OPENNESS IN TRADE AND TOTAL FACTOR PRODUCTIVITY GROWTH IN EAST ASIA

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STATEMENT

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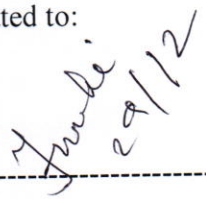

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TABLE OF CONTENT

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ABSTRACT

This paper attempts to analyze the factors that influence the total factor productivity (TFP) growth rate for six East Asian countries over 1980-2007. Data envelop analysis (DEA) approach is used to estimate the changes in the production frontier in first stage. The Malmquist productivity index has decomposed total factor productivity into technological change (TECHCH) and technical efficiency change (EFFCH). Empirical results suggest that TFP growth for the entire sample periods have not been encouraging due to unsatisfactory contribution from technological changes. The results reveal that the economies were able to cause shifts in their own frontier due to innovation. In the second stage the paper analyzes the factors responsible for the surge in total factor productivity experienced by the sample countries. Based on a panel regression with random effects of the six countries over the time period 1980-2007, the number of technical and journal articles was the only variable that had a positive impact on TFP growth and efficiency growth. On the contrary, trade openness and foreign direct investment were seen to be inconsequent as determinants of TFP growth and its components. This highlights the fact that internal technological improvements as opposed to foreign capital and technologies were the main determinants of TFP growth and improvements in efficiency.

1. Introduction:

The Assessment of economic performance, after adoption of trade liberalized policies since 1991, in view of linkages between trade liberalization and productivity growth has gained importance among academicians and policy makers. The economic literature on the influence of trade openness and liberalization on the industrialization and development process has been recently enriched by many contributions. Significant relationships between key variables, such as trade performance, international specialization and long-run growth, have been defined and/or redefined and new policy implications have also been offered. Theoretically, trade liberalization could have both a positive as well as negative impact on productivity and recent surveys have enlighten the empirical literatures in either positive effect or negative effect of trade liberalization on economic productivity of countries. Thus the effect of trade liberalization on productivity is an empirical question.

The success of East Asia persuaded policy makers in other parts of the world that outward-oriented policies were effective in promoting economic development. This success is often thought within the framework of traditional trade theory in which both competitiveness and external trade, which are the keys of rapid economic growth and stability, are achieved through series of economic liberalization. In 1993, the World Bank published a report, entitled the "East Asian Miracle", which identified eight countries that had achieved "seemingly miraculous" rates of sustained growth over the 25-year period from 1965 to 1990[1]. The eight were Japan, the "Four Tigers"; Hong Kong, South Korea, Singapore, and Taiwan; followed by the "newly industrializing economies', now called "emerging Tigers": Indonesia, Malaysia, and Thailand. Their public policies promoted rapid capital accumulation by making banks more reliable and encouraging high levels of

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[1] Billington.G. April 7.1997. 'Why the Asian Tiger Miracle is an Endangered Species. The American Almanac.

domestic savings. They increased the skilled labor force by providing universal primary schooling and better primary and secondary education. These countries try to keep price distortions in check and welcomed new technology and FDI. Trade in manufactured exports was promoted by government-established marketing institutions.

The East Asian growth "Miracle", as described by the World Bank (1993), has led to the penning down of vast and diverse literature on the debate regarding the determinants of growth (Young, 1995; World Bank, 1993). A little research have been made to analyze the impact of growth in total factor productivity (TFP) believing it as a potential factor influencing economic performance of OECD countries (Fare, Grosskopf, Norris and Zhang, 1994; Savvides and Zachariadis, 2005) and also on five East Asian countries (Mahmood and Afza, 2008) . But as empirical analysis on Asian countries could not provide any clear-cut direction of the determinants towards TFP growth, following a two-pronged approach, this paper studies total factor productivity in six high-growth East Asian economies; China, Indonesia, Malaysia, South Korea Thailand and Japan over the period 1980-2007,. First it calculates the growth in TFP, and then it proceeds to analyze the factors responsible for miracle growth.

This paper is organized as follows after introduction: section 2 provides an overview of the current literature on productivity growth and convergence and the determinants of TFP growth. Section 3 will continue by providing an in-depth explanation on productivity growth. Section 4 approaches with methodology used to calculate TFP growth and then explicate the model that evaluates the simultaneous contribution of various factors to growth in TFP. Section 5 goes on to describe the data description, while Section 6 discusses the results of the two stages and section 7 concludes the paper.

2. Literature Review:

Since the time of Adam Smith's classic Inquiry into the Nature and Causes of the Wealth of Nations, economists have paid considerable attention to the issue of understanding economic growth. The empirics of growth have been an important area of research since mid 1950s when Abramovitz (1956) and Solow (1957) highlighted the large contribution of total factor productivity (TFP) to output growth. The increase in productivity of newly industrialized countries was attributed to the convergence phenomenon of the neo-classical growth framework. According to De Long (1988) and Baumol (1986), economic convergence is primarily due to their incorporation of partial productivity measures, namely labor productivity, while Fare (1994) strongly opposed that and breaking TFP up into technical and allocative components he made insightful contributions to exiting literature on growth theory. This study has also been largely inspired by the framework employed by Fare *et al.* (1994).

The literature on the sources of growth of nations has grown since mid 1950s, and the issue of determinants of growth has occupied the attention of economists for the last 15 years or so. There is growing skepticism about the methodology of cross-country regressions employed in the analysis of determinants. Although high frequency panel data used in recent growth research provides many more observations and permits experimentation with better specifications and estimation methods, it cannot be claimed that the resulting parameter estimates are necessarily better estimates or closer to the true values of the parameters.

Bloom and Williamson (1998) found that economic growth is less rapid in the first phase of demographic transition in East Asia (prior to 1970) in which the growth rate of working-age population less than that of the population as a whole. Economic growth is more rapid when the growth rate of working population is higher than that of the total population (second phase of the transition, which coincides with the East Asian miracle). Rowen (1998) puts East Asian countries in the special category that is as countries that

are initially having primary and secondary school enrollment rate above the world norm, given their incomes, and later on growing faster than those with lower initial levels.

Using the year of 1960 as the base year, the preliminary work of Hahn and Kim (1999) also suggests that human capital significantly related to total factor productivity growth, implying that a country with high human capital has better chance to adopt advanced technology. Romer (1990) noted that countries with greater initial stocks of human capital tend to grow faster through rapid introduction of new ideas or products. Zachariadis (2004), in his study of ten OECD countries, regresses TFP growth on R & D intensity, according to which, internal R & D strongly determines the level of productivity growth in an economy. Grossman and Helpman (1991) explored the theoretical possibility that intervention in trade could raise growth if protection encourages investment in recent-intensive sectors for countries with a comparative advantage in these goods. Using different measure of trade policy, Levine and Renelt (1992) didn't find robust or consistent positive relationship between trade liberalization and long run growth. In that case, according to Nelson (1996), number of scientific and technical journal publications by domestic scientists can be employed as proxy for indigenous R & D.

To analyze the robustness of the relationship between openness and TFP growth, Edwards (1998) used comparative data for 93 countries. He used nine indexes of trade policy to investigate whether the evidence supports the view that TFP grow this faster in more open economies and the results suggested more open economies experienced faster economic growth. Zachariadis and Savvides (2005) argue that technology is embodied in capital and intermediate goods, so that the direct import of these goods is a channel of transmission of foreign technology, and hence eventual growth in TFP. Moreover, according to Zachariadis (2004), openness can also have a positive impact on an economy's productivity growth through other channels, such as increased competition in the domestic market.

Savvides and Zachariadis (2005) suggest that foreign direct investment (FDI) by multinational corporations (MNCs) might be another channel for the international transmission of technology.

Besides the import of capital goods by the subsidiaries of MNCs, FDI frequently involves the movement of employees and managerial talent across countries, as well as links between MNC subsidiaries and local firms; all potential channels for the transfer of new technologies (Savvides and Zachariadis, 2005).

3. Productivity:

In economics, a measure of productive efficiency calculated as the ratio of what is produced to what is required to produce it. Any of the traditional factors of production — land, labour, or capital — can be used as the denominator of the ratio, though productivity calculations are actually seldom made for land or capital since their capacity is difficult to measure. Labour is in most cases easily quantified — for example, by counting workers engaged on a particular product. In industrialized nations, the effects of increasing productivity are most apparent in the use of labour. Productivity can be seen not only as a measure of efficiency but also as an indicator of economic development. Productivity increases as a primitive extractive economy develops into a technologically sophisticated one. The pattern of increase typically exhibits long-term stability interrupted by sudden leaps that represent major technological advances. Following the development of technologies of steam power, the railroad, and the gasoline motor later in the 20th century, advances in productivity stemmed from a number of innovations, including assembly lines and automation, computer-integrated manufacturing, database management systems, just-in-time manufacturing, and just-in-time inventory management. Increases in productivity have tended to lead to long-term increases in real wages.

3.1 Total Factor Productivity:

There are two measures of productivity, namely, partial or single factor productivity (SFP) and total factor productivity (TFP). Partial factor productivity is calculated by dividing the total output by the quantity of an input and the main problem of this measurement of productivity is that it ignores the fact that the productivity of an input also depends upon the levels of other inputs used. For example, a higher amount of capital application may increase the productivity of labour even when other inputs including labour remain constant. The TFP approach over come from this problem by take into account the level of all inputs used in the production of output. TFP is defined as the ratio of weighted sum of output to the weighted some of inputs. In other words, the TFP approach measures the amount of aggregate output produced by a unit of aggregate inputs.

Over the last three decades, researchers have developed several theories and method of TFP measurement. The two main approaches applied for the estimation of growth in TFP are the Production Function Approach (PFA) and the Growth Accounting Approach (GAA). But both approaches have some limitations. One of the major disadvantages of using PFA is the problem of identification of production function due to the simultaneity in determination of input intensities and output levels (Balk, B.M. 2001). The problems of autocorrelation and multicollinearity encountered in the use of PFA vitiate the empirical estimates obtained by this approach. To massaging the data in order to take care of these statistical problems render it difficult to interpret the empirical results. On the other hand, the limitation of GAA is that, if the share of capital is treated as a residual, it implies the assumption of constant returns to scale. Moreover, if output elasticities are proxies by the observed factor shares, it implies the assumption of a competitive market structure. It is also assumes that an industry operates on its production frontier, implying that it has 100 per cent technical efficiency. Thus, TFP growth measured through this approach is due to technical change, not due to technical efficiency change (Mawson et al., 2003).

Among these, the most popular approach to measure productivity changes is based on using *Malmquist Productivity Indexes*-a method originated by Caves et al. (1982). According to MPI approach, TFP can increase not only due to technical progress (shifting of production frontier) but also due to improvement in technical efficiency (catching-up). The Malmquist index has three main advantages. First, it does not require the profit maximization, or cost minimization, assumption. Second, it does not require information on the input and output prices. Finally, if the researcher has panel data, it allows the decomposition of productivity changes into two components- technical efficiency change, or catching up and technical change, or changes in the best practice. Its main disadvantage is the necessity to compute distance functions. However, the Data Envelop Analysis (DEA) technique can be used to solve this problem.

Malmquist Productivity Index is explained by distance or technical efficiency functions. One feature of distance functions is that these allow description of multi-input, multi-output production technology without the need to specifying a behavioral objective, such as profit maximization or cost minimization. Distance functions are two types; the input distance functions and the output distance functions. Input distance functions look for 'by how much can input quantities be proportionally reduced without changing the output quantities produced?' On the other hand output distance functions addresses 'by how much can output quantities be proportionally expanded without altering the input quantities used?

4. Methodological Issues:

4.1 Approaches to Measure Productivity

This section defines the Malmquist productivity index (MPI) and the underlying assumptions. The specific Malmquist index of productivity change used in this paper is the index of total factor productivity change (TFP), proposed by Fare, Grosskopf, Lindgren & Roos (1992). Ten years earlier, in fact, Caves, Christensen & Diewert (1982)

already developed an index to measure productivity change which they named after Sten Malmquist (M. Ammara and A. Talat, 2008). However, Fare et al. (1992) merged efficiency theory as developed by Farrell (1957) with the Malmquist index of Caves et al. (1982) to propose a Malmquist index of productivity change that is now commonly used in the literature. Contrary to Fare et al. (1992), who considered an input based Malmquist index, an output based Malmquist index in the current paper.

Considering firms, which use *n* inputs to produce *m* output, denote $x \in R_+^n$ and $y \in R_+^m$ as, respectively, the input vector and output vector of those firms. The set of production possibilities of a firm at time *t* can be written as:

$$S^t = \{(x^t, y^t) \mid x^t \text{ can produce } y^t\} \qquad (1)$$

Assuming that S is closed, convex, exhibits constant returns to scale and free disposability of outputs and inputs, according to Fare, Grosskopf, Norris & Zhang (1994) followed Shephard (1970) to define the output distance function at time t as:

$$D_0^t(x^t, y^t) = \inf\{\theta \mid (x^t, y^t/\theta) \in S^t\} = (\sup\{\theta \mid (x^t, \theta y^t) \in S^t\})^{-1} \qquad (2)$$

The subscript o is used to denote the output-based distance function. Note that, $D_0^t(x^t, y^t) \leq 1$ if and only if $(x^t, y^t) \in S^t$, and $D_0^t(x^t, y^t) = 1$ if and only if (x^t, y^t) is on the frontier of the technology. In the later case, Farrell (1957) argued that the firm is technically efficient.

To define the Malmquist index, Fare et al. (1994) defined distance functions with respect to two different time periods:

$$D_0^t(x^{t+1}, y^{t+1}) = \inf\{\theta \mid (x^{t+1}, y^{t+1}/\theta) \in S^t\} \qquad (3)$$

and

$$D_0^{t+1}(x^t, y^t) = \inf\{\theta \mid (x^t, y^t/\theta) \in S^{t+1}\} \qquad (4)$$

The distance function in (3) measures the maximal proportional change in output required to make (x^{t+1}, y^{t+1}) feasible in relation to technology at time t. Similarly, the distance function in (4) measures the maximal proportional change in output required to make (x^t, y^t) feasible in relation to technology at time *t + 1*.

Then according to fare (1994) the productivity indices in period t and t+1 are:

$$M^t = \frac{D_o^t(x^{t+1}, y^{t+1})}{D_o^t(x^t, y^t)}$$

$$M^{t+1} = \frac{D_o^{t+1}(x^{t+1}, y^{t+1})}{D_o^{t+1}(x^t, y^t)}$$

The output Malmquist TFP productivity index can then be expressed as:

$$M_o(x^{t+1}, y^{t+1}, x^t, y^t) = \frac{D_o^{t+1}(x^{t+1}, y^{t+1})}{D_o^t(x^t, y^t)} \left[\frac{D_o^t(x^{t+1}, y^{t+1})}{D_o^{t+1}(x^{t+1}, y^{t+1})} \frac{D_o^t(x^t, y^t)}{D_o^{t+1}(x^t, y^t)} \right]^{\frac{1}{2}} \qquad (5)$$

The term outside the brackets shows the change in technical efficiency while the geometric mean of the two ratios inside the brackets measures the shift in technology between the two periods *t* and *t + 1;* this could be called technological progress. So:

$$\text{Efficiency change} = \frac{D_o^{t+1}(x^{t+1}, y^{t+1})}{D_o^t(x^t, y^t)} \qquad (6)$$

$$\text{Technical change} = \left[\frac{D_o^t(x^{t+1}, y^{t+1})}{D_o^{t+1}(x^{t+1}, y^{t+1})} \frac{D_o^t(x^t, y^t)}{D_o^{t+1}(x^t, y^t)} \right]^{\frac{1}{2}} \qquad (7)$$

In each of the formulas above, a value greater than one indicates an improvement and a value smaller than one presents deteriorations in performance over time.

4.2 The Method of Estimating the Econometric Model

To re-analyze the direction of the determinants, which are the freer trade (openness), secondary enrollment ratio (SER), foreign direct investment (FDI) and research & development (R&D) of total factor productivity growth, the panel data is constructed according to the model of Ammara and Talat, which they have experimented in the paper of "*Total Factor Productivity Growth in East Asia: A Two Pronged Approach*" (M. Ammara and A. Talat, 2008).

$$GTFP = \alpha_0 + \alpha_1 OPEN_{it} + \alpha_2 SER_{it} + \alpha_3 FDI_{it} + \alpha_4 RD_{it} + D_c + \varepsilon_{it} \quad (1)$$

$$TECHCH = \beta_0 + \beta_1 OPEN_{it} + \beta_2 SER_{it} + \beta_3 FDI_{it} + \beta_4 RD_{it} + D_c + \theta_{it} \quad (2)$$

$$EFFCH = \gamma_0 + \gamma_1 OPEN_{it} + \gamma_2 SER_{it} + \gamma_3 FDI_{it} + \gamma_4 RD_{it} + D_c + \tau_{it} \quad (3)$$

Alike Ammara and Talat the second part of the analysis first looks at the overall impact of the explanatory variables on TFP growth and then proceed to find the impact on the technical and efficiency change components of the Malmquist productivity index. In these equations, Dc represents country-specific dummies, explaining whether a country is a developed one or not. In terms of developed country Dc stands for 1 otherwise it stands for 0. *GTFP* refers to growth in TFP, *TECHCH* is the growth in innovation over time, *EFFCH* is the improvement in efficient utilization of available inputs. *SER* is the gross secondary school enrollment ratio, *FDI* is the foreign direct investment, *OPEN* is the economy's openness to foreign trade, and *RD* is the number of technical and scientific journal article publications taking place in the economy. The intercept terms α_0, β_0, γ_0 represent the estimated value of the dependant variables in each three equations when all the independents variables have a value of 0, while ε, θ and τ are the error terms for the equations. The subscripts i, and t are indexes for occupation and time, respectively.

5. Data & Variables:

5.1 Data Description:

The study is based on panel data and it comprises the six economies of China, Indonesia, Malaysia, South Korea, Thailand and Japan over the period 1980-2007. At an early stage, the importance of infrastructure investment in these countries, as an aid to exporters and import-competing firms, was recognized—and appropriate measures taken. Later in the reform process, greater emphasis was placed on liberalization of the trade and financial sectors. Thus the main thrust of economic policy became an outward orientation with strong incentives for exporters, and a commitment to growth through trade[2]. These striking features of South East Asian growth regional economic activity and the significant shift in the pattern of Asia's trade paves this study.

In order to calculate total factor productivity for the first part of this analysis, the data for capital stock and labor as inputs have been used in the Malmquist productivity index, and gross value added is taken to be the output.

The secondary data for capital, labor and gross value added have been obtained from the Penn World Tables (PWT) Mark (6.3). But, for non-availability of reliable data on capital stock, investment was used as a proxy. Data for labor comprises the total working population of each of the six sample countries. Similarly, GDP at constant prices was taken as a proxy for gross value added, in the absence of reliable figures for the latter.

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[2] See country specification in appendix 1.

The following table shows the means and standard deviations for gross value added, capital and labor for each country in the sample over the period 1980-2007.

Country	GDP	Labor	Capital
China	3239.891 (1960.562)	6.64e+08 (8.41e+07)	3.59e+13 (2.64e+13)
Indonesia	3717.769 (948.6903)	3.48e+08 (5.76e+07)	5.62e+15 (1.71e+15)
Malaysia	10982.77 (3852.597)	7979781 (2100881)	7.76e+11 (3.62e+11)
South Korea	14194.4 (5738.802)	2.01e+07 (3129887)	1.55e+15 (7.43e+14)
Thailand	6087.921 (2006.55)	3.20e+07 (4005394)	1.60e+13 (7.20e+12)
Japan	25387.16 (3829.449)	6.41e+07 (3829606)	1.10e+15 (1.83e+14)
Average	10601.65	1.89e+08	1.39e+15

Table 1: Summary statistics of GDP, Labor and Capital (1980-2007)

For the second part of this study, a host of variables have been employed on which TFP has been regressed. These variables are; gross secondary enrollment ratio (GSER), trade openness, number of technical and scientific journal articles published, and foreign direct investment (FDI).

The figures for GSER have been obtained from the database of World Development Report and statistics of the UNESCO. These figures have been compiled for the period 1980-2007.To gauge the extent to which an economy engages in international trade, we have obtained figures for trade openness from PWT version 6.3. Publication of scientific and technical journal articles has been used to measure indigenous research and development. These figures have been obtained from the World Data Bank for the period 1980-2007. FDI incorporates the import of capital goods by multinational corporations (MNCs), and the transfer of managerial and technical skills resulting from the link between parent companies and local subsidiaries of MNCs. The figures for FDI over the period 1980-2007 have also been obtained from the World Data Bank.

Table 2 shows the mean and standard deviations for secondary enrollment ratio, trade openness, scientific and technical journal article publications and foreign direct investment for each country in the sample, and the entire sample, over the observed time period. It shows that Malaysia appears to be the most open economy in terms of foreign trade and along with Thailand FDI also flourished in these countries. South Korea and Japan have pretty much higher mean SER. And Japan has also its dominant control over publishing journal articles.

Country	Variables			
	Openness	**Secondary enrollment ratio**	**FDI**	**Journal articles**
China	36.02603 (15.65137)	50.20991 (13.73519)	2.96e+10 (3.25e+10)	12876.86 (11019.91)
Indonesia	55.18097 (7.131248)	49.74389 (11.50052)	1.39e+09 (2.85e+09)	129.65 (45.07686)
Malaysia	156.5656 (44.92973)	58.55869 (7.883289)	3.00e+09 (2.08e+09)	362.3 (130.4333)
South Korea	47.96844 (20.54418)	93.19615 (5.90474)	2.47e+09 (2.90e+09)	5466.727 (5295.907)
Thailand	99.82935 (32.83824)	46.72224 (18.28044)	3.15e+09 (3.06e+09)	522.25 (314.3843)
Japan	19.31345 (4.625764)	98.10311 (3.406444)	2.99e+09 (5.36e+09)	45348.64 (10481.05)
Average	69.1473	64.70447	7.10e+09	11281.85

Table 2: Summary statistics of the explanatory variables

5.2 Variable Description:

Openness:

Exports plus imports divided by Real GDP per capita (constant price) the exports and import figures are in national currencies from the World Bank and United Nations data archives. This is the constant price and is the total trade as a percentage of GDP[3].

Gross Secondary Enrollment Ratio:

The secondary enrollment ratio is the ratio of total enrollment, regardless of age, to the population of the age group that officially corresponds to the level of education. Secondary education completes the provision of basic education that began at the primary level, and aims at laying the foundations for lifelong learning and human development, by offering more subject- or skill-oriented instruction using more specialized teachers[4].

Scientific and Technical Journal Articles:

Scientific and technical journal articles refer to the number of scientific and engineering articles published in the following fields: physics, biology, chemistry, mathematics, clinical medicine, biomedical research, engineering and technology, and earth and space sciences[5].

Foreign direct investment, net inflows (BoP, current US$):

Foreign direct investment are the net inflows of investment to acquire a lasting management interest (10 percent or more of voting stock) in an enterprise operating in an economy other than that of the investor. It is the sum of equity capital, reinvestment of earnings, other long-term capital, and short-term capital. This series shows net inflows

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[3] Country list .university of pennsylvania-center for international comparisons,university of pennsylvania.Penn world table.study documentation.dec12,2008.

[4] Source: United Nations Educational, Scientific, and Cultural Organization (UNESCO) Institute for Statistics.

[5] Source: National Science Foundation, Science and Engineering Indicators.

(new investment inflows less disinvestment) in the reporting economy from foreign investors. Data are in current U.S. dollars[6].

6. Empirical Analysis:

6.1 Empirical Finding of Productivity:

Applying Malmquist Productivity Indices, this study finds to measure TFP change and its sources using Data Envelope Approach by using the computer software DEAP (Coelli, 1996) to compute these indices. Table 1 demonstrates average estimates (geometric mean) of Malmquist indices of total factor productivity change (TFPC), decomposed into technical efficiency change (TEC) and technological change in capital-intensive countries. TEC is further decomposed into pure technical efficiency change (PTEC) and scale efficiency change (SEC). The countries are arranged in descending order of their Malmquist productivity indices (TFPC). The value of TFPC greater than one reveals productivity growth, value equal to one indicates no change and lower than unity indicates regress in productivity growth. To estimate percentage change in productivity, one in subtracted from the TFPC index and then value is multiplied by 100, [(TFPC-1) x 100]. The rule applies to the other indices presented in the table.

MALMQUIST INDEX SUMMARY OF COUNTRY MEANS

COUNTRY	EFC	TEC	PTEC	SEC	TFPC
China	1.039	0.674	1.030	1.009	0.701
Indonesia	0.996	0.646	1.000	0.996	0.644
Malaysia	1.000	0.902	1.000	0.996	0.902
South Korea	1.014	0.823	1.014	1.000	0.834
Thailand	1.009	0.925	1.008	1.001	0.934
Japan	1.000	0.874	1.000	1.000	0.874
Mean	1.010	0.800	1.009	1.001	0.807

Indices reported in the end of the last row of Table- 1 are the averages of country specific indices.

[6] Source: International Monetary Fund, International Financial Statistics and Balance of Payments databases, and World Bank, Global Development Finance.

In most cases, the growth in productivity seems to be caused by an improvement either in technological progress or in technical efficiency. China, Malaysia, South Korea, Thailand and Japan could manage to override their production frontier with technological progress. These have happened mostly due to the scale efficiencies, large scale production in the industries may be encouraged to take the advantage of the economies of scale, which would lead to greater efficiency in the countries, and consequently force the production points closer to the frontier.

The results suggest that TFP growth for the entire sample periods have not been encouraging due to unsatisfactory contribution from technological changes. The results reveal that the economies were able to cause shifts in their own frontier due to innovation. The economies need enhancement of their productivity-based catching-up capability, specifically use of human capital in the labor market, increase the number of skilled workers to operate more sophisticated technology and the adoption of new technology

The slowdown in TFP growth over time could be attributed to the financial crisis that most of these countries went through during the 1990s. Evidence shows that Thailand, South Korea and Indonesia were particularly badly hit. Also in the case of South Korea, the large drawback has been criticized for the mismanagement arising from large scale production over time.

By using the non-parametric technique of DEA-type Malmquist index in this paper, the productivity changes is measured for selected capital-intensive countries from 1980-2007. This model helped to isolate the contributions of technological change, efficiency change and scale change to productivity change in the country resources. Relatively TFP growth achieved by capital-intensive industries during the study period provides some indication that policy-induced factors, such as flow of foreign direct investment and import of advanced technology have made positive impact on the TFP growth. The economies of scale in the countries coupled with advanced technology acquisition would further develop downstream activities in the related countries should attract foreign direct

investment and import and adopt advanced technology to survive during era of globalization.

6.2 Empirical Findings of Regression

In order to analyze the determinants of TFP growth, total factor productivity growth has been regressed on the entire sample against SER, FDI, journal articles and openness. The results panel regressions with fixed and random effects are given in Table 4. Statistically, fixed effects are always a reasonable thing to do with panel data, but they may not be the most efficient model to run. Random effects will give the better P-values as they are a more efficient estimator, so it is statistically justifiable to run random effects if it is do so. The generally accepted way of choosing between fixed and random effects is running a Hausman test[7].

And table 5 illustrates the results of panel regression on technical change and efficiency change.

[7] The Hausman specification test compares the fixed versus random effects under the null hypothesis H_o that the random effects estimator is consistent and efficient, while the fixed effects estimator is consistent, but not efficient (Greene 1997).

Table 4: parameter estimates and summary statistics panel regression of explanatory variables on total factor productivity

Explanatory variables	Parameter Estimates	
	Fixed Effects	**Random Effects**
Intercept	9.846581* (4.258402)	8.538059 (4.627504)
Openness	-0.1511157 (0.4128598)	-.1827268 (.3940163)
Secondary enrollment ratio	-1.020313 (1.376139)	-.5927133 (1.287827)
FDI	-3.12e-10 (3.36e-10)	-2.16e-10 (2.23e-10)
Number of scientific and technical journals	0.0032633 (0.0037427)	.00341 (.003366)
Country dummy		.7899751 (6.954548)
R^2	0.0195	0.0239
Wu-Hausman test statistic	0.80 [0.8501]	

Note: Values in parentheses show standard errors, while those in square brackets are p-values and a single-asterisk indicates statistical significance at the 0.05 level.

Table 5: Parameter estimates and summary statistics for panel regression of explanatory variable on TFP, technical change and efficiency change

Explanatory variables	Dependent variables	
	TECHCH	EFCH
Intercept	8.831747 (4.645802)	1.838341* (.5256233)
Openness	-.1670956 (.3955743)	-.0414045 (.044755)
Secondary enrollment ratio	-.9689956 (1.292919)	.2617235 (.1462801)
FDI	-2.36e-10 (2.23e-10)	7.41e-12 (2.53e-11)
Number of scientific and technical journals	.0030693 (.0033793)	.0000572 (.0003823)
Country dummy	.9466976 (6.982048)	-.9620502 (.7899447)
R^2	0.0262	0.0577

Note: Values in parentheses show standard errors, while those in square brackets are p-values and a single-asterisk indicates statistical significance at the 0.05 level.

In Table 4, the first column shows the panel regression results for fixed effect model estimates for SER, FDI, journal articles and openness, along with t-values at 5 % significance levels. The second column shows random effect parameter estimates respectively. The table reveals that the fixed effects estimates yield the lower value for *R*-squared.

However, the Wu-Hausman test favors usage of the random effects model over the fixed effects model. A glance at the test-statistic and the p-value indicates that the random effects estimators are consistent and efficient[8]. Based on these statistics, it can be established that the random effects specification best suits the sample countries.

For the regression on the components of TFP, in table 5, technical change and efficiency change R^2 is higher with efficiency change as the dependent variable as compared to other two as the dependent variable. This shows that the explanatory variables chosen in the model are more significant for the determination of efficiency change relative to technical change, despite its importance.

We now proceed to interpret the parameter estimates for each variable under the random specification for TFP growth and for its two components technical change and efficiency change.

Unlike Talat and Ammara results (2008), for TFP growth only research and development sector is clearly presenting its vital performance in improving productivity of the sample countries. Unexpectedly all the other independent variables –openness, secondary enrollment ratio and FDI have no positive effect on the growth of the total factor productivity of the sample countries. Any unit changes of openness, SER and FDI result in declination of the growth of TFP by 0.1827268, 0.5927133 and 2.16e-10 units respectively.

The technical change in second column shows the same direction of the explanatory variables as the first column. Education, free trade, Foreign direct investments have not played an important role in shifting the production function of the sample countries; on the contrary research and development sector has assisted the countries to catch-up the frontier line.

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[8] The Hausman test-statistic = 0.80, p-value = 0.8501

In the third column, the efficiency change is positively moving with education, FDI and R&D performance. Only openness in trade, along with other equations, shows the negative impact on the efficiency change.

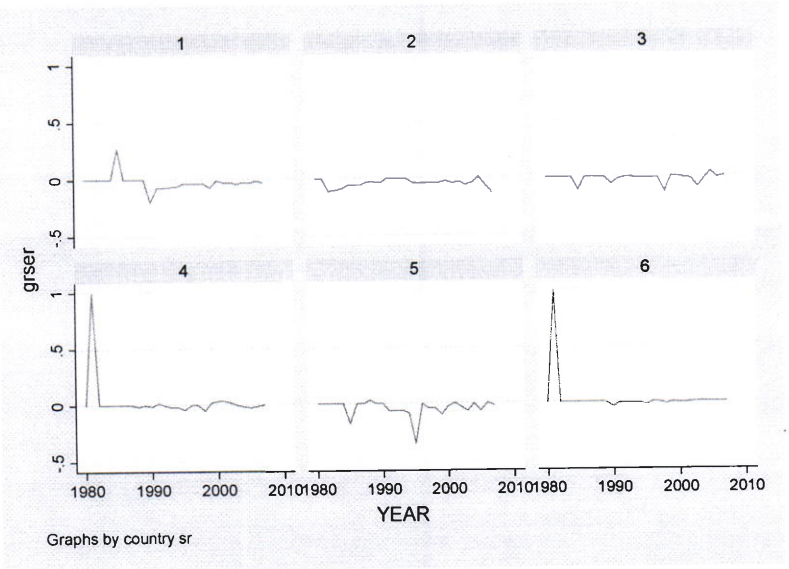
However, for the sample trade openness has a statistically insignificant negative value, at 5% level of significance, implying that high levels of imports and exports negatively impact TFP growth for the sample countries over the period under observation. FDI is also observed to have negative impact on productivity growth. Openness also has a insignificant negative value for efficiency change and also is insignificant in explaining technical change. The coefficient of FDI appears to be statistically insignificant for TFP growth as a whole, technical change and efficiency change. Similar to the coefficient of openness, the negative coefficient for FDI explains a lower percentage of the growth in TFP. This means that FDI, trade openness, secondary enrollment ratio and research variable may not be the main factors affecting TFP.

It can be said in line with Ammara and Talat that the impact of trade openness on efficiency change contradicts the generally held belief that growth in East Asia was primarily export-led and that these countries, especially South Korea, prospered by opening up to the world market. On the contrary, internally developed technology and production methods coupled with local policy initiatives are more important determinant of productivity growth relative to the role played by foreign technology transfers and competition in the international market.

Although internal research and development, as measured by the proxy the number of scientific and technical journal articles published, has a positive coefficient, this coefficient appears to be statistically insignificant for all the three dependent variables – TFP, TECHCH and EFCH variables. This invalidates the choice of the proxy for research and development, as scientific and technical journal articles may not have any substantial affect on the method of production.

Similarly, the negative coefficient for FDI explains very little of the growth in TFP. This means that FDI and trade openness are not the main factors affecting TFP. This is in line with Zachariadis (2005) observation that FDI and trade do not significantly impact TFP growth.

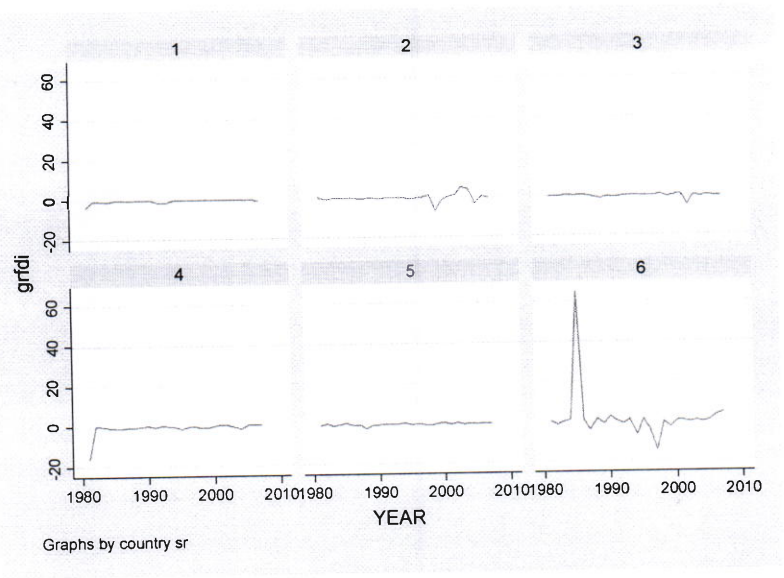
It is surprising to have such unwanted empirical impact of FDI and secondary enrollment ratio on the growth variables, as it contradicts to theories. The following graphs of the growth rate of these two variables over the year of 1980-2007 for the six Asian countries might provide some explanations for that.



Graph 1: Growth rate of secondary enrollment ratio of the six countries 1980-2007

Graph 1 shows the declining trend of the growth rate of education for the six countries-china (country-1), Indonesia (country-2), Malaysia (country-3), South Korea (country-4), Thailand (country-5) and Japan (country-6). It seems that lacks of promotions of the social gain from education are unable to boost the economic growth of these six Asian countries.

Graph 2 reveals almost steady level growth rates of FDI is responsible for such negative contribution to the total factor productivity growth. Asian Crisis in 1997 prompted global investors to reevaluate the risk of investing in emerging markets and often led to their withdrawal from emerging markets in earlier of 2000s. But, compared with other forms of international capital flow, FDI has been a relatively stable source of capital for the Asian countries during these years (H. Toshihisa, 2003).



Graph 2: Growth rate of FDI for the six countries over 1980-2007

The country specificities dummy, being developed or otherwise, shows expected positive impact on the productivity growth of the sample countries, except for the efficiency change dependent variable. A country being developed like Japan and Korea can be attributable for such performance comparing the following countries.

Summarizing the regression results, the determinants of TFP growth are showing little impacts of the chosen independent variables on economic growth for the six Asian countries over the year of 1980-2007. Foreign transfers of technology through increased