11), suggesting that the shocks to the random coefficient, say β_{K_t} , persist indefinitely. Notably, this dynamic system of state space model form is treated the capital stock (K_t) as a state variable.

Alternatively, one can allow β_{K_t} to follow an AR(1) process with a constant mean. The shocks to the random coefficient, say β_{K_t} , in this process have some persistence, but the coefficients eventually return to mean. Letting c be a mean coefficient and α be a slope coefficient, the estimating regression is as follow:

$$\text{Ln}Y_t = \phi + \sum_{i=1}^m \alpha_i Y_{t-i} + (\beta_{K_t} + c) \text{Ln}K_t + \beta_L \text{Ln}L_t + \beta_N \text{Ln}N_t + \sum_{i=0}^T \beta_D D_{t-i} + \sum_{i=1}^n \delta_i \varepsilon_{t-i} + \varepsilon_t \quad (12)$$

$$\beta_{K_t} = c + \alpha \beta_{K(t-1)} + \eta_t \quad (13)$$

The observation equation consequently has a fixed constant and a time-varying slope coefficient of that state variable K_t in AR(1) process (Equation (12) and (13)). To allow for time variation in coefficient β_{K_t} model in the form of Equation (10) and (12) are thus applied into a state space model¹¹ in this study. Because the production is a logarithmic linear procedure, the state space model is then specified as logarithmic linear. The time-varying parameter model converges to the fixed-parameter model, if the variance of the state variable β_{K_t} , in this example, becomes insignificantly small. As of the β_{K_t} measures the increment of the efficiency per unit of accusation of input factors, the production function is said to has an increasing return to scale.

4. Results of the Study

4.1 Summary statistics

Summary statistics for the annual output or gross domestic product, GDP, of Thailand and its change, GGDP over the sample period (1979 to 2007) are given in Table 1. The starting with G indicates the variable that is expressed in logarithmic first difference form or the growth data series. The growth expression can cause the higher number of those statistics. The value of mean and standard deviations indicate that GGDP data series exhibits higher volatile than GDP series throughout sample period. This is reassured by the leptokurtosis relative to the normal distribution. The value of skewness of GGDP shows that the distribution is negatively skewed relative to the normal distribution. This negative value of skewness reveals that Thai economy had not so outstanding performance in the past three decades. Moreover, the Jarque-Bera test of normal distribution shows a rejection at the conventional level. The reason for this rejection with a negative skewed and leptokurtotic distribution could potentially be the consequence of unknown and irregular shocks into the Thai economy, especially a big panic during the mid-1997 financial crisis in Thailand, which increases the degree of market's uncertainty or loss of its confidence and, in turn, sharply slows down their activities in economic system.

Table 1: Preliminary statistic for the annual output (GDP)

Statistics:	Level Form (GDP)	Percentage Change Form (GGDP)
# of obs.	30	30
Max.	8.35	12.48
Min.	6.72	-11.10
Mean	7.61	5.75
S.D.	0.53	4.23
Skew.	-0.33	-2.06
Kur.	1.64	9.79
JB	0.24	78.72 ^a
Q(1)	27.32 ^a	9.35 ^a
Q(2)	49.96 ^a	10.43 ^a

Notes: Annual GDP is the logarithmic form of gross domestic production of Thailand and GGDP is the first different form of the GDP, $GGDP = \log(GDP_t/GDP_{t-1})$.

JB is standard Jarque-Bera, Q-statistics is Ljung-Box values, S.D. is the standards deviation, skew and kur. are the skewness and kurtosis values, respectively, ^a statistically significant at 1% level, ^b statistically significant at 5% level, and ^c statistically significant at 10% level.

The Ljung-Box statistics $Q(k)$ for $k = 1$ and 2 lags are used to test for the autocorrelation in the annual output growth. The null hypothesis of no serial correlation is rejected at the significant level. Intuitively, this higher-order serial correlation behavior is possibly the result of economic regulations and policies, political environment in Thailand, external economic environment and reaction from private sector's decision during sample period. The output of Thai economy is thus necessary to be treated to avoid the spurious problem.

Table 2: ARCH tests for the annual output

Variable	Lags:	1	2	3
GGDP:				
F-Test	AR(1)	8.27 ^a	5.55 ^a	3.57 ^b
nR ²		6.80 ^a	8.61 ^a	8.57 ^b
Q		0.23	1.13	1.17
Q ²		7.71	7.74 ^a	7.79 ^b

Note: See Table 1

The null hypothesis assumes that the coefficients regression from the squared residual on its past values are jointly zero: $\varepsilon_t^2 = \gamma_0 + \sum_{i=1}^p \gamma_i \varepsilon_{t-i}^2$.

The test statistics are F-statistic (F-stat) and Lagrange Multiplier (nR²) test statistic with a number of lags as a degree of freedom.

Q-statistics and Q²-statistics are Ljung-Box values.

To ensure no spurious regression results caused by the unit root, the augmented Dickey-Fuller (ADF) test under the null hypothesis of unit root and the KPSS test under the null hypothesis of a stationary process are applied to each data series. The KPSS test is used lag truncations of 1 and 2. This alternative test is to reaffirm the robustness presented by ADF unit root test. Even though, the unreported values of ADF and KPSS obtain some ambiguous results in two series, land in agricultural usage and capital series, these results are still said to be an evidence of a difference stationary process. All variables employed in the empirical regression should thus be done in the form of logarithmic first differences.

The AR(1) specification clearly and completely captures the problem of serial correlation of original residuals of annual change in GDP, according to values of Ljung-Box statistics, in Table 2, however, they are not necessarily homoskedastic processes. Both F-test and Lagrange multiplier test statistic (nR²) with an asymptotic χ^2 distribution are used to test this hypothesis of ARCH effect. Regardless of which test is used, the null hypothesis of no conditional heteroskedasticity is statistically significantly rejected at conventional levels. This suggests that percentage change in GDP is not characterized as a white noise process or constant variance; thus, the ARCH-type framework is possibly needed in estimating growth of Thai economy.

4.2 The empirical results

Ideally, this investigation estimates the explanatory power of the input factors in Thai economy over 1977 to 2007 sample periods. To make a comparison, the least square models and ARCH estimating specifications are employed. Additionally, those of six potential factors are also incorporated in both estimating frameworks. The computed values of likelihood ratio (LR), log likelihood function (Log(L)), and t-statistic test is used to determine the most parsimonious and descriptively accurate model.

Table 3 provides the testing results of the general models that are used in forecasting its annual growth rate (GGDP) and time-varying variances. The empirical statistics show evidence of the predictive power of some determinants on the Thai GGDP. Regardless of which model is applied, the incorporation of factor inputs appear to considerably improve values of Log(L) and LR tests report the significant predictability of input factors. Consequently, the set of input factors cannot be ignored from estimating growth of Thai economy. As of the Equation C (AR(1) model) and E (AR(1)-ARCH(1) model), they also better explain the deviation from normal distribution for the error terms than the Equation A (AR(1) model) and B (AR(1)-ARCH(1) model) without additional variables, and Equation C (AR(1) model with significant variables). Even though, the pair wise comparison, the AR(1)-ARCH(1) provides better value of Log(L), the ARCH coefficient, a_1 , is statistically insignificant, according to statistic. The AR(1) specification (Equation C) is relatively regarded as appropriate specification to assess the economic growth in Thailand.

The significant first-order serial correlation can be explained by institutional factors, domestic regulations, irrational behavior of market participants, political environment, and so forth. For example, the Thai economy has experienced impressive growth and globalization with low inflation, macroeconomic stability, open economy, strong fiscal positions, saving rates, and thriving export sectors. Then came the financial crisis in July 1997. Since most of the economic activity in Thailand had been supported by the capital inflows was highly productive, the loss of economic activity resulting from the sudden reversal in capital flows has been enormous, which, in turn, force the economy into sharp downturns. Even thought, at the end of 1998, Thai economy shown strong signs of recovery from this crisis as ongoing structural reforms and favorable risk reassessments supported bullish sentiment. The market participants in Thai economy who have experienced the 1997 sudden fallout, still tended to be very much jittery, which leads output to potentially react more strongly to domestic and world issues. This also may reveal a signal extreme booms and busts since that 1997 fallout experience with a series of policy miss-step and economic accidents.

In addition, the computed results of the likelihood ratio test and the t -statistics from Equation C also demonstrate that the growth rate of capital stock, labor, domestic research and development funds, foreign direct investment, import of capital goods, government bond yield, and inflation uncertainty appear to have statistically predictive power for forecasting output growth. Meanwhile, factors used to proxy for quality of labor input, i.e. the ratio of industrial labor to agricultural labor, are statistically insignificant at conventional level.

However, the previous investigations¹² are under the main assumption of fixed-parameter model. With this implicit assumption, value of productivity is possibly spurious. It is then needed to be justified. As is commonly assumed, the simplest methodology to approach the question of time-varying parameter can be found in the state space modeling technique. Repeatedly, each value of estimated parameter of economic growth is allowed to vary through time, while others are assumed to be constant due to small size of observation. If the value of parameter is indeed variation through time, then this typical characteristic can potentially assess the true effect of input factors.

Table 3: The evidence on the predictability of annual growth of output (GGDP) on Thailand using local information variables: OLS and ARCH estimation of the equation for the conditional expectation

Base AR(1): $GGDP_t = \phi + \alpha_1 GGDP_{t-1} + \beta_K LnK_t + \beta_L LnL_t + \beta_N LnN_t + \sum_{i=0}^T \beta_D D_{t-i} + \varepsilon_t$ A

Base AR(1)-ARCH(1): $GGDP_t = \phi + \alpha_1 GGDP_{t-1} + \beta_K LnK_t + \beta_L LnL_t + \beta_N LnN_t + \sum_{i=0}^T \beta_D D_{t-i} + \varepsilon_t$ B.1

$h_t = a_0 + a_1 \varepsilon_{t-1}^2$ B.2

Parameters	Equation A	Equation B	Equation C	Equation D	Equation E
Conditional Mean Equation:					
ϕ	5.57 ^a	2.04 ^b	1.93 ^b	4.15	1.98 ^a
α_1	0.54 ^a	-0.10	-0.17	0.79 ^a	-0.19
GK	-	2.13 ^a	2.09 ^a	-	2.19 ^a
GK{1}	-	-1.59 ^a	-1.55 ^a	-	-1.66 ^a
GL	-	-0.05	-	-	-
GL{1}	-	-0.17	-1.10 ^b	-	-0.06 ^b
GN	-	0.44	-	-	-
GN{1}	-	0.16	-	-	-
GRL	-	-0.80	-	-	-
GRL{1}	-	2.45	-	-	-
GRD	-	0.01	-	-	-
GRD{1}	-	-0.02	-0.01 ^b	-	-0.01 ^c
GFDI	-	0.01	0.01 ^c	-	0.01 ^b
GFDI{1}	-	0.00	-	-	-
GIMC	-	0.00	-	-	-
GIMC{1}	-	0.06 ^c	0.07 ^a	-	0.06 ^a
GINT	-	-0.48	-0.44 ^b	-	-0.41 ^a
GINT{1}	-	-0.52	-0.61 ^a	-	-0.65 ^a
UINF	-	-1.44 ^a	-1.30 ^a	-	-1.17 ^a
UINF{1}	-	0.77	-	-	-
Conditional Variance Equation:					
a_0	-	-	-	1.56	0.15
a_1	-	-	-	1.34 ^b	0.75
# of obs.	30	28	29	30	29
Log(L)	-79.13	-25.81	-30.81	-67.89	-29.57
Skew.	-1.47	-0.64	0.07	-0.50	-0.06
Kur.	8.02	3.20	2.51	3.47	2.00
JB	42.30 ^a	1.93	0.32	1.54	1.24
nR ² (1)	8.27 ^a	1.12	0.02	0.04	0.06
nR ² (2)	6.80 ^a	1.33	0.02	0.38	0.13
LR(9)	-	-	93.56 ^a	-	71.55 ^a
LR(18)	-	98.68 ^a	-	-	-

Notes: nR² is Lagrange multiplier test statistics. LR is likelihood ratio test between models with and without incorporating other economic variables, Log(L) = log function likelihood, and the numbers in the bracket are the t-statistics.

The brief of empirical findings for the state space procedure are reported in Table 4. The value of those parameters for Thai production are assumed to specify not only a random walk process, but also an AR(1) (first-order autoregressive) and constant mean process for the volatile features of β .

Table 4: Estimates from the state space model

State Variables:	State Space procedure	Wald Test	Final β_t	SSR	Log(L)
GK _t	AR(1) and constant	9505.17 ^a	1.13	3.11	-10.05
GK _{t-1}	Random Walk	0.11	-0.89	3.21 ⁻¹³	-34.34
GL _{t-1}	AR(1) and constant	93.73 ^a	4.72	6.52 ⁻⁹	-4.39
GRD _{t-1}	Random Walk	0.01	-0.02	0.02	-17.68
GFDI _t	Random Walk	0.89	0.02	0.28	-23.69
GIMC _{t-1}	AR(1) and constant	4.11 ^b	0.06	0.04	-16.22
GINT _t	Random Walk	0.03	0.10	2.35	-15.30
GINT _{t-1}	Random Walk	1.03	-0.99	3.52	-13.77
UINF _{t-1}	AR(1) and constant	6.62	0.46	6.40 ⁻⁸	-4.70

Notes: SSR is sum of the squared residuals. Wald is the Wald test statistic to test the joint hypothesis with an asymptotic χ^2 distribution. Wald(1) test for the jointly significant effects of AR(1).

The measurement (observation) equation and the transition (state) equation are restricted to be diagonal, which assumes the error terms are contemporaneously correlated.

The favorableness of the Wald(1) test statistic under the null hypothesis of $\alpha=0$, confirms the t-statistic results that the time-varying value of estimated input parameters affecting growth in the Thai economy are better characterized by the AR(1) and constant means specification in GK_t, GL_(t-1), GIMC_(t-1), and UINF_t. This significance suggests that the slope (efficiency) of those four state variables can be categorized into two components; mean and time-varying terms. Hence, any shocks to those of coefficients have some persistence, but they eventually lie down and return to mean level at c in Equation (13). Meanwhile, the elasticity values of GK_(t-1), GRD_(t-1), GFDI_t, GINT_t, and GINT_(t-1) are empirically found to be best specified by random walk processes. Moreover, the unreported values of the log likelihood function suggest that most parameters of factors affecting GDP growth in Thailand should potentially have greater fidelity than fixed-parameter estimation.

Table 5: Preliminary statistic for the values of time-varying

Statistics:	GK _t	GK _{t-1}	GL _{t-1}	GRD _{t-1}	GFDI _t	GIMC _{t-1}	GINT _t	GINT _{t-1}	UINF _{t-1}
Max.	1.12	0.50	1.29	0.06	0.08	0.20	0.10	-0.52	0.86
Min.	0.86	-1.34	-2.59	-0.08	-0.06	-0.09	-1.04	-0.99	-1.33
Mean	0.99	-0.51	-0.09	-0.01	0.00	0.03	-0.48	-0.70	-0.13
S.D.	0.08	0.45	0.73	0.04	0.04	0.08	0.31	0.14	0.60
Skew.	0.11	0.33	-2.19	0.30	0.34	0.51	0.50	-1.27	-0.24
Kur.	-1.20	-0.15	9.01	-0.27	-0.09	-0.45	0.32	0.32	-0.61

Notes: See Table 1

An additional interpretation of the time-varying parameter β , Table 5 gives the statistics of the β_t . The standard deviations in the annual β do not indicate the volatile phenomena of β_t or it exhibits as a homoskedastic process. The β_t moves between minimum of negative values, except GK_t , and maximum of positive values, except $GINT_{(t-1)}$, and puts a negative effect of explanatory factors on economic growth, but GK_t and $GIMC_{(t-1)}$ are positive value. This can potentially be explained by the historical decision of real sectors in keeping their productivity with new technology and physical investment. Pair wise comparison of the mean values of β_t obtained from the state space model against the constant parameter obtained from the fixed-parameter model (as reported in Table 3 in Equation C), report the over-estimated effect or efficiency of the constant parameters. However, $GRD_{(t-1)}$, $GFDI_t$, $GINT_t$, and $GINT_{(t-1)}$ are insignificantly indifferent from constant parameters. Meanwhile, both models appear to have consistent direction of input determinants' effect on output growth.

Regardless of which specification is used to estimate the parameters, the remark upon selected effects of those of additional factors on Thai economy should be first discussed. The positive correlation between economic growth and growth of FDI in Thailand claimed possibility that inward foreign direct investment as a proxy of indirect technological spillover raises the productivity of domestic plants by bring the new knowledge into the host country. This could be the results of concurrent government policies, for instance, proactive investment strategies, and SMEs financial assistant program. However, the empirical estimator is significantly indifferent from zero which could indicate to the utmost capacity of domestic firms and labors, and efforts of government. Again, this investigation result contrasts to Damijan et al. (2003) and among others. They find a strong evidence of negative contribution of FDI to output growth, reflecting the large technology gap between domestic and foreign firms, and the insufficient technological absorptive capacity of advanced technology in domestic firms.

Meanwhile, according to asymptotic t-statistics, the negative significance of labor and R&D together with a failure of human capital (insignificant ratio of industrial labor and agricultural labor) over the last three decades appear to be a surprise outcome because most government of developing countries including Thailand tremendously invests in human capital and their political and economic institutions to foster the diffusion and absorption of foreign technology. Since the human invents the new technology, human is also one to make the best use of it. Hence, the growth of FDI positively generates impact on the Thai output growth that may not be sustainable because of possibility of henceforth inadequacy of absorptive capability. This nature of phenomena is eventually become the major reason of negative social returns to host countries and the FDI could turn out to hurt the welfare ground of host country.

As the import of capital goods as feasible channel to the learning of new technology, its positive significance then provides an important vehicle of international knowledge diffusion. This empirical analysis consists with, for example, Coe and Helpman (1995) in which highlights on such beneficial effects of international R&D via international trade on domestic productivity. Again, this positive transferring channel could be occurred if it can efficiently trigger the domestic innovation of new products, and credibly and compatibly domestic R&D spending to re-innovate on such foreign blueprints with respect to their rights. But, the domestic R&D, on average over three decades, significantly displays negative explanatory power for estimating Thai output which potentially illustrates an unsustainable contribution of imported capital goods to Thai economy¹³.

Turning onto the empirical findings from state space model, Figure 1 graphically plots the annual value of estimated parameters of factor affecting GDP growth rate that obtains from the state space model. They all shed some light upon the evidence supporting the hypothesis that the parameter β tends to change through time. It must be noted that a constraint on annual frequency of GDP growth and limitation of observation size should not be neglected for the further research.

Graphical analysis shows a sharp drop in the 1997 financial crisis in all parameters except the value of change of capital stock and the previous change of number of laborers. This evidence of sharp drop may possibly be the

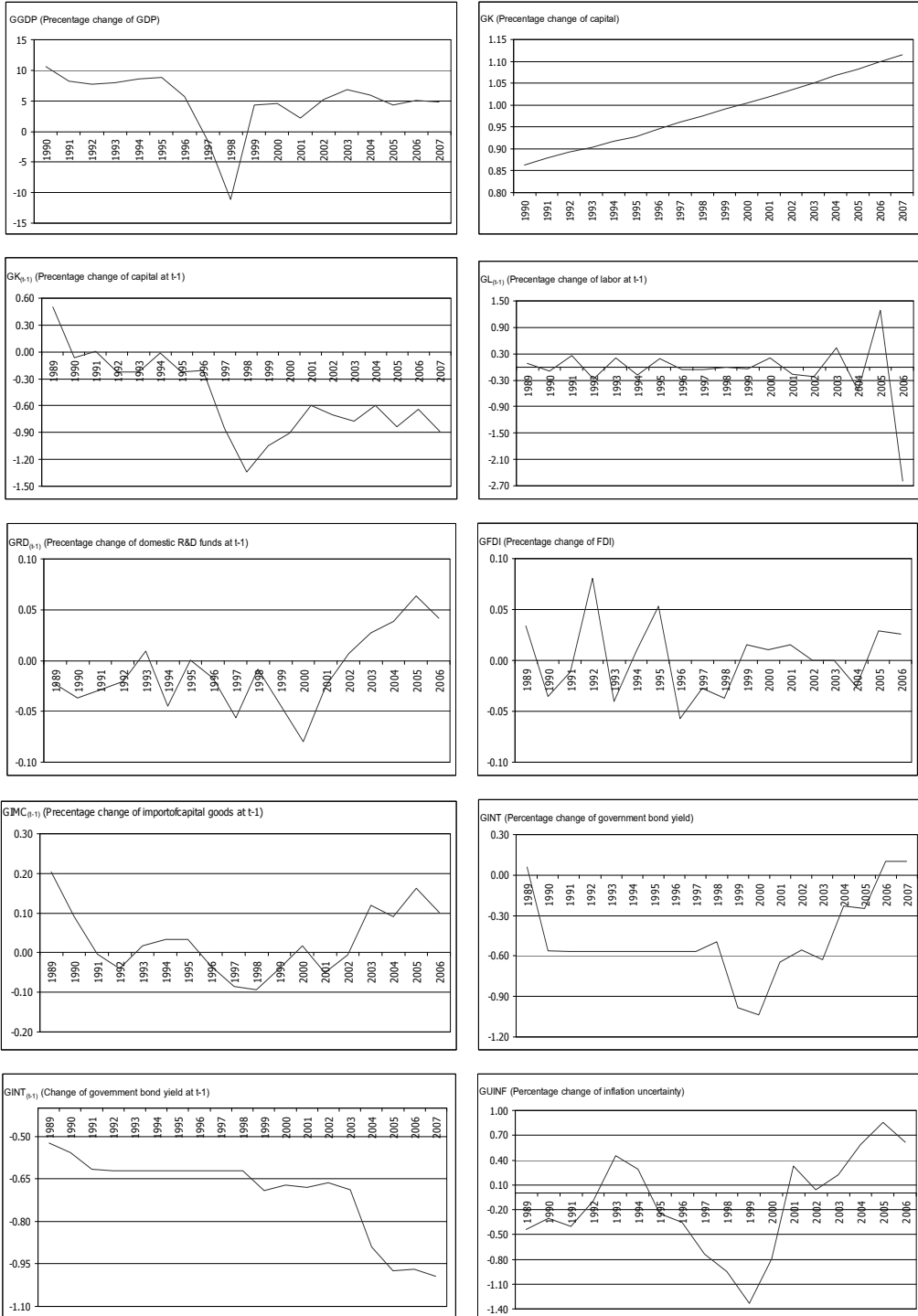


Figure 1: Time-varying Estimated Productivity

result of under capacity utilization in most of Thai firms during the crisis, which dragged the Thai economy into depression which reflect the decreasing return to scale of accumulation input. Fortunately, time varying parameter of R&D demonstrates that the domestic R&D expenditure graphically shows significant improvement of its efficiency as the upturn trend since year 2000. The reason for this reversion can possibly be explained by the serious focus on the property rights and explicit increasing in nonprofit R&D granted by government, which, in turn, create generous use of that new knowledge. Again, knowing the higher efficiency of R&D can possibly reveal to acquisition of human capital and incentives for political and social entrepreneur to organize to bring up capacity of the use of advanced technology. Hence, the empirical evidence, after this reversion occurrence, signals the augmentation of absorptive capability to those technological transfers which, again, also results the overestimated inefficiency in R&D obtained from fixed-parameter regression.

In the case of previous change of labor, its time variant parameters behave highly volatile in most cases as its highest value of kurtosis and skewness. This phenomenon may reflect the rapid reaction of the labor and employee to the cycle of business. This rapidity could create a large change in employee's requirement on qualification of workers and high competitiveness in labor market. Furthermore, the value of skewness shows that the distribution of previous labor efficiency series is negatively skewed, indicating that large negative labor efficiency tends to occur more often than larger positive ones. As can be seen from Figure 1, they have great negative values after the financial crisis event. This could be the results of, since this fallout occurrence, high competitiveness in labor market and labor unemployment.

In further, the upward trend parameters of GK_t over the last three decades in Thai economy provides the strong empirical evidence, not only, that new capital as the new technology has an increasing return to scale, but also, that Thai development process has continually been relied on capital accumulation. However, the capital dynamically seems to have a high depreciation rate as shown by the negative sign of its mean value of GK_{t-1} coefficients in Table 5. In addition, according to its graph in Figure 1, it thus seems that the old machine or $GK_{(t-1)}$ has a down trend of efficiency indicating a decreasing return to scale. Specifically, the decreasing return to scale statistically appears to be stressed after the financial crisis event. Knowing the old machine has higher cost of depreciation and the initial growth depends on the depreciation rate, the replacement of the new machines would then assist economy to reach new growth rate, but only temporally as mentioned by Grabowski and Shields (1996). Thus, this empirical finding could imply that, after the financial crisis, Thai firms may somehow ignore the investment in new capital for the old one as dramatically raising depreciation rate.

The empirical analysis also shows another interesting remark in impact of inflation uncertainty and government bond yield on economic growth of Thailand. There is an evidence from state space model (see Figure 1) indicating that the Thai output growth, before switching monetary framework, demonstrates much less sensitivity on Government bond yield, while significantly reacts after adopting the explicit inflation targeting in middle of year 2000. This behavior commonly reflects the interest rate as the key monetary instrument to signalize the monetary authorities' reaction on actual inflation and economic situation.

Despite of what the estimation technique is employed to forecast the growth of Thai economy, the statistical findings indicate that the uncertainty about inflation is significantly important to economic agents to account for volatility of future cost of investment and returns from investing. In particular, if economic agents believe that the monetary authorities will try to maintain inflation at the suitable level, they probably also believe the probability is high that monetary policymakers will miss their target. The impact of inflation uncertainty can reveal to monetary policymakers how credible their inflation policy actions to stabilize economy are in the marketplace (Shen, 1998). Consequence of empirical evidence, it is unsurprisingly that the inflation target from the middle of 2000 to at the end of 2007 did not gain much of confidence in the market place. As suggested by Shen (1998), public announcements alone

are not very useful. The consistent actions of the monetary authorities in controlling inflation must also be associated to gain their credibility in the marketplace. Further, the new framework of inflation target might be new experience for the market participants at the time of estimation and the consistence of controlling view generally takes time, the introduction of this explicit target did not thus immediately lessen inflation uncertainty and gain trustworthiness with the public.

According to a pair wise comparison, the constant parameter of inflation uncertainty obtained from the fixed-parameter AR(1) model is far greater than the mean value obtained from the state space model, which reflect the over-estimated constant parameter. Inflation uncertainty in time-varying process shows twice turning points of direction from negative to positive assessment power on economic growth at the middle of year 1992 and the first quarter of year 2000. The reason for both reverses can possibly be explained by the consumers' behavior respect to overestimate of future inflation after the fast growing of Thai economy and the increase in oil prices due to the tragic terrorism attack in 2002 and violence in Iraq afterward, respectively. This miss calculation turns out to induce consumers to consume now in order to hedge the loss of purchasing power and leads to increase in output. It must also mention that the failure of inflation targeting, captured by empirical analysis, might partly be caused by the shock of oil price.

Finally, the construct a time series for expected inflation to estimate for the variance of unexpected inflation, as discussed previously, should be noted. The residuals that obtain form the inflation estimation is accounted as inflationary uncertainty. The first step consists of regressing the observed inflation rates on the set of instruments up to 1 lag. Because the inflation rate series are not featured as heteroscedasticity according to the results of ARCH tests, the traditional specification is then more accurate to estimate the rate of inflation. To economize the space, several diagnostic tests for model adequacy are not reported and discussed in detail here. According to various statistic tests are significantly in favor to the ARMA(2,1) specification incorporating with previous money supply and interest rate. Because inflation is in the first difference form of logarithm of consumer price index, inflation uncertainty is, thus, also in logarithmic data series form.

5. Conclusions

The purposes of this empirical investigation have been to detect empirical explanation of phenomenon of Thai economy and its production inputs' efficiency under the developing procession. The notion of estimated parameters of input factors in production function used is technically the elasticity or efficiency, which was estimated through the econometric estimation of Cobb-Douglas production function in Thai economy during 1977-2007. A Cobb-Douglas specification includes three basic inputs, as well as additional determinant factors to explain economic growth of Thailand.

According to the various tests of statistics, AR(1) is more proper than traditional specification AR(1)-ARCH(1). A significant AR coefficient demonstrates the martingale process that suggests a long memory in any change in the annual gross domestic output to react to economic shocks at least for a one lag period of time.

Another aspect of this interpretation is to argue against the traditional belief in the way that the estimated productivity of production input indeed varies through time. The state space model is used to define the volatile feature of value of elasticity, β , whereas the production is still estimated by an AR(1) specification with inclusion of statistically significant factors of input production. The estimation findings suggest that the value of estimated β , of in each production factor, GK_t , $GL_{(t-1)}$, $GIMC_{(t-1)}$, and $UINF_t$, is better processed as AR(1) and constant mean specification, but each of estimated coefficient of $GK_{(t-1)}$, $GRD_{(t-1)}$, $GFDI_t$, $GINT_t$, and $GINT_{(t-1)}$ is better specified a random walk. Comparing the unreported estimated parameters of the state space model to the fixed-parameter model shows a number of interesting results of the over- and under-estimated value of parameters, so-called efficiency, but most cases obtain

the same effect direction. They also shed some light that efficiency of those predictive input factors is highly sensitive to the sharp fallout in the 1997 financial crisis.

Regardless of which estimation model is used to estimate the effect of those determinants on Thai output growth, the empirical analysis consistently provides some important remark conclusions. First, for the last three decades, development process of Thai economy has continually depended on capital with an increasing return to scale. However, it statistically demonstrates high depreciation rate and seems to be sharply increased after the crisis event because of possibility of firms' neglectful replacement of old machines. The Thai government should pay more attention on capital accumulation together with its utilization. Thus, the proactive monetary measures, for instance, long-term with special rate of interest loans for investment on physical capital, should be provided for business especially during recession state of economy.

Secondly, import of capital goods and FDI are significantly important vehicles of international knowledge spillovers from developed nations to developing countries, at least to Thailand, due to possibility of domestic investment enchantment. However, the statistical findings averagely provide a surprise failure of tremendous investment in human capital and negative significance of labor and domestic R&D funds over the last three decades. Consequently, the sustainable contribution of FDI and imports of capital on economic growth in Thailand is still doubted. Hence, enhancement of investment programs in upgrading absorptive capability must be seriously focused together with promoting FDI and increasing in imported capital in order to achieve the welfare ground improvement. Fortunately, domestic R&D expenditure shows some augmentation of its efficiency since year 2000.

Regardless of which estimation is employed, the framework of inflation targeting has not gain credibility to monetary policymakers in the marketplace. This unsuccessful new framework could generally be the reasons of new experience and long process of consistent controlling inflation view for market participants, and unexpected shock of oil price. Another remarkable finding is that time-varying parameter method provides evidence of two reversal direction of inflation uncertainty on economic growth from negative to positive effect. This could be the result of rapid growing rate and oil price shock which lead to uncertain in high future inflation. Market participants would decide to consume at this period in order to avoid the possibility of loss of purchasing power. This overestimation of inflation would ultimately influence economic expansion.

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Endnote

- ¹ See, for example, Barro and Sala i Martin (1992), Keller (1996), Borensztein et al. (1998), and López-Acevedo (2002) for a farmwork incorporating technological diffusion, human capital stock and knowledge, and economic uncertainty to explain output growth.
- ² To investigate the economic growth behavior and its determinations, the comprehensive extension of the factors and various approaches, capturing unobserved sources of growth, have been flowed incessantly to remodified growth model and identified proper specification for decades. See, for example, Tinakorn and Sussangkarn (1994), Maudos et al. (1999), Richards (2000), and Crespo (2005), and references therein.
- ³ Most of previous studies are likely to agree that unspecified inputs (for instance, human capital, technological level, government policies, and economic uncertainty) have significantly contributed to output. Certainly, those determinants are the plausible reason that more output can be produced today from a given quantity of capital, labor and land than could be produced in the

past. They are thus better treated as its growth rather than it is taken as given. The methodology approaches are used in both non-parametric and parametric modeling techniques to examine and decompose those determinants' effect on output. Extensive framework of this research area is to presence time-varying efficiency by using time-varying parameter regression in order to assure the true effect of deterrent factors. The previous study results are favor time-varying effect out of fixed effect. (See, Tinakorn and Sussangkarn (1994), Borensztein et al. (1998), Richards (2000), López-Acevedo (2002), Crespo (2005), and references therein for comprehensive exposition of investigating framework).

- ⁴ By applying growth accounting framework with the restrict changes in the neoclassical production function to Hicks-neutral change, Solow (1957) decomposes the rate of growth of aggregate demand into two main components; factor accumulation and a residual. This residual or the remaining term after decomposing growth of output per worker is commonly described as an estimate of Solow residual or Total Factor Productivity (TFP) that reflects the technical progress and other elements.
- ⁵ Borensztein et al. (1998), for example, find that the FDI is an important channel of technology transfer and more productive than domestic investment, but higher efficiency of FDI would be occurred only if the host country has a sufficient absorptive capability of those advanced technology transferred from foreign country and has less of interference on the role of FDI.
- ⁶ See Barro and Sala i Martin (1992), Keller (1996), Borensztein et al. (1998), López-Acevedo (2002), and among others for extensive framework associating technology diffusion's effect on economic growth.
- ⁷ The extensive GARCH model is known as GARCH in mean (GARCH-M), developed by Engle et al. (1987).
- ⁸ The comprehensive details for applying ARCH-family to analyze financial data have been stressed in previous researches, for example, Chancharoenchai et al. (2005), and Gao et al. (2008).
- ⁹ Harvey (1989) originates evidence on the stock market indicating that the risk factor varies through time and that the world of covariance risk is not constant. Harvey addresses this problem by introducing a state space model into the GARCH-M procedure and estimating them simultaneously.
- ¹⁰ See Engle (1983) and Coimano (1988) for a more extensive survey.
- ¹¹ See Harvey (1989) for extensive details of state space model.
- ¹² See, for example, Barro and Sala i Martin (1992), Tinakorn and Sussangkarn (1994), Keller (1996), and references therein.
- ¹³ Grabowski and Shields (1996) have broadly discussed the framework of technological adoption associated with knowledge accumulation human capital in the economic development. The lack of access to advanced technologies is not only a final answer to growth promotion, but also the lack of ability to use those technologies. The dynamic problem of technical and technological adoption then cannot be separated justified to analyze the suitable choice of technology. Therefore, capital may not be easily shifted between technologies.

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