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Total Factor Productivity Growth, Technical Change and Technical Efficiency Change in Asian Economies: Decomposition Analysis

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Abstract

The aim of this paper is to analyze total factor productivity (TFP) growth and its components in Asian countries applying Stochastic Frontier Analysis (SFA) to the time series data of 44 Asian countries from 2000 to 2010. Using Battese and Coelli approach, TFP is divided into technical efficiency change and technical change. TFP decomposition using SFA method for the years 1998 to 2007 indicates that in 75 % of these economies, the role of technical change in productivity growth is negative. Only in 11 countries technical change had a positive role in productivity growth. The growth of TFP shows that Japan has the highest productivity growth (2.55 %) and Saudi Arabia, Korea and Hong Kong are located in subsequent positions. Furthermore, due to the lowest technical progress, newly independent countries, such as Armenia, Azerbaijan, Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan have the slowest TFP growth.

Keywords: Efficiency, Productivity, Technical progress, Stochastic Frontier Analysis (SFA), Asian Economies.
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1. Introduction

Accumulation of production factors and productivity growth are among the major determinants of economic growth. Due to the scarceness of available resources, it is essential to consider other approaches toward development, especially efficiency and TFP. Productivity is a comprehensive concept and refers to the effective and efficient use of resources to obtain the highest and best output (Hejazi et al, 2008). Efficiency is an economic concept which shows the performance of a wide range of economic activities within a firm or a sector of the economy (Hakimi & Hozhbrkiani, 2008). It is reported that most of the developed countries gain a high percentage of their economic growth by increasing TFP. To make it clear we can mention USA which had 48%TFP growth during 1953 to 1969. However, the share of the capital stock and labor force growth was respectively 22% and 33%, (Shah Abadi, 2010). From 1994 to 1960, average annual growth of TFP has been 2.81% in Japan which composed of 53% of economic growth in this country (Hunma, 2001). During the same period, the average of South Korea's annual GDP growth has been 7.3 % out of which 44.53 percent was due to growth TFP (Lee, 2001). In Indonesia, the rate of productivity growth in its economic growth was -4% from 1970 to 2007 that demonstrates the negative impact of productivity growth in economic growth of this country (Van der Eng, 2009). Also in Philippines the share of productivity growth from economic growth is obtained -6.8 percent (Silva, 2001). According to a research conducted by Alimoradi et al, 2003, the average annual growth of TFP in Iran was approximately -8.12% from1966to 2000.They reported 10.8% of annual growth in labor force input and 1.83% of annual growth in capital input.

As it was reported, developed countries such as USA and Japan gain a big portion of their economic growth by TFP but in some developing countries such as Iran, the Philippines and Indonesia it is negative. In fact, the economic growth of these countries is more based on the accumulation of production factors not on TFP. Reviewing the literature, we did not observe a comprehensive study that compares developing countries in this regard and most authors considered developed countries such as OECD countries in their studies. One of the reasons is probably because of not having access to the data to determine the share and the price of labor force and capital in GNP. In this study, we aim to determine the productivity growth of Asian countries. Therefore we could compare these countries based on their productivity growth as well, as we specify the countries that obtained a portion of their economic growth by their TFP. Moreover, we tried to analyze productivity into two components: analysis of technical progress and changes in technical efficiency to determine the main factor of productivity growth in each country.

2. Literature Review

This paper uses an alternative way of measuring total factor productivity based on the analysis of stochastic frontiers. The great advantage of this approach is the possibility that it offers for decomposing productivity change into parts that can have a straightforward and simple economic interpretation. The stochastic frontier model used assumes the existence of technical inefficiency which evolves following a particular behavior. These assumptions allow one to split productivity changes into two parts. The first is the change in technical efficiency, which measures the movement of an economy towards the production frontier; the second is technical progress, which measures shifts of the frontier over time. The SFA has been used in many articles; some of which are mentioned here:

Recently, Soltane Bassem (2014) determined TFP of 33 MENA countries over the period of 2006–2011. They concluded that the MENA microfinance industries need a technological improvement to achieve both goals of reaching many poor people and financial sustainability as an important strategic implication. In another study, Arazmuradov et al (2013) used a Stochastic Frontier Approach (SFA) covering up to 15 FSU economies for 14-year periods from 1995 to 2008. They suggested that these countries can enhance public policies to attract foreign investment and improve domestic education to improve their economic growth. Furthermore, Aisen and Veiga (2013) investigated the impact of political instability on economic growth on a sample of 169 countries, over the period of 1960-2004. They found that political instability affects growth in an adverse manner by lowering the rates of productivity growth. Their results also indicate both economic freedom and ethnic homogeneity help growth. More, Azomahou et al (2013) studied the productivity growth of both developed and developing countries by applying a semi-parametric generalized additive model over the period of 1998–2008 and determined the relation among the productivity growth and the world productivity growth, human capital, total staff in R&D, the share of R&D expenditure, the increase in government spending on R&D and international trade. In addition, Ilmakunnas and Miyakoshi (2013) explored the TFP based on the quality of the labor and capital inputs in the manufacturing industries of some OECD countries and suggested two labor and ICT indexes to find some specific impacts on productivity.

Afonso and Aubyn (2010) estimated total factor productivity of OECD countries by using stochastic frontier and data envelopment analysis. The results indicated Belgium, Canada, Spain, Italy, Japan and Portugal have been more efficient. The results obtained from using TFP, technical efficiency and technical changes show that on average, there is a positive growth in TFP growth; however the contribution of technical efficiency is more than technical progress. The results of DEA method confirm the results of SFA for a large number of countries, as well.

Pires and Garcia (2004) obtained frontier production function for 75 countries in 1950- 2000. This study using the study of Bauer (1990) and Kumbhakar & Lovell (2000) analyzed the productivity of 36 countries in order to measure changes in efficiency, technology and scales. The results of the calculation of technical efficiency and technical progress in 2000 indicates that United States, Japan and Chile have the highest efficiency and Japan, the U.S. and Germany have the highest technical progress. They expressed that the best productivity growth belongs to OECD (Organization for Economic Co-operation and Development) countries. Japan has had the highest average growth rate and Austria, France, Norway and the USA are next in rank. But, Greece and Turkey have experienced negative productivity growth. Productivity growth of the United States, Japan, France, Switzerland, Italy, Britain, the Netherlands and Austria were due to technical advances. Among the 19 countries that have experienced technical progress positively in this period, 18 of them were the members OECD and Brazil was the only country as the non-member countries had a positive technical progress.

Deliktas (2008) compared technical efficiency and productivity growth of the Countries of the former Soviet Union before and after the collapse. Using DEA, total productivity changes and its components were estimated. The results of this study show that after the collapse, these countries averagely have had the technical efficiency growth of positive, but the technological and total productivity of negative. These results for pre-collapse are almost the reverse so that the average technical efficiency growth in these countries is negative, while the growth rate of technical progress in these countries averagely is positive.

Han et al. (2002) using the stochastic frontier approach estimated 20 production function industry in Hong Kong, Japan, Singapore and South Korea in 1987-1993.

Overall, these results indicate the importance of growth factors in the economy of these countries. Changes in technology have had a greater share of the economic growth compared to the technical efficiency. In Hong Kong, however technological changes for most counties have been positive but because of inefficiency effects, total productivity growth has been negative. In Japan, technical efficiency changes have been positive for all 20 industries while, technical progress has been negative. But since technical efficiency changes compared to technical progress have been negligible, TFP growth of Japan has been negative and the main factor of economic growth has been input growth as well. Singapore has been better placed than Japan in terms of the economic growth and development but has a similar rate in terms of factors growth. In South Korea averagely half of these industries have experienced positive changes in technical efficiency, while technological advances have occurred in most industrial countries. Thus, in this country TFP growth has been positive. Thus like the three above, the main factor of economic growth in the period under review has been the accumulation of factors of production.

3. Methodology

3.1 Accounting for inefficiency

In this section, we explain how inefficiency is taken into account by using a stochastic frontier model. Supposing that a country has a production function$f(Z_{it},\beta)$, in a word without error or inefficiency, in time t, the ith country would produce

$$q_{it} = f(Z_{it},\beta) \quad (1)$$

A fundamental element of stochastic frontier analysis is that each country potentially produces less than it might because of a degree of inefficiency. Specifically,

$$q_{it} = f(Z_{it},\beta)\zeta_{it} \quad (2)$$

Where$\zeta_{it}$is the level of efficiency for country i at time t; ζ_{it} must be in the interval $(0,1]$. $\zeta_{it} = 1$means the country is achieving the optimal output with the technology embodied in the production function $f(Z_{it},\beta)$ and$\zeta_{it} < 1$ indicates , the country is not able to maximize the using of inputs Z_{it} given the technology embodied in the production function $f(Z_{it},\beta)$ because the output is assumed to be strictly positive (i.e.,$q_{it} > 0$, the degree of technical efficiency is assumed to be strictly positive (i.e.,$\zeta_{it} > 0$).
Output is assumed to be subject to random shocks, implying that

$$q_{it} = f(Z_{it},\beta)\zeta_{it} exp(v_{it}) \quad (3)$$

Taking the natural log of both sides yields

$$ln(q_{it}) = ln\{f(Z_{it},\beta)\} + ln(\zeta_{it}) + v_{it} \quad (4)$$

Assuming that there are k inputs and that the production functions is linear in logs, defining

$$u_{it} = -ln(\zeta_{it}) \text{Yields } ln(q_{it}) = \beta_0 + \sum_{j=1}^{k} \beta_j ln(Z_{jit}) + v_{it} - u_{it} \quad (5)$$

Because u_{it} is subtracted from $\ln(q_{it})$, restricting $u_{it} \geq 0$ implies that$0 < \zeta_{it} \leq 1$, as specified above.
In the time invariant model,$u_{it} = u_i$, $u_i \sim N^+(\mu, \sigma_u^2)$,$v_{it} \sim N(0, \sigma_u^2)$, and u_i and v_{it} are distributed independently of each other and the covariates in the model.

In the time-varying decay specification, according to parameterization formulated by Battese & Coelli (1992):

$$u_{it} = \eta_t u_i = u_i exp(-\eta[t - T]), t\epsilon\tau(i) \quad (6)$$

Where T is the last period in the ith panel, η is the decay parameter and represents the rate of change in technical inefficiency and the non-negative random variable u_i is the technical inefficiency effects for the i-th country in the last year for the dataset. That is, the technical inefficiency effects in earlier periods are a deterministic exponential function of the inefficiency effects for the corresponding forms in the final period (i.e. $u_{it} = u_i$ given that data for the i'th country available in period T). $\tau(i)$ is the set of T periods and may contain all periods in the panel or only a subset of periods [Pires & Garcia, 2004].

The sign of μ indicates the trend of technical inefficiency that does not vary in time. When μ is not significantly different from zero, we have technical inefficiency that does not vary in time also called persistent inefficiency. If μ is positive, then $-\eta[t - T] = \eta[T - t]$ is positive for $t < T$ and so $(-\eta[t - T_i]) > 1$, which implies that the technical inefficiencies of countries decline over time. If μ is negative, then $\eta[t - T_i] < 0$ and thus the technical inefficiencies of countries increase over time.

3.2 Decomposition of TFP

Two methods usually use to TFP decomposition in articles, stochastic and DEA- Malmquist approaches. As Rath & Madheswaran (2004) indicated the most important difference between the stochastic frontier approach and the DEA- Malmquist approach in terms of TFP decomposition analysis lies in one assumption: “The existence of an unobservable and idealized production possibility frontier production--unit specific one-sided deviation from the frontier, i.e. explicitly allow for the inefficiency”. If a production unit operates beneath the production frontier, then its distance from maximal measures its technical inefficiency (Farell, 1957; lovell, 1993; Kumhakar&Lovell, 2000). Put differently, the frontier approach is capable of capturing both efficiency change and technological change as component of productivity change, which introduces an additional dimension to the analysis from the policy perspective (Nishimizu & page, 1982; Bayarsaihan, Battese & Coelli, 1998).

We define this so called best practice function f (0) as,

$$y_{it}^{F} = f(x_{it}, t) \tag{7}$$

Where y_{it}^{F} is the potential output level on the frontier at time t for production unit i, given technology f(.), and x_{it} is a vector of inputs. Take log and totally differentiate (1) with respect to time to get

$$\dot{y}_{it}^{F} = \frac{d \ln f(x_{it},t)}{dt} = \frac{\partial \ln f(x_{it},t)}{\partial t} + \sum \frac{\partial \ln f(x_{it},t)}{\partial x_{jt}} . \frac{dx_{jt}}{dt} = TP + \sum_j \varepsilon_{jt} \frac{dx_{jt}}{dt} \tag{8}$$

Where the first term on the right-hand side is the output elasticity of frontier output with respect to time, defined as TP, the second term measures the input growth weighted by output elasticity's with respect to input j, $\varepsilon_{jt} = \frac{\partial \ln f(x_{it},t)}{\partial x_{jt}}$. Note that the conventional conceptualization of TFP growth can be defined as output growth unexplained by input growth, i.e.

$$T\dot{F}P = \dot{y}_{it}^{f} - \sum_j \varepsilon_{jt} \frac{dx_{jt}}{dt} \tag{9}$$

Combining equation (7) and (8), one can get

$$T\dot{F}P = \dot{y}_{it}^{f} - \sum_j \varepsilon_{jt} \frac{dx_{jt}}{dt} = \frac{\partial \ln f(x_{it},t)}{\partial t} = TP \tag{10}$$

That is TP is the only source of TFP growth.

In the spirit of Nishimizu & Page (1982) and further frontier analysis, any observed outputy_{it} using$x_{it}$for input can be expressed as, [Liao et al. 2006]

$$y_{it} = y_{j}^{F} exp(v_{it} - u_{it}) = f(x_{it}, t) exp(v_{it} - u_{it}) \tag{11}$$

Where$(v_{it} - u_{it})$is a composed error term combining output-based technical efficiency u_{it}, and a symmetric component v_{it} capturing

random variation across production unit and random shocks that are external to its control. Regarding (10),
Growth rate of y_{it} is calculated as below (Liao et al, 2006):

$$\dot{y} = \frac{d\, lnf(x_{it},t)}{dt} - \frac{du_{it}}{dt} + \frac{dv_{it}}{dt} = TP + \sum_J \varepsilon_{jt} \frac{dx_{jt}}{dt} - \frac{du_{it}}{dt} \quad (12)$$

From equation (11), TFP growth consists of two components: technical change (innovation and shifts in the frontier technology) and technical efficiency change (catching-up), that is,

$$T\dot{F}P = T\dot{P} - \frac{du_{it}}{dt} \quad (13)$$

$T\dot{P} > 0$ Represents an upward shift of the production frontier. If the technology is immutable, it does not contribute in any way to productivity gains. The same happens with technical inefficiency. If it does not vary overtime, it also does not have any impact on the rate of variation of productivity [Pires & Garcia, 2004].This decomposition of TFP growth is useful in distinguishing innovation or adoption of new technology by ‘best practice’ production units from the diffusion of technology. Coexistence of a high rate of TP and a low rate of change in technical efficiency may reflect the failures in achieving technological mastery or diffusion (Kalirajan, Obwona & Zhao, 1996).

3.3 Model specification

To operationalize the model in equations (5) in our empirical analysis we need to specify a functional form. Following Kumbhakar and Wang (2005), we prefer a translog specification over a Cobb-Douglas specification due to the latter’s superior flexibility [Duffy and Papageorgiou, 2000]. Unlike Koop et al. (1999, 2000), we explicitly account for technology shifts in the frontier. That is, we include a trend variable t with interaction terms that allows us to identify the contribution of technological change to TFP growth. The reduced form of equation is then:

$$LnY_{it} = \alpha_0 + \alpha_L LnL_i + \alpha_k LnK_i + \frac{1}{2}\beta_{LL}(LnL_i)^2 + \frac{1}{2}\beta_{KK}(LnK_i)^2 +$$
$$\frac{1}{2}\beta_{tt}t^2 + \beta_{LK}(LnL_i)(LnK_i) + \beta_{tL}(LnL_I)t + \beta_{tK}(LnK_i)t + \alpha_{tt}t +$$

$$(v_{it} - u_{it}) \tag{14}$$

Rather than pursuing a mathematical programming approach, such as DEA Malmquist Index which is deterministic in nature (as do Fare et al. 1985; Fare et al 1994; etc). It is easy to debate the relative merits of this way, including its grounding in economic theory, the flexibility of translog from less sensitive to extreme observations and measurement error or rather statistical noise in the data due to modeled distributions of errors and efficiency, and so on (Sharma, Leung & Zaleski, 1997). For the case of agricultural and manufacturing application in developing countries, stochastic frontier analysis are likely to be more appropriate than DEA where the data are heavily influenced by measurement error.

The above specification allows the estimation of the both TP in the stochastic frontier and time-varying technical efficiency. Note that the translog parameterization of this stochastic frontier model allows for non-neutral TP. TP is neutral if all βs are equal to zero. The production function reduces to the Cobb-Douglas function with neutral TP if all the βs is equal to zero.

The distribution and parameterization of technical efficiency effects u_{it} were discussed above.

Since the estimation of technical efficiency are sensitive to the choice of distribution assumption, we consider truncated normal distribution for general specifications for one-sided error u_{it}, and half-normal distribution can be tested by LR test. The technical efficiency level of unit i at time t is then defined as the ratio of the actual output to the potential output,

$$TE_{it} = exp(-u_{it}) \tag{15}$$

And TEC is the change in TE, and the rate of technical progress is defined by,

$$TP_{it} = \frac{\partial lnf(x_{it}, t)}{\partial t} = \alpha_t + \beta_{tt}t + \beta_{tl}(lnL_i) + \beta_{tk}(lnK_i) \tag{16}$$

That is, the technical change for i-th country can be calculated directly from the estimated parameters by evaluating the partial derivative of the production function with respect to time.

3.4 Data specification

We construct a non-balanced panel data set consisting of 44 Asian countries over the period 1972-2010. The output variable is GDP measured at constant prices (2005 US$). It is obtained by taking the real GDP per capita chain series (rgdpch) from PWT6.3 and multiplying it by total population for each country.

With respect to labor we use a proxy, the population of equivalent adults (peqa), obtained from PWT (Penn world Table). These data are obtained indirectly from the PWT6.3, by performing calculation using three variables:

$$L = \frac{rgdpch}{rgdpeqa}.pop = \frac{GDP}{POP}.\frac{peqa}{GDP}.pop = peqa \quad (17)$$

Where rgdpch is the real GDP per capita chain series (rgdpch), rgdpeqa is real GDP per equivalent adult and pop is population.

The standard perpetual inventory method (PIM) is used here to construct the capital stock under a uniform 6% depreciation rate with 1970 as the reference year

$$\mathrm{K}_{\mathrm{i,t+1}} = \mathrm{K}_{\mathrm{i,t}} + \mathrm{I}_{\mathrm{i,t+1}} - \delta^{*} K_{\mathrm{i,t}} \quad (18)$$

Where $K_{i,t}$ is capital stock of country i at period t, $I_{i,t}$ is capital formation and δ is depreciation rate. Following Hall & John (1996), the initial capital stock series is initialized by assuming that the growth rate of investment series is representative of the growth of investment prior to the beginning of the series. That is,

$$\mathrm{K}_{\mathrm{i,0}} = \sum_{t=0}^{\infty} I_{j,-t-1}(1-\delta)^{t} = \sum_{t=0}^{\infty} I_{j,0}(1+g_i)^{-t-1}(1-\delta)^{t} = I_{i,0} \big/ (g_i+\delta) \quad (19)$$

Where$\mathbf{I_{i,0}}$ is the first year investment data,$\mathbf{g_i}$is the average growth in the first 10 years of investment series and δ is the depreciation rate. Here, we implicitly assume that no net capital stock exists before 1970 for all countries in question. Past studies have shown that given positive rates of depreciation and a sufficiently long investment series, the PIM is insensitive to the level of capital used to initialize the series (Liao et al. 2006).

4. Empirical Results

In this section we report specification tests, discuss efficiency, technical progress and TFP growth levels, also provide TFP decomposition.

4.1 Estimation of the Asian stochastic frontier (1972-2010)

The STATA11 software which includes among its preprogrammed models of Battese and Coelli (1992) was used to estimate the model and TFP decomposition.

Parameters presented in Table 1 are all significant at 1%. The mean inefficiency μ is significantly different from zero at 1%, showing that normal truncated distribution is an appropriate assumption (if it were not significant other case of distribution must be tested). The estimated value of η is positive, which means technical efficiency growth at decreasing rates (catch up).

Table1: Time variant inefficiency model

Time-varying decay inefficiency model
Group variable: id
Time variable: t
Log likelihood = 199.31833

Number of obs =1474
Number of groups = 44
Obs per group: min = 15
Avg =33.5
Max = 38
Wald chi2 (9) = 8854.64
Prob > chi2 = 0.0000

LnY	Coef	Std. Err.	Z	p>|z|	[95% Conf. Interval]	
T	-.104766	.0150332	-6.97	0.000	-.134231	-.075302
Lnk	-.807525	.1824968	-4.42	0.000	-1.16521	-.449838
Lnl	.5556781	.1614806	3.44	0.001	.239182	.8721741
t2	.0012097	.0001296	9.34	0.000	.0009557	.0014636
lnk2	.0852134	.010201	8.35	0.000	.0652199	.1052069
lnl2	.1762944	.0165895	10.63	0.000	.1437796	.2088091
Lnklnl	-.156111	.0208135	-7.50	0.000	-.196905	-.115318
Tlnk	.0035676	.0006806	5.24	0.000	.0022337	.0049016
Tlnl	-.002972	.0008431	-3.53	0.000	-.004624	-.001319
Cons	24.28848	1.863513	13.03	0.000	20.63606	27.9409
Mu	.686165	.1414601	4.85	0.000	.4089083	.9634218
Eta	.0228559	.0011867	19.26	0.000	.0205299	.0251818
lnsigma2	-1.06112	.3112756	-3.41	0.001	-1.67121	-.451036
Ilgtgamma	2.110568	.3512403	6.01	0.000	1.42215	2.798987
sigma2	.3460663	.107722			.1880187	.6369679
Gamma	.8919261	.0338574			.8056752	.942621
sigma_u2	.3086656	.1077222			.097534	.5197971
sigma_v2	.0374007	.0013996			.0346576	.0401439

4.2 The results of the hypothesis tests

Since this study is going to compare the productivity and efficiency by using frontiers and production functions approaches, it is necessary to consider some related hypothesis. All hypotheses are tested on two significant levels of 1% and 5% by applying generalized maximum likelihood method (relation 8). The results are shown in Table 2.

Table 2: LR tests

Null hypothesis	Log-likelihood function	LR test	Df	Critical value		Decision
				%1	%5	
Cobb-Douglas production function $\beta_{tt} = \beta_{ll} = \beta_{kk} = \beta_{lk} = \beta_{tl} = \beta_{tk} = 0$	-25.54	449.71	6	16.9	12.6	Reject
No technical inefficiency $\mu = \eta = \gamma = 0$	190.87	16.87	3	10.	7.0	Reject
Time-Invariant technical inefficiency $\eta = 0$	17.38	363.87	1	6.6	3.8	Reject
Half –Normal distribution of technical efficiency $\mu = 0$	196.80	5.03	1	6.63	3.84	Reject at 5%

First we test whether Cobb-Douglas production function are adequate to describe underlying technology. The hypothesis is rejected; therefore Translog function form is preferred to a Cobb-Douglas specification.

The second assumption considers the effect of technological changes. In other words, the neutrality of technological changes which names Hicks neutral technological change, as well, is examined.

The third and most important assumption is related to the absence of technical inefficiency in the model. In this assumption signifying the parameters η ‘ μ and γ , $\mu = \eta = \gamma = 0$ is simultaneously tested (Liao et al, 2006). The rejection of this assumption means inefficiency.

The fourth assumption is $H_0 = \eta = 0$ and means that inefficiency will change overtime.

Fifth assumption is related to the type of distribution of technical inefficiency and the rejection of $H_0 = \mu = 0$ means that the type of distribution is appropriate. However, the last two assumptions of the results of the model can decide the acceptance or rejection of them so that according to the coefficients, these assumptions are not accepted.

4.3 The results of productivity analysis using stochastic method

The results of calculation in Table 3 show that Japan, Saudi Arabia, South Korea, Kuwait and Hong Kong are on the top and newly independent countries are at the bottom of the Table. Ranking of countries in the Table is based on productivity growth. The results show that in a decade, 2000- 2010, countries in terms of productivity growth are generally divided into two groups: Countries with positive productivity growth and countries with negative productivity growth.

In some countries there are positive productivity growth, both the efficiency change and technical progress lead to improve productivity. These include: Among the countries where productivity growth is positive both Saudi Arabia and Kuwait have achieved greater share of productivity growth through changes in technical efficiency, while technical progress in these countries compared to East Asian countries Japan, Singapore, South Korea and Hong Kong was lower. As shown in Graph 1 and Graph 2, in East Asian countries such as Japan, Korea, Malaysia, Hong Kong and Singapore technology changes have had a great effect on the productivity growth. In Saudi Arabia, Kuwait and the UAE, changes in technology have had a positive impact on the productivity growth but are lower than Asian countries.

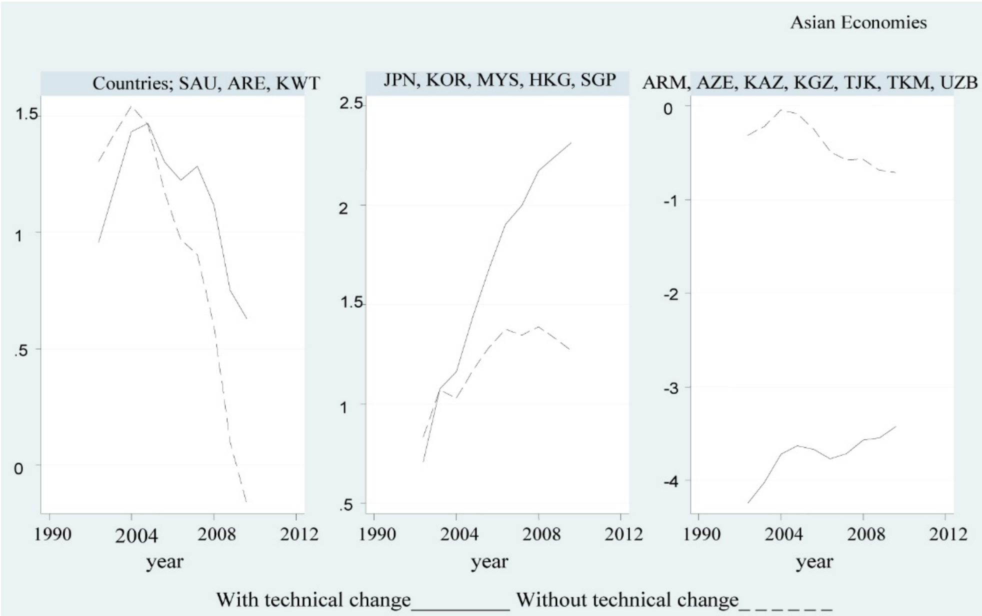

Figure 1. TFP growth in selected countries, with and without technical change (2000-2010)

In some of these countries despite the fact that the average technical change was negative, due to the relatively high efficiency changes, productivity growth has been positive. Iran is also in this group. This country holds thirteenth place in terms of productivity growth among the countries. The percentage of its technical progress growth is negative and close to zero while the percentage of technical progress is big enough and positive and consequently TFP growth has been positive (1.27). Therefore, efficiency change has been the main factor of productivity growth. It is clear that to achieve Iran's vision document that includes taking a leading position in the region, tackling poverty and creating new job opportunities, we need a high economic growth rate. More than half of this required high economic growth would be achieved through the TFP growth in accordance with Iran's vision document. But some factors such as a considerable decline in oil revenues, sharp fluctuating prices of oil, loss of purchasing power due to sanctions could have adverse effect on Iran's TFP growth. Other countries with efficiency change as the main factor of TFP growth are Oman, Thailand, Bahrain, Syria, Indonesia, Lebanon, the Philippines, Iraq, Jordan, Pakistan, China, India, Sri Lanka, Bangladesh and Mongolia.

In countries where average productivity growth was negative, the main factor of negative growth in productivity has been negative changes in technology. However, this point should not be forgotten that technical efficiency of all these countries has been on average less than one but technology changes are negative in most of these countries so that even the best countries in terms of performance, cannot compensate for it.

Figure 2. TFP Growth, with and without technical change (2000-2010)

The newly independent countries of Kyrgyzstan, Kazakhstan, Uzbekistan, Azerbaijan, Turkmenistan, Armenia and Tajikistan in this group, as shown in Graph 1 and 2 are interesting due to negative changes in technology. However, due to significant capital losses in these countries, in the first half of 1990, the result is not unexpected. Taskin and Zaim (1997) Deliktas and Balcilar (2005) and Angeriz et al. (2006) have noted this point.

Furthermore, technological progress and changes in technical efficiency and productivity analysis indicated that 70% of these countries have been faced with negative technical progress. In other words, technical progress has a negative role in productivity growth in many countries, while the performance of all countries has a positive role in productivity growth. Japan, Singapore, Hong Kong and South Korea have the highest technical progress and the newly independent countries of Kazakhstan, Turkmenistan, Azerbaijan, Armenia and Tajikistan have the lowest rank.

4.4 Decomposition results

Table 3.TFP decomposition (1998-2007)

Rank	country	Technical efficiency change	Technical progress(%)	Productivity growth	Rank	country	Technical efficiency change	Technical progress(%)	Productivity growth
1	JPN	1.691	0.864	2.555	23	JOR	1.043	-0.505	0.538
2	SAU	2.235	0.152	2.387	24	PAK	1.025	-0.688	0.337
3	KOR	1.941	0.422	2.364	25	CHN	0.625	-0.288	0.337
4	KWT	2.178	0.147	2.325	26	IND	0.738	-0.479	0.259
5	HKG	1.705	0.466	2.171	27	LKA	0.919	-0.694	0.224
6	ISR	1.642	0.359	2.001	28	BGD	0.970	-0.799	0.172
7	TUR	1.902	0.030	1.932	29	MNG	0.346	-0.245	0.101
8	ARE	1.601	0.314	1.915	30	BTN	0.320	-0.589	-0.268
9	SGP	1.336	0.483	1.819	31	MDV	0.318	-0.608	-0.290
10	MYS	1.517	0.067	1.584	32	AFG	0.909	-1.235	-0.326
11	QAT	0.917	0.371	1.288	33	VNM	0.651	-1.133	-0.482
12	OMN	1.290	-0.01	1.280	34	LAO	0.698	-1.210	-0.511
13	IRN	1.332	-0.05	1.274	35	KHM	0.646	-1.217	-0.571
14	THA	1.183	-0.10	1.078	36	RUS	0.781	-2.343	-1.562
15	BHR	1.113	-0.04	1.069	37	KGZ	1.131	-2.923	-1.792

Rank	country	Technical efficiency change	Technical progress(%)	Productivity growth	Rank	country	Technical efficiency change	Technical progress(%)	Productivity growth
16	CYP	0.963	0.091	1.054	38	KAZ	0.919	-3.266	-2.347
17	MAC	0.836	0.098	0.934	39	UZB	0.551	-2.989	-2.438
18	SYR	1.308	-0.54	0.765	40	YEM	0.665	-3.255	-2.589
19	IDN	1.156	-0.40	0.747	41	AZE	0.555	-3.600	-3.045
20	LBN	1.138	-0.46	0.670	42	TKM	0.389	-3.512	-3.123
21	PHL	1.209	-0.54	0.662	43	ARM	0.505	-3.843	-3.339
22	IRQ	1.400	-0.79	0.607	44	TJK	0.373	-4.215	-3.842

The significant point of calculating the technical change efficiency is that Saudi Arabia and Kuwait have the highest rank with an average equal 2.23 and 2.17 respectively and the newly independent countries of Azerbaijan, Uzbekistan, Armenia, Turkmenistan, Tajikistan and Mongolia follow consecutive that probably is due to similar economic structures after the formation of the Union commonwealth countries.

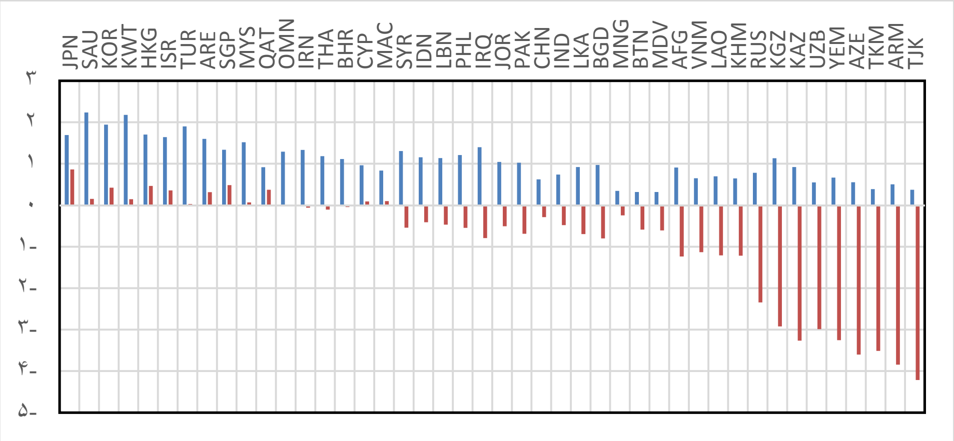

Figure 3. Technical efficiency change and technical progress (%) of economics of Asian countries for 10-year periods from 1998 to 2007.

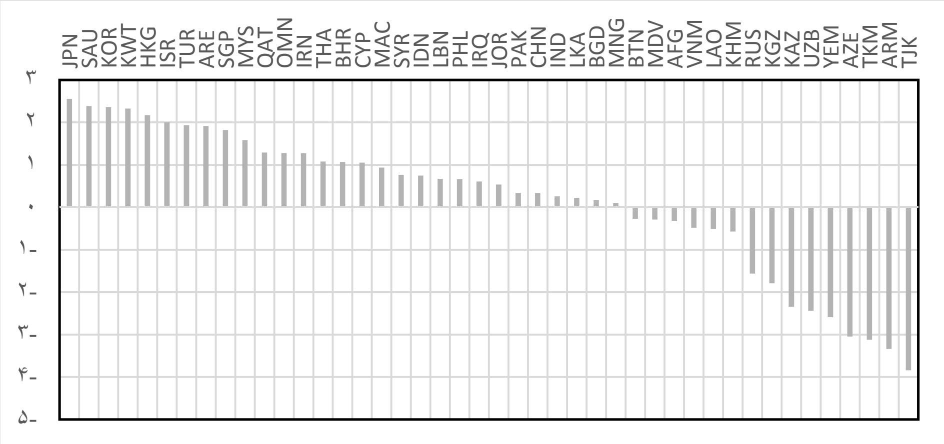

Figure 4. TFP change of Asian countries economics for 10-year periods from 1998 to 2007

Access to the high growth rate of productivity is not easy and needs taking optimal use of all facilities and resources.

5. Conclusion

The results of this study demonstrated that there are two groups of countries in terms of productivity growth: Countries with positive productivity growth and countries with negative productivity growth. Japan with an average growth of 2.55% ranked first among other countries which was a result of its considerable technical progress. Saudi Arabia, South Korea, Kuwait and Hong Kong were in the latter ranks. However, Saudi Arabia and Kuwait had most of their productivity growth for the sake of changes in technical efficiency; while the technical progress of these two countries was lower than the East Asian countries such as Japan, Singapore, South Korea and Hong Kong.

In some countries despite the fact that the average of technical change was negative, yet due to the relatively high efficiency changes, productivity growth has been positive. In other words, efficiency changes have been the main factor of productivity growth in these countries. Iran is in this group as well. These countries were Oman, Iran, Thailand, Bahrain, Syria, Indonesia, Lebanon, the Philippines, Iraq, Jordan, Pakistan, China, India, Sri Lanka, Bangladesh and Mongolia

In some countries, the main reason for negative productivity growth has been the result of negative changes of technology. These changes were negative in Russia, Kazakhstan, Turkmenistan, Azerbaijan, Armenia, Uzbekistan and Tajikistan and were relatively high. However, it should be considered that the average of technical efficiency has been lower than one in all of these countries. But in many countries, negative technical changes were in such a way that cause a negative growth of total productivity. Furthermore, division of productivity into technical efficiency and technological change showed that changes of efficiency in all countries had a positive impact on productivity growth whereas the role of technical progress has been negative.

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