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EXPLORING THE EFFECT OF TOTAL FACTOR PRODUCTIVITY GROWTH ON FUTURE OUTPUT GROWTH
Evidence from a Panel of East Asian Countries

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Abstract. Total factor productivity (TFP) has gained increased importance as it has been helpful in accelerating the rate of economic growth in developed countries. The East Asian Countries (EACs) have also followed the developed countries. There has been a debate among growth economists whether the unprecedented growth of these countries has been factor-driven or productivity-driven. In this backdrop, the present study has tested the predictability of TFP for economic growth in four EACs (Hong Kong, Korea, Malaysia and Thailand) using the fixed effects regression model and the pooled regression model over the period 1970-2004. The study concludes that productivity growth is a significant source of output growth as well as of investment growth. Further, the countries under study converge to their own steady state paths.

I. INTRODUCTION

One of the major areas of research in economics has been to identify factors of output growth. There is ample literature on the subject matter. These factors differ from country to country. If these factors can be identified, it would be helpful to accelerate growth by focusing on the major leading sources of growth. In this regard, Solow (1956) initiated a new debate by identifying that economic growth involves technical change. The same became known as total factor productivity growth (TFPG), in economic literature. Later his thesis became popular because certain economies attained a very high growth rate as compared to others. This fact attracted

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many researchers to look beyond the mere accumulation of factors of production. The debate has not yet been settled. In the study of economic growth two tendencies are observed.

(*i*) Rich countries enjoyed higher savings and capital formation rate.

(*ii*) In these countries resources were put to more efficient use.

Because of above two facts growth rate in these countries generally remained high as compared to others. The second observation led to the study of TFPG. These studies explaining TFPG are directed on the one hand to the developed world and on the other hand it addresses the issue of developing countries, *i.e.* the lackluster, non-persistent, and slow growth. The studies pertaining to developing countries can be classified on the basis of theories supporting the idea of TFPG, and the factor accumulation theories with special reference to the East Asian tigers.

TFP remains important because it not only measures economic growth and cross-country growth differences, but also economic fluctuations and business cycle frequencies (Comin and Mark, 2006). Higher TFP indicates better level of technology, higher per worker capital, and larger returns. It enhances an economy's ability to produce more output from a given stock of inputs. Thus TFP captures all effects that raise the productivity of physical factors including technical change, human capital, vintage capital, development expenditures, economies of scale, government policies, international trade policies and remittances etc. Another practically important point which goes into the favour of TFP studies is scarcity of real factors as a result of which, long term sustained growth becomes impossible. The other course which remains open is to put the available resources to more productive and efficient use which is possible with the improvement in technology. This is the core of the TFP thesis.

The objective of this study is to explore the effect of TFP growth on the future investment and economic growth in respect of a panel of East Asian countries (EACs). The present study uses data on TFP measured through the growth accounting approach. Another objective of this study is to investigate the predictive ability of growth accounting measure of TFP.

The rest of the study is organized as follows: Empirical studies are reviewed in section II. Section III discusses theoretical foundations of the growth accounting approach for measuring TFP growth, relations between TFP growth and future investment growth and output growth. Methodology and sources of data are explained in section IV. Empirical results are interpreted in Section V. Finally, section VI concludes the study.

II. REVIEW OF LITERATURE

In economic literature, there exist two views about economic growth. One view is called “accumulationist view” or “traditional view”. It is because traditionally growth has been linked to accumulation of resources. The other school of thought, called the “revisionist” school is a reaction to the former. The followers of this school of thought derive support in favour of their view from the miracle of EACs. They argue that factors other than accumulation were responsible for the economic miracle of Asian tigers (Han, 2003).

Young (1992) and Kim and Lau (1994) made a pioneering research in the accumulationist framework. Young (1992) measured TFPG for Singapore and Hong Kong. He found that TFPG was zero for Singapore and it was negligible in case of Hong Kong. He also noted that much of the growth in these two countries was the result of accumulation of resources. Young (1995) compared TFPG of non-agriculture sectors of EACs with that of OECD and less developed countries. He found that TFPG ranged from 0.2 percent to 2.3 percent in case of EACs, from 0.4 percent to 2 percent in case of OECD, and from 0.8 percent to 1.6 percent in case of less developed countries. On the basis of this comparative study he concluded that TFPG in EACs is not much different from that of OECD and less developed countries. In the above backdrop he argued that rapid growth in EACs is the result of factor accumulation.

Kim and Lau (1994) investigated the sources of economic growth in the post world war II period. They included East Asian countries and G5 industrialized countries in their sample. The study assumed that the production function was elastic enough to allow for productivity increasing technical change. They measured TFP with respect to time. According to their estimates 48 to 72 percent of the output growth in EACs was the result of capital accumulation. In contrast, technical progress along with innovation caused 46 to 71 percent of total output growth in the industrialized world.

Supporters of revisionist view, *e.g.* Atkinson and Stiglitz (1969) and Lapan and Bardhan (1997), argued that technical progress is not evenly spread in all sectors of the economy. Generally it is restricted to few sectors only. Sometimes it is very conspicuous in one sector. This limited technological progress indicates the fact that technical advancement is not all-pervasive. It is specific because it involves research with particular combinations of inputs. Successive capital-intensive innovations generate more profit and as a result, investment in those sectors increase, which in turn enhances overall output growth in these sectors. Under the conventional approach for TFPG estimation, this output growth is associated to capital deepening and hence the role of technical progress remains ignored.

Van and Wan (1997) followed Atkinson and Stiglitz (1969) and reached at similar findings. They suggested that under sector-specific technical progress, growth would remain restricted to that sector. Van, *et al* (2003) studied technological progress in Korea, Singapore, and Taiwan over the period 1972-1992. They found sector-specific technological progress in case of these countries. They compared their findings with previous studies based on the aggregate production function. According to their findings previous studies have underestimated the contribution of technology in Korea, Singapore, and Taiwan.

Han (2003) investigated the predictive ability of TFPG for a large sample of countries over the period 1966-1990. He divided the sample into sub-samples of top 24 OECD countries, top 20 OECD countries, 34 non-OECD (developing) countries and 4 East Asian countries. He used TFPG as independent variable and growth rate of real per capita GDP and investment as dependent variables in two different models. He did this on the assumption that if TFPG represents technical progress then its effect should be positive and significant on future investment and future economic growth. If the above relations hold higher TFP growth is expected to be followed by higher future investment and higher future output growth. This gives the idea of testing the predictive ability of TFP growth for future economic growth. Results of the study showed that TFPG positively and significantly affects future economic growth in the full sample, and in the sub-sample of OECD countries. Weak evidence for TFP growth as a significant predictor of future economic growth in non-OECD countries was also found. However, the study could not find evidence that TFPG is significantly correlated with future economic growth in the East Asian countries. Yet, he argued that such results for EACs might be due to small time span which varied from 1966 to 1990.

III. THEORETICAL FOUNDATIONS

GROWTH ACCOUNTING METHOD

We have used growth accounting approach for estimation of TFP growth. This approach starts with an aggregate production function of the neoclassical form as:

$$Y_t = F\,(K_t, L_t, t) \qquad (3.1)$$

Where Y_t, K_t and L_t represent output, capital input and labour input in physical units respectively and t represents time. The function F is assumed to be subject to constant returns to scale.

In the above model technical change shifts the function F over time. If there is a technical progress the function F shifts upward and a technical regress causes F to shift downward. Technical progress, in the above context, means an output growth keeping the inputs fixed.

Technical change comes over time in a special form referred as Hicks-neutral (Solow, 1957).[1] We can write the above aggregate production function in the case of Hicks-neutral technical progress as:

$$Y_t = A(t)\,F(K_t, L_t) \qquad (3.2)$$

In equation (3.2), $A(t)$ measures the effects of technical changes on the shifts of aggregate production function over time and is known as total factor productivity (TFP). Differentiating equation (3.2) with respect to time we have:

$$\frac{dY}{dt} = \dot{A}F(K,L) + A\frac{\partial F}{\partial K}\frac{\partial K}{\partial t} + A\frac{\partial F}{\partial L}\frac{\partial L}{\partial t} \qquad (3.3)$$

Using the convention $\frac{dY}{dt} = \dot{Y}$, $\frac{\partial K}{\partial t} = \dot{K}$, and $\frac{\partial L}{\partial t} = \dot{L}$, and dividing both sides of equation (3.3) by Y we have:

$$\frac{\dot{Y}}{Y} = \frac{\dot{A}}{A} + \frac{\partial Y}{\partial K}\frac{K}{Y}\frac{\dot{K}}{K} + \frac{\partial Y}{\partial L}\frac{L}{L}\frac{\dot{L}}{L} \qquad (3.4)$$

In equation (3.4), $\frac{\partial Y}{\partial K} = A\frac{\partial F}{\partial K}$ and $\frac{\partial Y}{\partial L} = A\frac{\partial F}{\partial L}$.

Denoting $\frac{\partial Y}{\partial K}\frac{K}{Y}$ by S_K and $\frac{\partial Y}{\partial L}\frac{L}{Y}$ by S_L, where S_K is the capital elasticity of output or relative share of capital in output and S_L is the labour elasticity of output or relative share of labour in output, we can write equation (3.4) as:

$$\frac{\dot{Y}}{Y} = \frac{\dot{A}}{A} + S_K\frac{\dot{K}}{K} + S_L\frac{\dot{L}}{L} \qquad (3.5)$$

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[1]Hicks-neutral technical change expresses that the efficiency of both the capital stock and labour force increases at the same rate

Under the assumption of constant returns to scale we can replace S_L by $(1 - S_K)$ in equation (3.5) and write it as:

$$\frac{\dot{Y}}{Y} = \frac{\dot{A}}{A} + S_K \frac{\dot{K}}{K} + (1 - S_K)\frac{\dot{L}}{L}$$

Denoting output per worker by y and capital per worker by k, we can write the above equation as follows:

$$\frac{\dot{y}}{y} = \frac{\dot{A}}{A} + S_K \frac{\dot{k}}{k} \qquad (3.6)$$

In equation (3.6), $\frac{\dot{y}}{y}$ is the growth of output per worker, $\frac{\dot{k}}{k}$ the growth of capital per worker, and $\frac{\dot{A}}{A}$ the growth rate of total factor productivity. The above equation describes the basic relationship, which is used to measure TFP growth in growth accounting approach. Given the above production function we can decompose growth of output per worker into two parts, one due to growth of capital per worker and the other due to technical progress. TFP growth $\left(\frac{\dot{A}}{A}\right)$ is measured in the growth accounting approach as follows:

$$\frac{\dot{A}}{A} = \frac{\dot{y}}{y} - S_K \frac{\dot{k}}{k} \qquad (3.7)$$

If three data series, output per worker, capital per worker and share of capital are available then TFP growth can easily be measured using equation (3.7) through growth accounting approach. Han (2003) argued that in an aggregate production function of a Cobb-Douglas form share of capital, S_K, is time-invariant. He, further, suggested two ways to estimate S_K. First, share of labour, S_L, is easy to calculate through the aggregate wage-bill (WL) divided by total output, where W is the average wage and L is total employment. Since, in an aggregate production function under constant returns to scale, $S_K = 1 - S_L$, so S_K is measurable. Second, output per worker can be regressed on a constant and capital per worker according to the equation (3.6). In this equation share of capital appears as the coefficient of capital per worker. This method is convenient to use in case of a panel study. He argued that it is quite hard to get data on average wage level and total employment for a number of countries, so aggregate wage-bill method is not advisable to calculate the share of capital. However, in the regression method one must assume that all countries included in the panel have the same production function and same capital share. After running the regression according to equation (3.6) under the above mentioned assumptions, TFP growth can easily be calculated using equation (3.7). In the present study we have used our own estimate of capital share to measure the TFPG.

Since required data on capital stock was not available, we constructed it using perpetual inventory method. This method measures capital stock as the accumulation of the flow of past investments as:

$$K_t = \sum_{i=0}^{t} I_{t-i}(1-\delta)^i \tag{3.8}$$

Where K_t is the capital stock in the current period, I_t is investment level in the current period and δ is the rate of depreciation of capital. The problem in estimating the above equation is the selection of depreciation rate, δ. Following Nehru and Dhareshwar (1993), Collins and Bosworth (1996) and Khan (2006) we used 4 percent depreciation rate of capital.

EFFECT OF TFP GROWTH ON FUTURE INVESTMENT AND ECONOMIC GROWTH

According to the Neoclassical growth model, technical progress causes an upward shift of the aggregate production function and the economy adjusts to a new steady state. At the initial level of capital per worker (k), output per worker (y) increases, due to increased marginal product of capital (MPk). This increased MPk raises investment which in turn, raises the level of capital per worker above the initial level. Capital per worker will continue increasing until MPk reaches its initial level.[2] Increased investment raises the output per worker. If TFP growth rightly measures technical change then positive change in TFP would raise the investment level, which would cause output per worker to increase. The effect of TFP growth on future economic growth can be further enhanced with the help of time lags involved in the process of capital formation. It takes several periods for the actual stock of capital to reach its desired or optimum level. Koeva (2000) explored that different US industries need 13 to 86 months for the installation of new plants. Since investments cannot be made at once rather these are continued reasonably in the future once started in the present, the current technical progress affects the future output growth through investment.

[2]This statement is true only under the assumption of constant relative factor price.

IV. DATA AND METHODOLOGY

DATA AND VARIABLES

This study includes four East Asian countries (Hong Kong, Korea, Malaysia and Thailand) and uses annual time series data over the period 1970-2004. For the countries included in this study data on different variables are collected from three sources: The Penn World Tables (PWT) mark 6.2, The International Financial Statistics (IFS) dated 2007 and World Development Indicators (WDI) dated 2007. The main objective of this study is to test whether TFP growth affects future output growth? This requires data on TFP growth and growth of real per capita GDP. TFP growth was calculated using growth accounting approach. For this, we need two time series: capital stock per worker (k) and GDP per worker (y). To construct capital stock per worker and GDP per worker, data on gross fixed capital formation (GFCF) and GDP are used from IFS and data on labour force from WDI. Total factor productivity growth (TFPG) was estimated using equation (3.7). Capital share was estimated to be 0.57.

The channel through which TFPG affects future output growth is that TFPG raises marginal productivity of capital per worker (MP_k) which raises rate of investment. Increased investment raises the real output per capita (RGDP). Since investment responds to TFPG with a time lag, therefore, the later affects future output growth through its effect on the former. To investigate the relationship of TFPG with growth of investment we need one more data series on investment growth. To test the effect of TFPG on investment growth we use two different measures of investment growth: the growth rate of total fixed investment (GFI) and the growth rate of investment share of GDP (GISH) as used by Han (2003).

To estimate the effect of TFPG on RGDP we used growth rate of RGDP per capita (GRGDP). Data on GFI are collected from WDI, and data on GISH and GRGDP are taken from PWT.

This study regressed growth of real GDP on first lags of TFPG, and first lags of growth rates of GFI and GISH in separate equations. The study also includes several time-varying control variables, commonly used in growth models, as independent variables besides investment and TFPG. Among these control variables we included growth rate of inflation (INF), government’s share of GDP (GOVSH), population growth rate (GP), and Growth rate of private credit (GPC). We collected data on INF, GP and GPC from IFS, whereas data on GOVSH were collected from PWT. To test the convergence of real GDP per capita we used one period lagged natural log of GRGDP (*i.e.* $LGRGDP_{t-1}$).

ECONOMETRIC MODEL

All the variables used in this study are growth rates. They are expected to be integrated of order 0, *i.e.* I(0). To confirm our expectations regarding this we performed two panel unit root tests, which include Levin *et al* (2002) and Im *et al.* (2003). Levin, Lin, and Chu (LLC) test assumes that there is a common unit root process across cross-sections, whereas the Im, Pesaran and Shin test allows for individual unit root processes across cross-sections. Null hypothesis in these panel unit root tests assumes the unit root. If null hypothesis is rejected then a series is said to be stationary.

To test the effect of TFPG on future output growth we employ two models: a pooled cross-section, time-series model and a fixed-effects penal data model. Pooled cross-section, time-series model disregards space and time dimensions. Our pooled model takes the following form:

$$\mathrm{GRGDP}_{\mathrm{it}} = \beta_0 + \beta_1 \mathrm{TFPG}_{it-1} + \beta_2 \mathrm{LGRGDP}_{it-1} + \sum_{\mathrm{j=1}}^{\mathrm{M}} \lambda_{\mathrm{j}} \mathrm{X}_{\mathrm{jit}} + \mathrm{U}_{\mathrm{it}} \qquad (4.1)$$

Where: $i = 1, 2, 3, \ldots, N$ and $t = 1, 2, 3, \ldots, T$

In the above equation $GRGDP_{it}$ is the dependent variable, $TFPG_{it-1}$ is the first lag of TFPG for country i in time period t, $LGRGDP_{t-1}$ is the first lag of natural log of GRGDP and X_{jit} is the set of M control variables for country i in time period t, whereas U_{it} is the error term. The model specified in equation (4.1) estimates the effect of TFPG on future output growth. It also tests whether β-type conditional convergence of real GDP per capita exists or not for the full sample and sub-samples. Negative sign of β_2 exhibits that each country's real GDP per capita converges to its own steady state level.

To test the effect of two measures of investment growth on future output growth along with the effect of TFPG our model takes the following form.

$$\begin{aligned} \mathrm{GRGDP}_{\mathrm{it}} = {} & \beta_0 + \beta_1 \mathrm{TFPG}_{it-1} + \beta_2 \mathrm{LGRGDP}_{it-1} \\ & + \beta_3 \mathrm{GFI}_{it-1} + \sum_{\mathrm{j=1}}^{\mathrm{M}} \lambda_{\mathrm{j}} \mathrm{X}_{\mathrm{jit}} + \mathrm{U}_{\mathrm{it}} \end{aligned} \qquad (4.2)$$

Where: $i = 1, 2, 3, \ldots, N$ and $t = 1, 2, 3, \ldots, T$

GFI_{it-1} is the first lag of GFI for country i in time period t and other variables are same as in equation (4.1).

$$\text{GRGDP}_{\text{it}} = \beta_0 + \beta_1 \text{TFPG}_{it-1} + \beta_2 \text{LGRGDP}_{it-1} + \beta_3 \text{GISH}_{it-1} + \sum_{\text{j=1}}^{\text{M}} \lambda_{\text{j}} \text{X}_{\text{jit}} + \text{U}_{\text{it}} \quad (4.2')$$

Where: $i = 1, 2, 3, \ldots, N$ and $t = 1, 2, 3, \ldots, T$

GISH_{it-1} is the first lag of GISH for country i in time period t.

To investigate the effect of TFPG on future investment we used the same pooled model specified as (4.2) with slight modification. In this case we excluded first lag of LGRGDP and GFI from the model and used GFI and GISH as dependent variables.

$$\text{GFI}_{\text{it}} = \beta_0 + \beta_1 \text{TFPG}_{it-1} + \sum_{\text{j=1}}^{\text{M}} \lambda_{\text{j}} \text{X}_{\text{jit}} + \text{U}_{\text{it}} \quad (4.3)$$

Where: $i = 1, 2, 3, \ldots, N$ and $t = 1, 2, 3, \ldots, T$

$$\text{GISH}_{\text{it}} = \beta_0 + \beta_1 \text{TFPG}_{it-1} + \sum_{\text{j=1}}^{\text{M}} \lambda_{\text{j}} \text{X}_{\text{jit}} + \text{U}_{\text{it}} \quad (4.4)$$

Where: $i = 1, 2, 3, \ldots, N$ and $t =1, 2, 3, \ldots, T$

In addition to pooled regression model we employed fixed effects panel data model. Since pooled regression model disregards the space and time dimensions, we employed fixed effects penal data model to estimate the variability of all coefficients across individual countries. Hsiao (1986) argued that useable degrees of freedom in panel models are higher and the chances of collinearity are lower as compared with cross sectional or time series models. Cross sectional analysis does not allow each country to assume country specific production function. In case, some explanatory variable is correlated with country specific effects in cross sectional analysis then such analysis may suffer from omitted variable bias. Panel data models allow the variability of coefficients across individuals and make it possible to avoid omitted variable bias.

Our fixed effects panel data models take the following form:

$$\text{GRGDP}_{\text{it}} = \beta_{0\text{i}} + \beta_1 \text{TFPG}_{it-1} + \sum_{\text{j=1}}^{\text{M}} \lambda_{\text{j}} \text{X}_{\text{jit}} + \text{U}_{\text{it}} \quad (4.5)$$

$$\text{GRGDP}_{\text{it}} = \beta_{0\text{i}} + \beta_1 \text{TFPG}_{it-1} + \beta_2 \text{GFI}_{it-1} + \sum_{\text{j=1}}^{\text{M}} \lambda_{\text{j}} \text{X}_{\text{jit}} + \text{U}_{\text{it}} \quad (4.6)$$

$$\mathrm{GRGDP}_{\mathrm{it}} = \beta_{0\mathrm{i}} + \beta_1 \mathrm{TFPG}_{it-1} + \beta_2 \mathrm{GISH}_{it-1} + \sum_{\mathrm{j}=1}^{\mathrm{M}} \lambda_{\mathrm{j}} \mathrm{X}_{\mathrm{jit}} + \mathrm{U}_{\mathrm{it}} \tag{4.7}$$

$$\mathrm{GFI}_{\mathrm{it}} = \beta_{0\mathrm{i}} + \beta_1 \mathrm{TFPG}_{it-1} + \sum_{\mathrm{j}=1}^{\mathrm{M}} \lambda_{\mathrm{j}} \mathrm{X}_{\mathrm{jit}} + \mathrm{U}_{\mathrm{it}} \tag{4.8}$$

$$\mathrm{GISH}_{\mathrm{it}} = \beta_{0\mathrm{i}} + \beta_1 \mathrm{TFPG}_{it-1} + \sum_{\mathrm{j}=1}^{\mathrm{M}} \lambda_{\mathrm{j}} \mathrm{X}_{\mathrm{jit}} + \mathrm{U}_{\mathrm{it}} \tag{4.9}$$

Where: $i = 1, 2, 3, \ldots, N$ and $t = 1, 2, 3, \ldots, T$

β_{0i} is the constant term which represents the country specific effects for country *i*. Since we use dummy variables to estimate the variability of the coefficients across individuals, the above model is also called least-square dummy variable (LSDV) model.

V. EMPIRICAL FINDINGS

We estimated the capital share of output according to equation (3.6). The result is shown in Table 5.1. The estimated value of the capital share of output is 0.57 and it is statistically significant at one percent level of significance. The value of the constant is the average TFPG.

TABLE 5.1

Estimation of Capital Share of Output

$\left(\frac{\dot{A}}{A}\right)$	S_k	Adj. R^2	DW-stat	F-stat
4.15** (1.214)	0.57* (0.026)	0.875	1.678	948.94

Figures in parentheses are standard errors and * indicates statistical significance at 1%, and ** at 5% level.

Two unit root tests of all the time series are conducted in this analysis. Unit root tests investigate whether the time series are stationary or not. Results of unit root tests are presented in Table 5.2.

All unit root tests strongly reject the null hypothesis of unit root for all of the series included in the study, which indicate that all the time series included in this study are stationary at the level. Absence of unit roots is in accordance with the expectations as all the series used in this study are growth rates.

TABLE 5.2

Unit Root Tests
(Null hypothesis: Unit root)

Series	Method	Statistic	Cross-Sections
GRGDP	Levin, Lin & Chu t	–7.209*	4
	Im, Pesaran and Shin W-stat	–4.404*	4
TFPG	Levin, Lin & Chu t	–3.374*	4
	Im, Pesaran and Shin W-stat	–3.025*	4
GFI	Levin, Lin & Chu t	–3.535*	4
	Im, Pesaran and Shin W-stat	–3.012*	4
GISH	Levin, Lin & Chu t	–2.568*	4
	Im, Pesaran and Shin W-stat	–2.006**	4
INF	Levin, Lin & Chu t	–3.870*	4
	Im, Pesaran and Shin W-stat	–3.259*	4
GP	Levin, Lin & Chu t	–2.421*	4
	Im, Pesaran and Shin W-stat	–1.722**	4
GPC	Levin, Lin & Chu t	–7.896*	4
	Im, Pesaran and Shin W-stat	–6.328*	4
GOVSH	Levin, Lin & Chu t	–1.775**	4
	Im, Pesaran and Shin W-stat	–1.968**	4

*indicates statistical significance at 1%, and ** at 5% levels.

TFPG AND FUTURE ECONOMIC GROWTH

The effect of TFPG on future economic growth is shown in Table 5.3. The growth rate of real GDP per capita (GRGDP) is used as dependent variable and the first lag of TFPG [TFPG (–1)] is used as predictor of output growth. Besides this, we used four control variables: growth rate of inflation (INF), growth rate of population (GP), growth rate of private credit (GPC) and growth rate of government share in GDP (GOVSH), which are commonly used in growth regression models.[3] Further, we included one period lagged values of natural log of real GDP per capita [LGRGDP (–1)] in pooled regression models to check the conditional convergence of output growth for the countries included in the sample. Table 5.3 contains six regressions. First three regressions are pooled regressions, whereas, the last three are fixed-effects panel regressions. First regression of each type excludes any measure of investment as a predictor of output growth. Second regression, however, includes first lag of growth of total fixed investment [GFI(–1)]; whereas third regression includes first lag of growth of investment share of GDP rather than lagged values of GFI.

The effect of TFPG on future economic growth is shown in Table 5.3. The results presented in the table reveal that TFPG is a significant predictor of future output growth according to two regression models in pooled regression analysis and according to all models in fixed-effects panel regression analysis. The only exception is the 3rd regression model in pooled regression analysis. The average magnitude of the significant coefficients of lagged TFPG in fixed-effects panel data models is 0.90. This average magnitude of the coefficients of lagged TFPG in fixed-effects panel data models means that a 10 percent increase in TFPG would lead to an increase in output growth rate by 9 percent in East Asian countries.

The effect of both the measures of investment, *i.e.* GFI and GISH on future economic growth is positive and statistically significant in both the pooled regression and the fixed-effects panel regression. The effect of government share of GDP (GOVSH) is negative and statistically significant in both the pooled and the fixed-effects panel regressions. The effect of growth of private credit is not statistically significant in any case. The effects of inflation and population growth are statistically significant only in fixed effects panel data models. The signs of the coefficients of the said variables are negative. The coefficients of lagged values of natural log of real GDP per capita [LGRGDP (–1)] in pooled regression models are negative and statistically significant which gives the evidence of existence of conditional convergence of output growth. This shows that each of the economies included in the study converges to its own steady state.

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[3]For details see Limam and Miller (2004) and Khan (2006).

TABLE 5.3

Effect of TFPG on Future Economic Growth
Dependent Variable: growth rate of real per capita GDP (GRGDP)

Independent Variables	Pooled Regression			Fixed-effects Panel Regression		
	1	2	3	1[4]	2[5]	3[6]
Constant	0.65* (0.09)	0.92* (0.11)	0.43* (0.17)	14.55* (0.56)	6.34* (0.37)	16.85* (0.95)
TFPG(–1)	0.027* (0.006)	0.048* (0.008)	0.013 (0.011)	1.045* (0.131)	0.500* (0.055)	1.169* (0.134)
GFI(–1)		0.012* (0.003)			0.573* (0.021)	
GISH(–1)			0.028*** (0.015)			0.477** (0.160)
INF	0.0001 (0.0007)	0.0001 (0.0007)	0.00005 (0.0007)	-0.023* (0.006)	–0.002 (0.002)	–0.019* (0.006)
GP	0.007 (0.008)	–0.005 (0.008)	0.009 (0.008)	–0.898* (0.092)	–0.137* (0.045)	–0.789* (0.097)
GPC	–0.0005 (0.0004)	–0.0004 (0.0003)	–0.0006 (0.0004)	0.001 (0.003)	0.001 (0.001)	0.003 (0.003)
GOVSH	–0.006* (0.0009)	–0.012* (0.001)	–0.004* (0.001)	–0.036** (0.016)	–0.056* (0.006)	–0.073* (0.020)
LGRGDP(–1)	–0.200* (0.004)	–0.217* (0.005)	–0.208* (0.004)			
Adj. R^2	0.998	0.999	0.998	0.884	0.983	0.891
DW-Stat	1.895	1.872	1.891	1.677	1.739	1.693
F-Stat	15235.54	14501.81	13188.89	126.213	835.735	120.316
Prob (F-Stat)	0.000	0.000	0.000	0.000	0.000	0.000

TFPG AND FUTURE INVESTMENT

The effect of TFPG on future investment is shown in Table 5.4. Two measures of investment, (GFI) and (GISH), are used as dependent variables

[4]Fixed effects are 0.85, 0.20, –0.09 and –0.96 for Hong Kong, Korea, Malaysia and Thailand respectively.

[5]Fixed effects are 2.63, 0.62, –1.25 and -2.00 for Hong Kong, Korea, Malaysia and Thailand respectively.

[6]Fixed effects are 0.60, 0.27, –0.08 and –0.79 for Hong Kong, Korea, Malaysia and Thailand respectively.

and the first lag of TFPG with different capital shares is used as an independent variable. The results show that TFPG is a significant predictor of future investment.

TABLE 5.4

Effect of TFPG on Future Investment

Independent Variable	Dependent Variable in Pooled Regression		Dependent Variable in Fixed-effects Panel Regression	
	GFI	GISH	GFI[7]	GISH[8]
Constant	6.05* (0.88)	4.35* (0.13)	16.70* (1.07)	3.16* (0.37)
TFPG(–1)	0.560* (0.127) Adj. R^2: 0.678	0.560* (0.127) Adj. R^2: 0.688	2.793* (0.126) Adj. R^2: 0.964	0.494* (0.065) Adj. R^2: 0.742

NOTE: Figures in the parentheses are standard errors and * indicates statistical significance at 1%.

The impact of TFPG on future investment is positive and significant in both the models. However, the magnitude of the coefficient of lagged TFPG significantly differs in the fixed effects panel model and the pooled model. Since the fixed effects panel models are better than pooled models on the basis of their assumptions, hence it is better to rely on fixed effects panel data model in our case. The significant effect of TFPG on future investment reinforces the idea that growth accounting approach is a good measure of TFPG.

VI. CONCLUSION

In this study we empirically examined the predictability of growth accounting measure of total factor productivity growth for four East Asian countries.[9] We used the output growth and investment growth as dependent

[7]Fixed effects are –3.55, 6.59, –0.03 and –3.01 for Hong Kong, Korea, Malaysia and Thailand respectively.

[8]Fixed effects are 0.23, –0.68, 0.09 and 0.36 for Hong Kong, Korea, Malaysia and Thailand respectively.

[9]The East Asian Countries included in the study are Hong Kong, Korea, Malaysia and Thailand.

variables to test the predictability of growth accounting measure of total factor productivity growth. Two different measures of investment growth, *i.e.* growth rate of total fixed investment and growth rate of investment share of GDP are used as dependent variables to estimate the effect of total factor productivity growth on future investment. Given the output per worker and capital per worker, total factor productivity growth depends on capital share of output.[10] We found that estimated capital share of output was 0.57. We used pooled regression models and fixed-effects panel regression models to investigate the effect of TFPG on future output growth and investment growth. Hypothesis of conditional convergence in income is also tested in this study.

The empirical findings showed that total factor productivity is a significant predictor of future output growth and investment growth. Since total factor productivity growth is a significant predictor of future output growth and investment growth, it is recommended that countries concerned should take such measures which give boost to total factor productivity growth. These include investment in human capital, skill, training, and technical progress etc. Our findings support the revisionist view, which suggests that TFPG has significantly contributed in output growth in East Asian countries.

The effect of total factor productivity growth on future investment growth is positive and significant at one percent level in both the pooled and fixed effects panel models. Two measures of investment growth: growth rate of total fixed investment and growth rate of investment share of GDP are included in the study to investigate the effect of total factor productivity growth on future investment. The effect of total factor productivity growth on future investment growth holds for both the measures of investment growth. This supports the idea that growth accounting approach is a good measure of total factor productivity growth.

Empirical results support the evidence of conditional convergence in income. Conditional convergence suggests that countries included in the sample converge to their own steady state level of output. The results of the convergence test of income reinforce the relevance of the endogenous growth theory in our case.[11]

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[10]For details see section III.

[11]Endogenous growth theory supports the idea of conditional convergence rather than absolute convergence. Absolute convergence postulates that all the countries converge to the same steady state level of output.

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