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The Determinants of TFP Growth in Middle Income Economies in ASEAN: Implication of Financial Crises

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Abstract

Maintaining a sustained level of productivity growth is an important aspect of the economic development process, particularly in periods of economic turbulence. This paper examines the determinants of total factor productivity (*TFP*) growth and their behavior in five middle-income ASEAN countries during events such as the Asian Contagion and the Global Financial Crisis. In particular, this paper examines the effects on *TFP* of foreign direct investment (*FDI*), trade, the agricultural sector, government spending, human capital, and dummy variables representing the financial crises. The results show that trade, government spending, the scale of the agricultural sector, and the dummy variables have significantly influenced productivity growth. Government spending affects it positively, and the scale of the agricultural sector and the dummy variables representing the Asian Contagion influence it negatively. These empirical findings support the popular belief that trade significantly influences *TFP* growth, but the trend is not consistent with expectations. Despite strongly supportive theoretical arguments, this study does not find the human capital and *FDI* variables to be significant. Notably, there is no evidence to suggest that the Global Financial Crisis has had a significant influence when compared with the Asian Contagion.

Key words: total factor productivity; economic growth; financial crises

JEL classification: C23; G01; O47

1. Introduction

One of the main objectives of economic growth in developing countries is to increase social welfare through reducing unemployment. The sustainability of economic growth is crucial in the context of environmental protection and

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conservation, social equality, intergenerational equity, and cultural reserve, including religious conformity. Economists have examined the issue of economic growth starting with the 14th century (Weiss, 1995). However, the development of the theory of economic growth is attributed to Solow (1956) with the introduction of his exogenous growth model. This theory postulated that economic growth could be achieved by the combination of the accumulation of production input factors (such as labor, capital, and land) and an increase in total factor productivity (TFP). Since then, TFP has received a great deal of attention from economists.

Although some remarkable advances have been made by theorists, including Paul Romer, Robert E. Lucas and Robert J. Barro, in attempts to establish a new endogenous growth theory by adding several predictor variables, such as human capital and technological change, these fail to identify the overall determinants of TFP growth. This may be because TFP determinants vary with the economic, geographical, and political conditions of countries and regions. In general, it is accepted that TFP growth determinants are similar in countries with similar socioeconomic conditions. The aim of this paper is to identify the determinants that influence the TFP of some middle-income countries in the Association of Southeast Asian Nations (ASEAN) region.

Despite some differences between ASEAN economies in cultural, social, political, and religious beliefs, there are common features in the process of moving towards economic growth. The last two decades saw an increase in economic activity in five middle-income economies in the ASEAN region, namely Indonesia, the Philippines, Malaysia, Thailand, and Vietnam. The lessons from the financial crisis in the late 1990s helped these countries transform their economies by focusing on industrialization and service sector developments. These countries recorded an average annual growth rate in real GDP of 5.8% over the 1990–2008 periods. Also, their annualized average growth rate has remained steady. Vietnam was the fastest growing country with an annualized average growth rate of 7.4%, followed by Malaysia with 6.3%, Thailand and Indonesia with 4.9% each, and the Philippines with 3.8%.

Although there is considerable controversy over the effect of TFP on recent ASEAN economic growth, its influence on long-term economic growth is widely accepted (Solow, 1956; Arrow, 1962; Romer, 1986; Lucas, 1988). Nevertheless, Prescott (1998) argued that neoclassical theory is not appropriate for explaining economic development because it has failed to explain the reasons for large differences in the pattern of development around the world. Prescott (1998) suggested a two-sector model to solve the problem of falling prices of durable goods, and recommended the use of variables for capital at steady state in lieu of capital stock that is not measured accurately. However, in the case of fast growing economies, such as ASEAN countries, this method may not be appropriate, as their current status is far removed from a steady state.

This paper is set out as follows. In Section 2 the literature on TFP and its influence on economic growth is reviewed, with a particular focus on the literature covering the determinants of TFP. Section 3 offers a background to the TFP

growth estimation process, with a particular focus on the selection of labor and capital determinants, and the *TFP* growth parameters such as trade, agriculture, government, foreign direct investment, and human resources, and the techniques adopted in measuring them. Section 4 presents the results for *TFP* growth determinants of the economies identified in the study. The final section summarizes this paper and implications of the results.

2. Literature Review

Lipsey and Carlaw (2000) pointed out that *TFP* clearly means different things to different observers. Subsequently, they revised the concepts related to *TFP* and highlighted the difference between *TFP* and technological change. Following this, they argued that low *TFP* figures for the Asian Tigers do not mean they are in the same league as communist Russia, and that the numbers are quite compatible with successful technology-enhancing policies and technological transformation of a country through domestically generated or imported capital. Further, Durlauf and Quah (1999) showed that the choice of variables is often different for each empirical study. Durlauf and Quah (1999) surveyed the empirical growth literature and identified over 90 potential growth determinants. Schultz (1998) examined the determinants and variables, and their measurement, and noted that macroeconomic studies of growth often seek to explain differences in economic growth rates between countries in terms of education and health, among other variables. However, the estimates were plagued by measurement errors and specification problems. Brock and Durlauf (2001) further suggested that it is necessary to categorize a relatively homogeneous group of countries. This method is useful because it enables inferences about all members of the group to be made and, on the other hand, the panel data allow for regression models to have more degrees of freedom.

Most empirical researches on growth were based on between-country regression models (Barro, 1991; Mankiw et al., 1992) using either levels or rate of change variables. Tsu-Tan Fu deployed a trans-log function form to consider the possible effects of technological change and time trend variables to estimate the production technology of Taiwan, while Hananto Sigit relied on the Cobb-Douglass production function to estimate *TFP* in Indonesia. Hananto Sigit determined the depreciation rate by considering the technical lifetime of each type of capital stock. In contrast, Tran Tho Dat[1] used the same model specification as did Hananto Sigit, but for Vietnam. In this case, the depreciation rate was set at 6%. Despite the existence of various ways of estimating capital stock (as suggested by Nehru and Dhareshwar, 1994), the perpetual inventory method is the most widely accepted measure. Although previous researchers have attempted to estimate the determinants of *TFP* based on pool data from each country, the results are deemed unreliable due to the small number of observations. Conversely, panel data from several countries provide better estimates.

In order to examine why a group of countries differs from the rest of the world, the *TFP* growth rate estimates need to be regressed on some basic measures of initial conditions. This means that one should consider per capita income, indicators of health and education, and the external environment (for example, terms of trade) as predictor variables, with some regional dummy variables as well. Results of the regression will then demonstrate what initial conditions have significant effects on *TFP* growth. Robertson (1999) suggested a method for interpreting growth accounting studies in terms of the neoclassical growth model. In particular, the neoclassical growth model explained that the growth accounting contribution of capital reflects the gap between the real state of the economy and its steady state income. This led to the conclusion that growth accounting estimate results are confusing because they implicitly consider capital accumulation as an exogenous variable. Thus, the neoclassical growth model ignores the prediction that capital accumulation depends on productivity growth. For this reason, the role of labor and productivity (in terms of *TFP*) allocated to growth will be underestimated when applying the growth accounting framework.

Abdih and Joutz (2005) used time series data for the USA to estimate the parameters of the knowledge production function to assess the extent of knowledge spillovers. They concluded that there is a positive long-term relationship between *TFP* and the stock of knowledge (using patents as a proxy). Furthermore, they showed evidence of strong inter-temporal knowledge spillovers. Nevertheless, the long-term impact on *TFP* growth from these spillovers seemed to be small. That may be due to the complexity and slow diffusion of the application and incorporation of knowledge.

Collins and Bosworth (1996) further examined the determinants of *TFP* by regressing the changes in *TFP* (obtained from their initial growth accounting exercise) on various macroeconomic and trade policy indicators such as budget balance, change in terms of trade, standard deviation of terms of trade, standard deviation of real exchange rate, and an "openness" indicator. They found that, in all macroeconomic and trade policy indicators of interest, only real exchange rate stability seemed to be consistently and significantly associated with *TFP* growth. Accordingly, they suggested that the channel by which policies affect growth is increasing capital accumulation rather than *TFP* growth.

Fagerberg (2000) investigated the relationship between the economic structure of a country and its productivity growth, and found that countries specializing in "high-tech" production have achieved higher productivity growth than countries specializing in low-tech products. The finding also confirmed that a flexible production structure is a significant element in productivity growth because it helps an economy to quickly redistribute its resources to take advantage of changing patterns in technological progress.

In a study that examined the impact of industrial structure on aggregate income and growth in some 28 OECD countries over the period 1985–1998, Peneder (2003) found that structural change made both positive and negative contributions to aggregate productivity growth and that productivity growth differed between industries. However, the impact of structural change tended to be weak and not uniform.

It is often argued that government operations are frequently less efficient than private operations (Barro and Lee, 1994). Accordingly, it could be expected that, as the ratio of government expenditure to GDP increases, the economy will experience lower efficiency and economic growth. Thus, the correlations between the ratio of government expenditure to GDP and *TFP* and economic growth are expected to be negative. In a study covering 115 countries over the period 1960–1980, Ram (1986) concluded that government's relative size also exhibits positive externality effects on the rest of the economy. Garces-Ozanne (2006) found that government intervention (as indicated by total government consumption expenditure) has a positive influence on *TFP*. Similarly, Thomas and Wang (1993) found that, in developing countries, government policies have a significant impact on productivity growth. The measure of macroeconomic stability (measured by an index) is positively and significantly associated with productivity growth. The measures of government expenditure (measured by a separate index) at a certain level, are positively and significantly associated with productivity growth, but, beyond a threshold, are negatively associated.

Studies in the USA focusing on employee training show that such human capital development significantly increases the productivity of companies, but obviously, it was previous rather than current training initiatives that were positively affecting productivity (Bartel, 1992). This highlights the need for human capacity building to improve *TFP* and economic growth. The argument for the importance of training in improving productivity was further supported by Barret and O'Connell (1999) in a study that focused on 642 Irish firms. Nevertheless, Miller and Upadhyay (2000, 2002) found that there was no evidence to support the role of human capital (education) in improving productivity. However, they showed that when an interaction term between trade and human capital is inserted, human capital shows a negative effect on *TFP* growth. The extension of this study to examine whether the effect of human capital differs across levels of economic development and income showed that, in low-income countries, human capital was negatively-correlated with *TFP* growth while, in middle- and high-income countries, the influence was positive.

Barro and Lee (1994) measured educational attainment as the percentage of each country's over-25-years-of-age population that attained certain levels of education in 1960–1990. The study used the perpetual inventory procedure to calculate each category of educational attainment. However, the data were not available for every year in the period and were more likely to be available for five-year periods, especially in developing countries. To deal with this difficulty, enrollment data were used to interpolate between benchmark years and, together with available data on literacy rates, to calculate missing data. Subsequently, researchers have employed educational attainment as an predictor variable for economic growth. However, it is often argued that educational attainment should be considered as an initial condition and not as a proxy for human capital accumulation. For this reason, many studies found no significant relationship between years of schooling and economic growth (for example, Psachoropoulos, 1994; Bosworth et al., 1995; Card and Krueger, 1996).

Mayer (2001) examined two strands of literature dealing with productivity growth. The first strand demonstrated trade as a carrier of knowledge and focused on imports as a way of introducing foreign (relatively advanced) technology into domestic production, which in turn has a positive effect on TFP. The second strand showed that human capital facilitates both technology adoption from abroad and the development of appropriate technology at home. The study was further supported by Coe et al. (1997) by introducing a measure of technology transfer and then combining it with human capital. The resulting measure was used as a measure of TFP changes in between-country growth estimations.

Trade is a significant carrier of knowledge and technology, provided the recipient countries possess the necessary level of human capital (Isaksson, 2001). However, research shows that the relationship between trade openness and human capital is inconclusive. For instance, Harrison (1996) argued that trade openness and human capital are not related, while Miller and Upadhyay (2000) found positive interactions between exports and human capital. Cameron et al. (2005) further supported the proposition that, at the industrial productivity level, trade is a means of technology transfer.

The role of foreign direct investments (FDI) on TFP and economic growth also has been a subject of prior research. Keller and Yeaple (2003) found a strong link between FDI and productivity growth in the US economy: FDI spillover contributed to approximately 14% of productivity growth. Furthermore, the effects of FDI spillovers appear to be stronger in "high-tech" than in other sectors. This view was further supported by Griffith et al. (2003), who argued that multinational firms promote productivity growth in manufacturing industries in the UK. The literature highlights two mechanisms through which FDI influences the level, or growth rate, of domestic productivity. The first is the contribution of new technologies. The second is the role of a foreign presence in increasing competition in the domestic market as well as expanding the market by opening it to foreign markets. However, Aitken and Harrison (1999) found negative effects of FDI on productivity among Venezuelan firms. It is argued that foreign-owned firms normally recruit the most skilled workers and hence deprive domestic firms of their services. Hanson (2001) added further supportive evidence for this proposition, suggesting that spillovers are non-existent or limited.

3. Measurements of *TFP* Growth

In general, there are two empirical approaches to the estimation of TFP, namely growth accounting and growth regressions. Growth accounting is a popular method because it allows for decomposition of output growth into the contributions of factor accumulation and a residual measure of the increase in efficiency. It assumes that the economies are constant in scale and in competitive equilibrium to ensure that input factors are paid to their marginal products.

From a traditional Cobb-Douglas production function:

$$Y_t = A_t F(K_t, L_t)\,, \qquad (1)$$

Differentiating both sides of (1) with respect to time (t) yields:

$$\frac{dY}{dt} = \frac{dA}{dt}F(K_t, L_t) + A_t\frac{\partial F}{\partial K}\frac{dK}{dt} + A_t\frac{\partial F}{\partial L}\frac{dL}{dt}$$

$$\frac{\frac{dY}{dt}}{Y_t} = \frac{\frac{dA}{dt}}{A_t} + \frac{\frac{\partial F}{\partial K}\frac{dK}{dt}}{F(K_t, L_t)} + \frac{\frac{\partial F}{\partial L}\frac{dL}{dt}}{F(K_t, L_t)}$$

$$\hat{Y}_t = \hat{A}_t + \left(\frac{\partial F}{\partial K}\frac{Yt}{Ft}\right)\frac{Kt}{Yt}\left(\frac{dK}{dt}\frac{1}{Kt}\right) + \left(\frac{\partial F}{\partial L}\frac{Yt}{Ft}\right)\frac{Lt}{Yt}\left(\frac{dL}{dt}\frac{1}{Lt}\right)$$

$$\hat{Y}_t = \hat{A}_t + \left(\frac{\partial F}{\partial K}A\right)\frac{Kt}{Yt}\left(\frac{dK}{dt}\frac{1}{Kt}\right) + \left(\frac{\partial F}{\partial L}A\right)\frac{Lt}{Yt}\left(\frac{dL}{dt}\frac{1}{Lt}\right)$$

$$\hat{Y}_t = \hat{A}_t + r\frac{Kt}{Yt}\left(\hat{K}_t\right) + w\frac{Lt}{Yt}\left(\hat{L}_t\right)$$

$$\hat{A}_t = \hat{Y}_t - S_K\hat{K}_t + S_L\hat{L}_t\,, \qquad (2)$$

where[2] Y_t is real output at time t ; $\hat{A}_t$, $\hat{K}_t$, $\hat{L}_t$ are *TFP* growth, capital stock growth, and labor growth, respectively; r , w are prices of capital unit and labor unit, respectively; and S_K , S_L are income shares of capital and labor, respectively.

3.1 Measures of Capital Stock (K_t)

Since it is assumed that owners of capital goods are the users, it is difficult to measure the value of capital service. If all capital is hired, one could use the rental price as a proxy to estimate the value of capital in an economy. Unfortunately, capital stocks have a long service life, so their value and depreciation cannot be observed directly. Therefore, it is necessary to estimate indirectly the value of capital stock, with an assumption that the stock of capital is proportional to capital services. Consequently, there is considerable controversy among economists over calculating the value of capital stocks. In general, two methods are employed to evaluate them. The first is to evaluate stock of capital by direct survey. This method is costly and complicated due to problems with accuracy and an absence of information on rental and salvage values. The second is the more indirect perpetual inventory method (PIM). As this has few limitations, it has been widely used by researchers.

This study uses the PIM to estimate capital stock (K_t) with a geometric annual depreciation rate. The PIM assumes that capital stock is the accumulation of investment streams. It is generalized by the following equation:

$$K_t = \Omega_t I_t + \Omega_{t-1} I_{t-1} + \ldots + \Omega_{t-T} I_{t-T}\,,$$

where I_t is the fixed investment formation at time t; $t-T$ is the vintage of the oldest surviving capital asset; and $\Omega_t = 1$ and $0 < \Omega_{t-1} < 1$. Here Ω_{t-x} demonstrates the efficiency of investment in period $t-x$ at the time t. The sequence of Ω_{t-x} depends on the nature of the capital asset, production process, and technology upgrade.

To compute the stock of capital, this study applies a geometric depreciation ratio. In addition to the benefit of simple computation, there are two advantageous characteristics of a geometric depreciation ratio. First, geometric depreciation tends to be consistent with other asset depreciation patterns. In general, the average efficiency sequence for a cohort of assets is different from the efficiency sequence of individual assets. In the case that individual assets follow a "one-hoss shay[3]" pattern of depreciation, because each asset has a different useful life, the cohort approximately follows a geometric pattern of decay. Second, geometric depreciation ensures internal consistency between a decay pattern in the valuation of capital stock and the depreciation rate. If the efficiency sequence is based on a constant depreciation rate such as the one-hoss shay or straight-line method, the decline of rental value of the asset is non-linear (see Jorgenson, 1990).

Based on the theoretical and empirical strength of geometric depreciation, the PIM has the form:

$$K_t = (1-\varphi)^t K_0 + \sum_{i=0}^{t-1} I_{t-i}(1-\varphi)^i , \tag{3}$$

where K_0 is the initial stock of capital in period 0 and φ is the rate of geometric decay. From (3), we have:

$$K_{t+1} = (1-\varphi)K_t + I_{t+1} \tag{4}$$

$$K_{t-1} = \frac{K_t - I_t}{1-\phi} . \tag{5}$$

Initial stock of capital

Equation (3) highlights the importance of the initial stock of capital in period 0. While there are various approaches to estimating K_0, none is perfectly satisfactory. The simplest way is to assume that the initial stock is equal to zero; however, this will lead to upward bias of capital stock growth. A sound approach is to assume that the capital:output ratio is the same between the initial year and the current year. A better technique is to assume that the capital:output ratio is a function of the labor:output ratio (Benhabib and Spiegel, 1991). An alternative way is to estimate the initial stock from a production function, together with labor and technical progress (Nehru and Dhareshwar, 1994). The most popular approach relies on the assumption that the growth rate of capital is equal to the growth rate of output (Harberger, 1978). Nonetheless, the correlation coefficients of the initial capital stock estimated by the above approaches are higher than 0.99 (Nehru and Dhareshwar, 1994). Therefore, it seems that the choice of approach is not crucial.

This study uses the Harberger (1978) method to estimate initial capital stock for each cross-sectional unit. From the accumulation equation:

$$\frac{K_t - K_{t-1}}{K_t} = -\phi + \frac{I_t}{K_{t-1}} . \tag{6}$$

The left-hand side is the growth rate of capital stock that is assumed to be equal to the rate of growth of output. It can be rewritten as:

$$K_{t-1} = \frac{I_t}{g+\phi} , \tag{7}$$

where g is output growth.

A three-year average of output growth rate and the corresponding three-year average of gross fixed capital formation are used to estimate the initial stock of capital. The base-year is chosen to be the middle of three years.

Decay rate

Although the initial stock influences the capital stock estimate, the decay rate, in fact, is much more important than the initial stock. While errors in the estimate of initial capital stock diminish over time, errors in the estimate of the decay rate accumulate (Nehru and Dhareshwar, 1994). First, the decay rate affects capital stock estimates through the efficiency sequence. Second, it affects the estimates of initial capital stocks in (7), and hence these two errors are resonant in the capital stock estimate. For example, if the decay rate is estimated to be lower than the actual value, the initial capital stock will be higher than the actual, and the capital stock estimates in the subsequent years will be much higher.

However, data on the decay rate are not available for developing countries. There are some data on the service life of capital stock in industrial countries, but these data are normally based on the tax rules on depreciation (Nehru and Dhareshwar, 1994). Therefore, all estimates of capital stock in developing countries assume a particular decay rate. This study assumes a single decay rate for all countries when estimating capital stock. For instance, in the OECD's estimates of capital in 1988, the decay rate estimate was 4.1% in France, 1.7% in Germany, 2.6% in Great Britain, 4.9% in Japan, and 2.8% in the USA (OECD, 1991). Based on aggregated investment data obtained from the World Bank, Nehru and Dhareshwar (1994) suggested a common decay rate of 4% for all countries in order to build up a new database on physical capital stock. Collins and Bosworth (1996) also assumed a decay rate of 4% when calculating TFP for East Asian countries. In the survey on TFP for selected Asian countries, Sigit applied a rate of depreciation of 3% for Indonesia; Tran Tho Dat assumed 6% in the case of Vietnam (APO, 2004).

Table 1. Sensitivity Analysis of Decay Rate

Decay Rate			3.0%	4.0%	5.0%	6.0%	7.0%
Capital stock (billion 2000 USD)	Indonesia	Mean	464.98	427.55	394.69	365.73	340.10
		SE	155.98	137.64	122.27	109.33	98.39
	Malaysia	Mean	260.19	239.45	221.49	205.82	192.05
		SE	92.78	83.49	75.59	68.83	62.99
	Philippines	Mean	219.31	193.93	173.08	155.80	141.33
		SE	44.98	38.07	32.78	28.69	25.46
	Thailand	Mean	513.80	467.25	427.45	393.17	363.40
		SE	138.12	119.13	103.58	90.74	80.09
	Vietnam	Mean	86.22	82.65	79.32	76.22	73.32
		SE	45.98	42.60	39.50	36.65	34.03
Capital stock growth rate (%)	Indonesia	Mean	6.7	6.4	6.2	6.0	5.9
		SE	2.6	2.7	2.8	2.9	3.0
	Malaysia	Mean	7.9	7.8	7.7	7.6	7.5
		SE	4.0	4.2	4.5	4.8	5.0
	Philippines	Mean	3.5	3.3	3.2	3.1	3.0
		SE	0.7	0.8	0.8	0.9	1.0
	Thailand	Mean	5.8	5.5	5.3	5.1	5.0
		SE	4.2	4.4	4.7	4.9	5.1
	Vietnam	Mean	11.8	11.2	10.6	10.1	9.6
		SE	0.9	0.7	0.6	0.8	1.1

The results of the sensitivity analysis are given in Table 1 using decay rates of 3.0% to 7.0%. As can be seen from the table, the decay rate appeared to significantly influence the capital stock estimates. However, for the capital stock growth rate, the fluctuation caused by the sensitivity of the decay rate did not vary significantly. Young (1992) found the same conclusion that with positive decay rate and sufficiently long investment formation, the estimates would be reasonably accurate. Considering the above, although a common decay rate of 4% is often preferred in cross-country data studies such as Nehru and Dhareshwar (1994) or Collins and Bosworth (1996), it should be noted that fixed capital tends to depreciate at higher rates in developing countries than industrial countries (see Bu, 2006). Based on the results, a decay rate of 5% is assumed for all cross-sectional units in this study.

3.2 Measures of Income Shares of Capital and Labor (S_k, S_l)

An important step in *TFP* growth estimation is to choose the weights for the contributions of factor inputs. Theoretically, in a perfectly competitive economy, the weights are the income shares of input factors (labor and capital), and do not depend on the production function under consideration. However, official measures of factor income shares are not normally available for developing countries. Even in the case of developed countries, it is difficult to estimate factor income shares due to the problem of self-employed capital and labor. In fact, the weights would change over time. There is much debate on the validity of absolute levels of input factor shares. For example, United Nations National Accounts Statistics data (1992 edition) show wide variance in the employee compensation shares of GDP for 94 countries. Ghana reported the lowest share of employee compensation with 0.05 of GDP, and Ukraine reported the highest share with 0.77 of GDP. Eighteen countries reported employee compensation shares of less than 0.3 of GDP and eight countries reported employee compensation shares of more than 0.6 of GDP. Moreover, it seems that developing countries tend to have lower shares of employee compensation in GDP than do industrial countries (see Douglas, 2002). Nevertheless, Douglas (2002) found that, after adjusting for the self-employed, there are no systematic differences of labor income share between developing and industrial countries.

According to the estimates of Maddison (1987), the income share of capital is around 0.3 in industrial countries. Englander and Gurney (1994) estimated the capital income share of OECD countries and found that it varies from 0.3 to 0.4. For developing countries, the estimated capital income shares based on national accounts data are normally larger than those of industrialized countries. For instance, Young (1995) estimated the factor income shares, with adjustments for the self-employed, for newly industrializing countries in the Asian region and reported that the capital income share is 0.32 for Korea, 0.29 for Taiwan, 0.53 for Singapore and 0.37 for Hong Kong. During a period of three decades, the capital income share was approximately constant for Taiwan and Singapore, slightly lower in the case of Korea, and higher in the case of Hong Kong. APO (2004) provides further information on other countries in Asia. For instance, in Indonesia, the capital income share slightly increased from 0.61 to 0.70 over the period 1989–2000, and in Malaysia it ranged from 0.59 to 0.64 and showed a decreasing trend over the period 1981–2000. In Vietnam, the value of the capital income share was about 0.4.

Kim and Lau (1994) applied parametric estimation and found that the capital income share is 0.40 for Hong Kong, 0.44 for Singapore, 0.45 for Korea, 0.49 for Taiwan, 0.28 for France, 0.25 for Germany, 0.30 for Japan, 0.27 for the UK, and 0.23 for United States. Harrison (1996) looked at developing countries and found that the capital income share varies from 0.41 to 0.63 depending on countries' openness. In fact, capital income shares are likely to be overestimated in developing countries due to the role of the self-employed and the existence of monopoly profits. Collins and Bosworth (1996) suggested that a reasonable range for the capital income share is from 0.3 to 0.4. Furthermore, the more developed a country is, the lower its capital income share. In a study on East Asia countries, Collins and Bosworth (1996) used a uniform capital income share of 0.35.

By considering the information gathered from the previous literature, this study assumes fixed weights of factor inputs for all cross-sectional units (constant over time) to minimize concerns over methodological differences. Accordingly, the uniform capital income share was assumed to be $S_k = 0.4$ and hence the uniform labor income share was $S_l = 0.6$. Nevertheless, a sensitivity analysis was performed to examine the credibility of this assumption.

Table 2. Sensitivity Analysis of Income Share

	S_k			0.3	0.4	0.5
TFP growth (%)	Indonesia	1992–2008	Mean	1.81	1.34	0.86
			SE	4.39	4.34	4.31
	Malaysia	1992–2007	Mean	2.33	1.82	1.31
			SE	3.54	3.48	3.48
	Philippines	1992–2008	Mean	1.61	1.50	1.39
			SE	2.51	2.42	2.34
	Thailand	1992–2008	Mean	2.60	2.14	1.68
			SE	3.74	3.70	3.71
	Vietnam	1994–2008	Mean	3.74	2.77	1.80
			SE	1.38	1.33	1.30

Table 2 shows that a greater income share attributed to capital will lead to a lower role for TFP . The estimates of TFP growth seem to vary with the change of income share. The sensitivity exists because the growth rate of capital stock is much greater than that of labor in the case of the five middle-income ASEAN countries (FMIE). An assumption of a value for S_k is essential for the growth accounting TFP estimation method to work. This study recognizes this limitation.

3.3 Data

The data required for this study were sourced from the World Bank. The World Bank collects data from officially recognized international sources and under the World Bank's Debtor Reporting System. This database is available on the official World Bank website (http://databank.worldbank.org) and is updated regularly. Data comprised time series of output, fixed capital formation, and employment in five countries: Malaysia, Indonesia, Philippines, Thailand, and Vietnam. The mean values of input data are given in Table 3.

3.4 Estimated *TFP* data

There are 82 observations of TFP growth rates in 1992–2008. An unbalanced panel of TFP growth rates was generated from estimate s. In the panel, Indonesia, the Philippines, and Thailand comprise 17 observations, and Malaysia and Vietnam comprise 16 and 15 observations each. The data are presented in Table 4.

When the period of the Asian Contagion (1997–2000) was excluded, TFP growth rates seemed quite stable in each cross-sectional unit (see Figure 1). During the crisis, as aggregate demand decreased, economies would not have fully exploited resources such as labor and capital. That is equivalent to a downward shift in the production function. Therefore, even with the same input factors, the output would decrease due to the effects of low aggregate demand. The decrease in TFP growth rates during the Asian financial crisis was due to the exogenous shock effect; it cannot be attributed to *TFP* growth determinants.

Table 3. Input Data for *TFP* Growth Estimate, 1990–2009

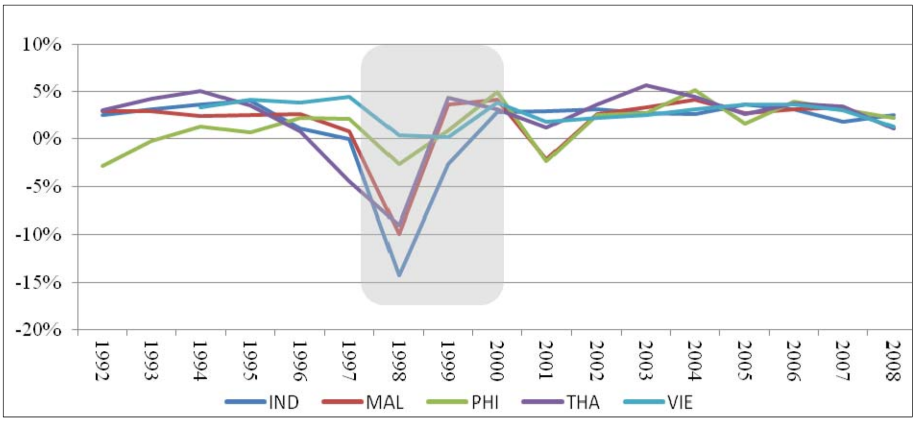
Input data		Indonesia	Malaysia	Philippines	Thailand	Vietnam
GDP*	Mean	176	93	78	130	33
	SE	41	28	19	29	14
GDP growth (%)	Mean	4.75	5.87	3.71	4.33	7.46
	SE	4.69	4.40	2.29	4.91	1.43
Gross fixed capital formation*	Mean	40	25	14	39	12
	SE	10.30	5.80	2.12	9.69	5.67
Capital stock*	Mean	395	221	173	427	79
	SE	122	76	33	104	39
Capital stock growth (%)	Mean	6.2	7.7	3.2	5.3	10.6
	SE	2.83	4.41	0.84	4.85	0.63
Population (million)	Mean	204	23	77	62	77
	SE	16.38	2.95	9.19	3.45	6.33
Employment (million)	Mean	126	14	46	46	56
	SE	7.59	1.66	4.97	1.59	2.63

Notes: * in billion USD at 2000 prices.

Table 4. *TFP* Growth Rate (%)

Year	Indonesia	Malaysia	Philippines	Thailand	Vietnam
1992	2.50	2.88	–2.88	2.98	NA
1993	3.16	2.94	–0.22	4.23	NA
1994	3.60	2.45	1.33	5.08	3.35
1995	4.04	2.54	0.68	3.57	4.17
1996	1.09	2.63	2.22	0.84	3.87
1997	0.04	0.75	2.13	–4.47	4.45
1998	–14.32	–9.97	–2.68	–9.07	0.43
1999	–2.63	3.65	0.91	4.34	0.15
2000	2.78	4.18	4.91	3.17	3.83
2001	2.95	–2.17	-2.36	1.16	1.83
2002	3.12	2.61	2.57	3.66	2.22
2003	2.73	3.30	2.73	5.61	2.56
2004	2.62	4.14	5.17	4.46	3.16
2005	3.67	2.77	1.65	2.58	3.65
2006	3.08	3.08	3.96	3.70	3.60
2007	1.83	3.34	3.17	3.39	2.99
2008	2.49	NA	2.22	1.13	1.26

Figure 1. TFP Growth Rate



As mentioned, the *TFP* literature lacks a common framework to deal with the *TFP* estimation problem; therefore, it is not surprising that there is inconsistency among *TFP* estimates, even within studies on the same countries and period.[4]

In this study, *TFP* growth estimates were higher than in most other studies. Note that, in a number of studies, the labor input variable was considered to include not only the number of employed people, but also the quality of labor. Therefore, human capital, which was considered a source of *TFP* growth in this study, was aggregated into the contribution of labor variable. For this reason, the estimate model in this study tends to generate higher values for the *TFP* growth rate.

4. *TFP* Growth Determinants

The Solow exogenous model demonstrated *TFP* to be the key determinant of growth in the long run but did not explain its determinants. Since there is no sound theoretical framework from which to study determinants of *TFP* growth, a variety of predictor variables were used to estimate *TFP* growth. However, most empirical research focuses on R&D, openness, economy structure, government spending, and human capital as key determinants. The literature usually considers R&D to be a crucial determinant of *TFP* growth in developed countries but less important in developing countries. As Savvides and Zachriadis (2005) pointed out, less developed countries often carry out little R&D of their own, and therefore, for those economies, technology diffusion across international borders assumes a crucial role as a propellant of growth in *TFP*. In the case of the FMIE, data on R&D was severely limited. Considering the above, R&D is not introduced as a determinant in this paper. The changes in *TFP* growth are expressed as:

$$\begin{aligned}\Delta TFPG_{it} &= a_0 + \sum_{p=1}^{m_1} \beta_1 TFPG_{i(t-p)} + \sum_{n=0}^{m_2} \beta_2 \Delta TRA_{i(t-n)} + \sum_{l=0}^{m_3} \beta_3 \Delta AGR_{i(t-l)} \\ &+ \sum_{k=0}^{m_4} \beta_4 \Delta FDI_{i(t-k)} + \sum_{q=0}^{m_5} \beta_5 \Delta GOV_{i(t-q)} + \sum_{\lambda=0}^{m_6} \beta_6 \Delta HUM_{i(t-\lambda)} \\ &+ D_t + U_{it}\end{aligned} \tag{8}$$

where $i = 1,\ldots,5$ indicates panel index; $t = 1992,\ldots,2008$ indicates year; $TFPG$ is TFP growth rate; TRA is % ratio of total trade to GDP; FDI is % ratio of net inflow FDI to GDP; AGR is % ratio of agricultural output to GDP; GOV is % ratio of government expenditure to GDP; and D_1 and D_2 are the dummy variables with $D_1 = 1$ if observations are in the Asian Contagion period (1997–2000) and 0 otherwise, and $D_2 = 1$ if observations are in the Global Financial Crisis period and 0 otherwise; HUM is Human Quality Index, calculated by the method suggested by Collins and Bosworth (1996) and others, applying relative wage structure for workers with different years of schooling to construct weights for aggregating workers across educational level. Specifically, $HUM = \sum W_j P_j$, where P_j is the percentage of population aged over 25 years that achieved a certain educational attainment ($j = 1$ for no schooling, $j = 2$ for completed primary school [6 years of schooling]; $j = 3$ for completed secondary school [12 years of schooling]; $j = 4$ for completed tertiary education [16 years of schooling]); W_j is weight of return to level of schooling. With a 7% return rate to each year of schooling, $W_j = (1+7\%)^n$, where n is the number of schooling years, and the weights are $W_1 = 100\%$, $W_2 = 150\%$, $W_3 = 225\%$, and $W_4 = 300\%$.

The data on trade, government expenditure, FDI inflow, and agriculture value were directly extracted from the World Databank. The World Databank only collects the data on the share of population with certain educational attainment employed for every five years, and hence linear interpolation must be applied to generate annual data (see Table 5).

4.1 Empirical Results

The robustness of the econometric model depends on the number of lagged differences integrated in the regression equation. The lagged differences are important because they ensure that the error terms are white noise and not auto-correlated. A model with over-specified lag lengths would have the same consequences as the inclusion of irrelevant variables. Equivalently, an under-specified lag lengths model is similar to the case of omitted variables that could be more severe due to effects of biased and inconsistent estimates. Therefore, incorrect lag values make subsequent statistical inferences invalid. To deal with this problem, several procedures have been proposed to determine the appropriate length of the distributed lag; some of the better known include Akaike (1973) information criteria, the Schwarz (1978) or Schwarz-Bayes information criteria, and the Campbell and Perron (1991) and Hall (1994) "general to specific" (GS) testing strategy. In this paper, we applied the GS procedure because it tends to choose models of higher order and the problems of over-specified lags are generally less serious than under-specified ones.

Table 5. Descriptive Input Data

Input data (share to GDP)		Indonesia	Malaysia	Philippines	Thailand	Vietnam
TRA	Mean	58.44	189.30	88.13	110.53	110.91
	SE	11.11	22.60	17.93	26.15	33.77
FDI	Mean	0.79	4.56	1.68	3.17	6.08
	SE	1.52	2.02	0.87	1.52	2.85
AGR	Mean	16.27	9.07	17.72	10.29	26.39
	SE	2.06	5.55	3.19	1.24	5.80
GOV	Mean	7.89	12.21	11.04	10.91	7.16
	SE	0.98	1.16	1.34	1.09	1.51

In order to test for stationary data over time, the unit root test for panel data was performed using the panel unit root tests suggested by Im et al. (1997) (hereafter IPS)[5]. The null hypothesis of unit root was rejected at the 1% significance level in the case of TFP growth, FDI, and first difference of TRA, AGR, and GOV variables. HUM exhibited stationarity; however, its first difference accepted the null hypothesis of unit root[6]. This atypical property of HUM data seems to be caused by the interpolation technique applied when there is no available annual data on the educational attainment of the population. It should also be noted that the non-stationarity of the above predictor variables in levels does not conflict with theoretical foundations of the Solow exogenous growth model and the constant return to scale production function. The literature does not offer any argument for the convergence in level of these variables that are exogenous from the neoclassical growth model.

The tests for heteroskedasticity, performed using the likelihood ratio test, found that the model was heteroskedastic. Similarly, the test for autocorrelation was carried out using the method suggested by Wooldridge (2002) for autocorrelation in panel-data models. The test showed evidence of autocorrelation in the data. To deal with these problems, some remedial measures were taken. In the cases of heteroskedasticity and autocorrelation, panel data, fixed effects, random effects, and pooled OLS were problematic. If these assumptions are violated, OLS standard error could be incorrect (Beck and Katz, 1995), and the coefficients derived from the generalized least squares method could be inconsistent (Wooldridge, 2002). In order to deal with the problems, we applied panel corrected standard errors (PCSE) as suggested by the Beck and Katz (1995). The results are presented in Table 6.

A strongly negative relationship between the response variable (D_TFPG) and predictor variable ($TFPG_{t-1}$) was found, demonstrating that the higher the rate of TFP growth in the current period, the larger the decrease in TFP growth rate in the subsequent period. Therefore, without changes in TFP determinants, TFP tends to grow at a diminishing rate.

Trade was found to have a negative impact on TFP growth, with the coefficient of trade variable statistically significant at the 5% level in terms of first difference. The empirical result did not support our hypothesis that trade affects

TFP growth positively. Although this conclusion is not similar to those of major empirical studies, it is supported by the finding of Khan (2006) on a negative association of openness of trade with *TFP* in the case of Pakistan. In this study, trade was defined in terms of import and export volumes; therefore, it represents in general the openness of economies. This limitation could be a reason for types of trade having different influences on *TFP*. Unlike the case of trade, this study does not support the proposition that *FDI* influences *TFP* growth, even though *FDI* is also an indicator of openness. Nevertheless, this finding is not surprising because previous researchers argued that inefficiency of *FDI*, and crowding out effects, may have contributed to such an observation (Haddad et al., 1993; Aitken and Harrison, 1999).

Table 6. PCSE Method for Heteroskedasticity and Autocorrelation

	Regression 1		Regression 2	
TFP_growth	**Estimate**	**SE**	**Estimate**	**SE**
$TFPG_{t-1}$	–0.7898***	0.1196	–0.7910***	0.1199
D_TRA_t	–0.0007**	0.0003	–0.0006**	0.0003
D_AGR_t	–0.0083***	0.0019	–0.0083***	0.0019
D_AGR_{t-1}	0.0061***	0.0019	0.0060***	0.0019
D_FDI_t	–0.0005	0.0020	–0.0005	0.0020
D_GOV_t	0.0019	0.0061	0.0020	0.0061
D_GOV_{t-1}	–0.0030	0.0056	–0.0030	0.0056
D_GOV_{t-2}	0.0115**	0.0053	0.0116**	0.0053
HUM_t	–0.0082	0.0168		
D1	–0.0300***	0.0080	–0.0297***	0.0080
D2	–0.0052	0.0128	–0.0055	0.0129
Cons	0.0400	0.0313	0.0248***	0.0044
	$n = 77$, $R^2 = 0.60$, Wald$\chi^2(11) = 112.39$, Prob > $\chi^2 = 0.0000$		$n = 77$, $R^2 = 0.60$, Wald$\chi^2(10) = 112.88$, Prob > $\chi^2 = 0.0000$	

Notes: ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

The coefficient of the share of agricultural sector to GDP variable was found to be statistically significant at the first difference and one-period lagged first difference. Notably, when the coefficient of the first difference term showed negative effects, the coefficient of the one-period lagged first difference term showed positive effects. The absolute value of the D_AGR_t coefficient was larger than the D_AGR_{t-1} coefficient, and hence the overall impact of *AGR* variables tended to be negative. Therefore, the regression result is consistent with the theoretical literature that suggests that a decrease in the share of the agricultural sector in GDP will lead to an increase in the level of *TFP*.

The government expenditure variable was found to have a positive effect on *TFP* growth. The coefficient for two-period lagged difference was found to be statistically significant at the 5% level. The positive impact of government expenditure was consistent with a priori expectations. This finding is supported by Governed-market Theory, especially in the case of high performance economies such as the FMIE, where governments normally play their roles efficiently.

This study found no evidence for an effect of human capital on *TFP* growth. Furthermore, the coefficient shows a negative influence of human capital on *TFP* growth, although the theoretical literature strongly supports a positive effect of human capital on productivity. In fact, the impact of human capital on economic growth and productivity is not frequently observed in empirical researches. This may be due to an ad hoc measurement of human capital, because there is no common framework for assessing the quality of a labor force. Moreover, the data on education are limited when they are collected only every five years. In order to construct the panel data in this study, interpolation was used. Therefore, the examined relationship between *HUM* variables and *TFP* growth may have been somewhat undervalued.

The dummy variable D_1, referring to the period of the Asian Contagion (1997–2000), was strongly statistically significant. The result clearly shows that *TFP* growth decreased in this period. When interpreting the coefficient of D, it was quite surprising that the crisis caused a decrease of nearly 4% in *TFP* growth each year in 1997–2000. Notably, the results show that the impact of the Global Financial Crisis was not as strongly felt by the countries in the study as was the Asian Contagion.

5. Conclusion

The novelty of this paper is that it adopts the previous method to highlight the implications of the Asian contagion and the Global Financial Crisis. Second, the PCSE method was applied to correct for nonstandard error issues. Third, the model was applied to a wider range of countries of similar socioeconomic conditions than were considered by previous research. This study examined *TFP* and its determinants, with particular emphasis on the experience of the FMIE. It estimated *TFP* growth for the FMIE over the period 1992–2008 by applying a growth accounting method. To mitigate the inconsistency of previous estimation methods, this study adopted sensitivity analyses for the value of decay rate and income share. Based on the analysis of results, this study confirms that the Asian financial crisis had negative effects on *TFP* growth. The study also highlights the strongly significant roles of trade, agricultural sector scale, government spending, and human capital as determinants of *TFP* growth in the FMIE. Agricultural sector scale and government spending were found to be significant determinants of *TFP* growth, consistent with theory. In contrast, trade influences *TFP* growth, but not to the degree that is expected in the theory. However, there was no significant evidence to suggest that *FDI* and human capital influence *TFP* growth, despite strong theoretical support.

Due to the nature of the growth accounting method, this study used a few ad hoc methods to estimate initial stock, decay rate, and income shares. This can be considered to be a limitation. However, this study found no evidence of stability when the ad hoc chosen values for decay rate and income shares were changed. In order to examine the impact of trade, this study used the ratio of trade to GDP. Although this proxy was found to be statistically significant, the other popular proxies of trade could be considered in further research, such as Tradetax or Black (Gwartney et al., 1996). It seems that the proxy used to measure *FDI* , the ratio of net capital inflow to GDP, was not well represented. In fact, the role of *FDI* is normally more obvious in industry-based approaches examining the productivity of firms or labor.

This study found little evidence for the role of human capital. This seems to be inconsistent with the theoretical literature. Limitations of data may be one of the most crucial reasons, as population surveys have been conducted only every five years in the countries examined. As in previous studies, this study used an interpolation method to overcome the problem. Moreover, in contrast to Collins and Bosworth (1996), who divided the education attainment ladder into seven subgroups, this study divided the education attainment ladder into four subgroups. Therefore, the advantage of higher education may have been somewhat understated. In future studies, a detailed education attainment ladder could be constructed to reflect better the human capital of an economy.

Two dummy variables were deliberately selected to highlight the impacts of the Asian contagion and Global Financial Crisis. This is due to the hypothesis that financial crises have implications for productivity. However, it might be possible that some other factors could have contributed to productivity either as direct impact or flow impact in the crisis periods. In future research it would be useful to examine whether financial crises were the only things going on over these periods.

Using contemporaneous predictor variables might be lead to endogeneity issues in regression models. However dropping contemporaneous predictor variables could omit the effects of the current period, which were believed to be significant. It is recommended that using instrumental variables technique be considered to rectify endogeneity in future research. Moreover, it would be interesting to examine the interactive effects and threshold levels of determinants.

Appendix A: Asian Economies

Source	Period	Annual average *TFP* growth (%)	% *TFP* contribution to output growth
Indonesia			
This study: TFPG	1992–2008	1.34	30
Bosworth et al. (1995)	1986–1992	0.8	20
Collins and Bosworth (1996)	1984–1994	0.9	24
Lindauer and Roemer (1994)*	1965–1990	2.7	42
Young (1994)	1970–1985	1.2	24
Kawai (1994)	1970–1990	1.5	24
Sarel (1997)	1991–1996	2.2	43
Sigit (2004)**	1980–2000	–0.8	–15
van der Eng (2010)	1951–2008	0.6	12
Park (2010)	2000–2007	2.6	58
Malaysia			
This study: TFPG	1992–2007	1.82	30
Bosworth et al. (1995)	1986–1992	2.8	52
Collins and Bosworth (1996)	1984–1994	1.4	37
Young (1994)	1970–1985	1.1	22
Kawai (1994)	1970–1990	1.6	24
Sarel (1997)	1991–1996	2.0	37
Ab. WahabMuhamad**	1991–2000	1.8	25
Indris Jajri (2007)	1995–2004	4.1	59
Park (2010)	2000–2007	2.3	45
Philippines			
This study: TFPG	1992–2008	1.5	36.5
Bosworth et al. (1995)	1986–1992	0	0
Collins and Bosworth (1996)	1984–1994	–0.9	60
Kawai (1994)	1970–1990	–0.7	16
Sarel (1997)	1991–1996	0.7	41
Caesar B. Cororaton**	1980–2000	–0.8	–15
Caesar and Teresa (1999)	1990–1996	–0.6	–21
Park (2010)	2000–2007	2.3	47
Thailand			
This study: TFPG	1992–2008	2.14	48
Bosworth et al. (1995)	1986–1992	4	48
Collins and Bosworth (1996)	1984–1994	3.3	48
Kawai (1994)	1970–1990	1.9	27
Sarel (1997)	1991–1996	2.3	35
Chandrachai et al.**	1977–1999	1.27	20
Tinakorn and Sussangkarn (1994)	1981–1990	2.48	32
Park (2010)	2000–2007	3.3	69
Vietnam			
This study: TFPG	1994–2008	2.77	37
Tran ThoDat**	1980–2000	3.4	51
Park (2010)	2000–2007	2.0	26.6

Notes: * see van der Eng (2010). ** see APO survey 2004.

Appendix B: Asian Economies

Countries		GDP per capita (Current $)	GDP (Current $ billion)	Population (million)
High income	Singapore	36.537	182.23	4.99
	Brunei	30.391*	11.47*	0.40
Middle income	Malaysia	7.030	193.09	27.47
	Thailand	3.893	263.77	67.76
	Indonesia	2.349	540.27	229.96
	Philippines	1.752	161.20	91.98
	Vietnam	1.113	97.18	87.23
Low income	Cambodia	940	10.45	14.81
	Lao	706	5.94	6.32
	Myanmar	NA	NA	50.02

Notes: Year 2006. Source: World Bank, 2009.

Appendix C: Unit Root Test Results

Results of IPS Panel Unit Root Tests

Variables	$\Omega_{\bar{t}}$ Original: No trend	Original: Trend	Demean: No trend	Demean: Trend
$TFPG$	–3.1591***	–3.3710***	–3.2404***	–3.3556***
D_TFPG	–4.7420***	–4.7539***	–4.8196***	–4.8551***
FDI	–1.6596**	–2.4954***	–1.4546**	–2.1695**
D_FDI	–6.5365***	–6.5437***	–6.6072***	–6.6282***
TRA	1.3536	–0.7325	2.6853	–0.0677
D_TRA	–5.5047***	–5.6742***	–5.9420***	–6.2208***
AGR	0.4583	–1.3903*	–0.6831	–1.8394**
D_AGR	–5.6610***	–5.8075***	–5.5543***	–5.6124***
GOV	–0.0818	0.0295	–0.2959	–0.6291
D_GOV	–5.1001***	–5.3510***	–5.4217***	–5.5869***
HUM	–4.9068***	4.9059	1.9067	2.5372
D_HUM	1.4383	–1.0467	0.3354	–0.4231
$LnHUM$ [7]	–8.3710***	3.8157	0.1462	1.9356
$D\_\ln HUM$	2.1724	–1.1043	0.6815	–0.5806

Notes: ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Notes

1. These studies have been collated in APO (2004).

2. All variables in (2) are percentages.
3. A model of depreciation, in which the durable delivers the same services for each vintage.
4. See Appendix A.
5. A test suggested by Westerlund (2007) is applied to find co-integration between the non-stationary variables but fail to reject the null hypothesis of no co-integration.
6. See Appendix C.
7. The log term of *HUM* variables was not used in regression. This is used only for the purpose of further examination of the *HUM* data stationary property.

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