

# Productivity Growth and Technical Efficiency Change in the Southern Mediterranean Countries under the Barcelona Process

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## Abstract

Most economies in the Southern Mediterranean countries (SMCs) have been criticised for experiencing an insignificant total factor productivity growth. This study investigates the sources of economic growth by estimating the technical efficiency and its determinants of five SMCs: Algeria, Egypt, Jordan, Morocco and Tunisia. Using data from 1980 to 2007, the Cobb-Douglas form of the stochastic frontier production function and the inefficiency function were estimated. The empirical results indicate that the technical efficiency of production ranges from a minimum of 55.1% to a maximum of 99.2%, with an average level of technical efficiency estimated at 79.5%. This implies that the economies of the five SMCs can increase their productivity by an average of 20.5% through more efficient use of technology and production inputs. The relative contribution of technical efficiency to productivity growth estimated at 30.5% indicates that an improvement in technical efficiency significantly contributes to productivity growth. The main factors that contributed to the improvement of technical efficiency were import of technology embodied in manufacturing goods and technology transfer through foreign direct investment (FDI). While the technical efficiency of SMCs has been improving since the mid-1990s when the Barcelona Process was launched,

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openness to international trade is inevitable but does not promise improvement in technical efficiency. To seize the positive effect, it is important to stimulate technology diffusion and knowledge spillover by attracting FDI and promoting technology imports.

*Keywords:* total factor productivity; technical efficiency; stochastic frontier production function; Barcelona Process; Southern Mediterranean countries

## I. Introduction

Economic integration with the European Union (EU) became almost inevitable for the Southern Mediterranean countries (SMCs), as a consequence of having concluded the association agreement under the framework of the Euro-Mediterranean Partnership (Barcelona Process) that began in 1995.<sup>1</sup> This EU enlargement to the southern Mediterranean region has a growing effect of 'lock-in' that requires SMCs to open their markets and join the EU-Mediterranean free trade area. Increasing discipline towards free trade in multilateral and bilateral trade negotiation processes, as well as the abolition of quotas imposed by the Multi-Fibre Agreement (MFA) in 2005 will not allow the SMCs to implement conventional protectionist policies. Most of the SMCs also ratified the IMF article XIII, but this step-up also constrains conventional methods such as foreign exchange rationing. While options and alternatives are becoming limited under the Barcelona Process, it is necessary for the SMCs to promote industrialization and catch up by enhancing the competitiveness of domestic industries.

In the face of growing international competition, one of the main challenges for the SMCs' economies is the enhancement of productivity and technology levels. Historical experience suggests that application and imitation of advanced foreign technology is a key to success for developing economies. In the emerging East Asian economies including Asian NIEs and ASEAN, openness to international trade and investment promoted import of advanced technology

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1 The Euro-Mediterranean Partnership proposed an initiative to construct a zone of shared prosperity through an economic and financial partnership, and the gradual establishment of a free-trade area by the target date of 2010. Negotiations for Agreements already concluded include those with Tunisia in 1995, Morocco in 1996, Jordan in 1997, Algeria in 2002 and Egypt in 2004. See the Euro-Mediterranean Partnership-Overview <[http://ec.europa.eu/external\\_relations/euromed/index.htm](http://ec.europa.eu/external_relations/euromed/index.htm)>(accessed: 30 September, 2010). Though the countries included in SMCs are not clearly classified, it is defined in this paper that SMCs is a group countries consists of 10 Mediterranean partners under the Euro-Mediterranean Partnership, namely Algeria, Egypt, Israel, Jordan, Lebanon, Morocco, Palestinian Authority, Syria, Tunisia, Turkey, and Libya which obtained observer status since 1999.

embodied in capital and intermediate goods. As for the SMCs, most of them predominantly import manufactured and semi-finished products from the EU while a majority of their export is either agricultural products or raw materials. Considering the current trade relation with the EU, improvement in technical efficiency and technological progress through import and transfer of foreign advanced technology are important challenges for the SMCs to further upgrade their competitiveness.

However, most economies in the Middle East and North Africa (MENA), as well as the SMCs, have been criticised for creating insignificant total factor productivity (TFP) growth. Pissarides and Vegganzones-Varoudakis (2007) estimated that the average annual growth rate of TFP from 1960 to 2000 was 0.5% in MENA whereas it was 1.3% in East Asia. Makdisi, Fattah and Limam's (1997) estimation found a negative growth in TFP of MENA at  $-0.02\%$  (1960–1997). Abu-Qarn and Abu-Bader (2007) assert that the sluggish growth of GDP in most MENA economies is a major factor for the decline in TFP. While the reasons behind the stagnated growth of TFP in the MENA have not been well clarified, the overriding conclusion is that capital accumulation, rather than productivity growth, has been the underlying source of income growth (Devlin, 2010). Indeed, many Arab countries including the SMCs have been losses in international competitiveness in the recent years through 2000, and fewer countries are enjoying export growth (Dasgupta et al., 2003). The stagnated growth of TFP and the losing in international competitiveness imply that the MENA economies suffered from lower production efficiency and failed to improve the efficiency and induce technological progress.

On the other hand, the above-mentioned studies which used the conventional growth accounting approach do not distinguish between the two components of TFP growth. Even for the analysis of the MENA, Robert Solow's well-known residual approach is widely applied to investigate the sources of economic growth and technological change (Nugent and Pesatan, 2007). As first argued by Nishimizu and Page (1982) and empirically applied by Kalirajan, Obwona and Zhao (1996) and by Mahadevan and Kalirajan (2000), TFP growth stems from a combination of technological progress and improvements in technical efficiency. Failure to consider changes in technical efficiency in measuring TFP growth produces biased estimates (Mahadevan and Kalirajan, 2000). However, investigation of technical efficiency for the SMC as a source of growth is merely absent. Although many studies that applied the residual approach found low and even negative TFP growth in MENA economies, growth and contribution of an improvement in technical efficiency is worth analysing by distinguishing these two components of TFP growth.

This study investigates the sources of economic growth by estimating technical efficiency and its determinants in five SMCs: Algeria, Egypt, Jordan, Morocco and Tunisia, as well as applying the stochastic frontier approach to aggregate data from 1980 to 2007. An investigation of the

level of productivity and the degree of efficiency in these five countries may provide valuable insights into potential productivity improvements. This is particularly important because of the implementation of the free trade agreement with the EU and the abolition of the Multi-Fibre Agreement, which has led to the elimination of tariffs, other trade barriers and export quotas.

This paper is structured as follows: Section II summarises the model and data used in this study. Section III discusses the empirical results. The conclusion is presented in Section IV.

## II. Model and data

This section describes a model for estimating technical efficiency and its determinants at the aggregate level in the Southern Mediterranean economies. As Coelli et al. (2005) comprehensively reviewed, the measurement of technical efficiency has become a common framework with the development of the Stochastic Production Frontier (SPF) models by Aigner, Lovell and Schmidt (1977) and Meeusen and Van don Broeck (1977). The approach adopted in this study is the general form of the panel data version of Aigner, Lovell and Schmidt (1977), which extended the Battese and Coelli (1995) model of the stochastic frontier production function. The SPF model is based on a parametric specification of technology with inefficiency effects. The disturbance term in stochastic production frontier is assumed to be composed of two elements: a symmetrical error term ( $v$ ) that accounts for random effects and a one-sided non-negative random disturbance ( $u$ ) that is not explained by the production function and associated with technical inefficiency of production. By decomposing the error term, the stochastic frontier production function for panel data can be expressed as:

$$Y_{it} = f(X_{it}; \beta) \exp(v_{it} - u_{it}), \quad (1)$$

where  $Y_{it}$  denotes the gross production for the  $i$ th country;  $\beta$  is a vector of unknown parameters to be estimated;  $X_{it}$  is a vector of production inputs;  $v_{it}$  refers to statistical random disturbance terms, assumed to be independently and identically distributed  $N(0, \sigma_v^2)$ ;  $u_{it}$  represents non-negative random variables, assumed to be independently and identically distributed  $N(0, \sigma_u^2)$  with truncations at zero.

In this specification,  $-u_{it}$  measures the distance between the realised output and the frontier output. The  $\exp(-u_{it})$ , which varies between 0 and 1, is a measure of technical efficiency of the  $i$ th country. Following Battese and Coelli (1995), the technical inefficiency effect,  $u_{it}$ , in the stochastic frontier model (1) could be specified:

$$u_{it} = \delta z_{it} + w_{it}, \quad (2)$$

where  $\delta$  is a vector of unknown parameters to be estimated;  $z_{it}$  is a vector of explanatory variables associated with technical inefficiency in production;  $w_{it}$  is a random variable with zero mean and variance  $\sigma^2$  defined by the truncation of the normal distribution such that the point of truncation is  $-z_{it}\delta$ , i.e.  $w_{it} \geq -z_{it}\delta$ . The technical efficiency of production of the  $i$ th country is defined by the ratio of the observed output to the corresponding frontier output:

$$TE_{it} = \exp(-u_{it}) = \exp(-z_{it}\delta - w_{it}), \quad 0 \leq TE_{it} \leq 1. \quad (3)$$

The prediction of the technical efficiencies of the  $i$ th country relies on the conditional expectation of  $u_{it}$ , given the observed value of  $v_{it} - u_{it}$  [Jondrow et al. (1982); Battese and Coelli (1993); Battese and Coelli (1995)]. Given the assumptions of the statistical distribution of  $u_{it}$  and  $v_{it}$  and the maximum likelihood (ML) estimates of production frontier, the best predictor of  $u_{it}$ , given  $v_{it} - u_{it}$  is obtained as (Battese and Coelli, 1993):

$$E[\exp(-u_{it}) | (v_{it} - u_{it})] = \left[ \exp\left\{ \frac{1}{2} \sigma_v^2 - u_{it}^* \right\} \right] \left[ \frac{\Phi(u_{it}^*/\sigma_v) - \sigma_v}{\Phi(u_{it}^*/\sigma_v)} \right], \quad (4)$$

$$\text{where } u_{it}^* = \frac{\sigma_v^2(\hat{\delta} z_{it}) - \sigma_u^2(w_{it})}{\sigma_v^2 + \sigma_u^2} \quad \text{and} \quad \sigma_v^2 = \frac{\sigma_v^2 \sigma_u^2}{\sigma_v^2 + \sigma_u^2}.$$

The function  $\Phi(\cdot)$  denotes the cumulative distribution function (cdf) of the standard normal random variable evaluated at  $(\mu_{it}^*/\sigma_v)$ .

Given the above assumptions, the following Cobb-Douglas functional form was used to estimate the stochastic frontier production function:

$$Y_{it} = A_{it} K_{it}^{\beta_k} L_{it}^{\beta_l} e^{v_{it} - u_{it}}, \quad (5)$$

where  $Y_{it}$  denotes gross production,  $K_{it}$  and  $L_{it}$  represent the capital stock and the labour input, respectively, of the  $i$ th country in period  $t$ .  $\beta_i$  ( $i = k, l$ ) is an unknown parameter to be estimated.  $A_{it}$  denotes an indicator that considers changes in technology and represents technological progress in period  $t$ .  $\beta_t$  is an unknown parameter to be estimated that detects the rate of technological progress.

$$A_{it} = e^{\beta_t t}. \quad (6)$$

Assuming constant returns to scale (CRTS), equation (5) is rewritten as:

$$y_{it} = A_{it} k_{it}^{\beta_k} e^{v_{it}-u_{it}}, \quad (7)$$

and the model is specified in logarithmic form, as in equation (8).

$$\ln y_{it} = \beta_0 + \beta_t t + \beta_k \ln k_{it} + v_{it} - u_{it}, \quad (8)$$

where  $y_{it}$  denotes gross production per labour ( $Y_{it}/L_{it}$ ),  $k_{it}$  denotes the capital-labour ratio (Kit/Lit) for the  $i$ th country in period  $t$ .  $\beta_i$  ( $i = 0, t, k$ ) is an unknown parameter to be estimated.

Equation (8) indicates that the technical efficiency of  $i$ th country is estimated by the difference between maximum possible output and the observed output. A change in technical efficiency shows the movement of the country's actual output to its maximum possible output, given the technology. However, the extent of technological progress is measured by the extent to which the industry's potential frontier shifts from one period to another.

The technical inefficiency effect to be estimated is defined as follows:

$$u_{it} = \delta_0 + \delta_1 (TRD_{it}) + \delta_2 (MFI_{it}) + \delta_3 (FDI_{it}) + \delta_4 (DUN_{it}) + \delta_5 (DUO_{it}) + \delta_6 (DUE_{it}) + w_{it}, \quad (9)$$

where  $TRD$  is the share of trade to GDP;  $MFI$  represents the ratio of manufacturing goods imports to total volume of import;  $FDI$  denotes the share of foreign direct investment inflow to GDP;  $DUN$  is a dummy variable that equals 1 if the country is located in the North African region and zero otherwise;  $DUO$  denotes a dummy variable that equals 1 if the country is oil-producing and zero otherwise;  $DUE$  is a dummy variable that equals 1 for all the period after the conclusion of association agreement with the EU and zero otherwise;  $w_{it}$  refers to a random term.<sup>2</sup> The parameters of the stochastic frontier production function in equation (8) and the model for technical inefficiency effects in equation (9) may be estimated simultaneously by the maximum likelihood model (Reinischneider and Stevenson, 1991; Huang and Liu, 1994).

The data used in this study are taken from the CD-ROM of World Development Indicators provided by the World Bank. The data of five SMCs (Algeria, Egypt, Jordan, Morocco and Tunisia) covering the period from 1980 to 2007 were collected. A series of data on gross domestic

2 The EU is the dominant trade partner for North African countries and for the Magreb countries in particular while that of Jordan is Saudi Arabia, Iraq and the US. The rationale behind inserting the regional dummy  $DUN$  that separates Jordan from North African countries is to capture the difference in the direction of trade that may affect the level of technical efficiency.

product (GDP), capital stock and labour force in these five countries were used in the estimation of the stochastic frontier model. To estimate the inefficient effects model, the data for volume of trade, volume of manufacturing goods imports and foreign direct investment inflow were collected. All monetary values were real value in US dollars at the constant price of the year 2000. To construct a series of physical capital stock for the five countries, the perpetual inventory method (PIM) was used. The capital stock for the year  $t$  in the  $i$ th country equals the capital stock of the previous year,  $K_{i,t-1}$ , the rate of depreciation,  $\delta$  and the flow of gross investment in the current year,  $I_{it}$ . The series of capital stock for each country can be calculated as follows:

$$K_{it} = I_{it} + (1 - \delta)K_{i,t-1}. \quad (10)$$

The series of investments were extended back to 1975. The initial capital stock was calculated by the following equation to construct the series of capital stock:

$$K_{it} = I_{it} \frac{1 + g_{it}}{g_{it} + \delta}, \quad (11)$$

where  $g_{it}$  denotes the average annual growth rate of the real GDP over subsequent years.<sup>3</sup> For the aggregate capital stock, a depreciation rate ( $\delta$ ) of 4% to 6% is frequently assumed. In this estimation, the initial capital stock and the consequent series of capital stock were estimated using alternative assumptions: 4%, 5% and 6%. When applied to the estimation of the stochastic frontier production function, the choice of depreciation rate did not seem to matter. Thus, estimated results with a depreciation of 5% were presented in this study. This is consistent with many studies on economic growth of developing economies, including the SMCs [Collins and Bosworth (1996); Abu-Qarn and Abu-Bader (2007)].

Summary statistics of the variables are presented in Table 1.

3 Many studies frequently adopted this measure for the estimation of initial capital stock, since it captures long-run effects and avoid short-run fluctuations. See Abu-Qarn and Abu-Bader (2006:756-757).

Table 1. Summary statistics of the data

Variables	Mean Values	Standard Deviation	Maximum	Minimum
<i>Y</i> : GDP (million USD)	36,855.3	29,113.6	135,867.0	4,213.0
<i>K</i> : Capital stock (million USD)	131,942.1	94,123.8	317,069.0	11,932.7
<i>L</i> : Labour (thousand)	7,781.1	6,406.2	25,498.8	435.8
<i>y</i> : Labour productivity (USD)	5,502.8	1,739.9	10,193.4	3,244.9
<i>k</i> : capital-labour ratio (USD)	20,423.5	8,886.5	44,536.9	10,401.1
<i>TRD</i> : Share of trade to GDP (%)	75.5	29.6	154.6	32.7
<i>MFI</i> : Share of manufacturing goods to total import (%)	62.4	8.4	79.8	40.3
<i>FDI</i> : Share of foreign direct investment inflow to GDP (%)	2.0	2.9	21.7	-0.6

### III. Empirical Results

The maximum likelihood (ML) estimates of the parameters of the model were obtained using the computer programme FRONTIER 4.1 (Coelli, 1996). Parameter estimates and *t* values of the ML estimators are given in Table 2. The signs of the estimated parameters of the Cobb-Douglas stochastic frontier production model are as expected. The estimated coefficients of the capital-labour ratio and the time, *t*, are positive and statistically significant at the 1% level. These results indicate a positive relationship between the capital-labour ratio and labour productivity. The rate of technological progress is 0.6%. However, these results imply that the output growth was largely explained by capital accumulation, although the contribution of technological progress was also significant.

The estimated coefficients in the technical inefficient model are also as expected. The estimated coefficients of the share of manufacturing goods imports to total imports (*MFI*) and the share of foreign direct investment (*FDI*) to GDP are negative and statistically significant at the 1% level. These results indicate that technology imports within manufacturing goods and technology transfer through FDI contribute to improved technical efficiency. However, the estimated coefficient of the share of trade (*TRD*) to GDP is positive and statistically significant at the 5% level. This implies that opening up to international trade negatively affects the increase in technical efficiency. The estimated coefficient of the dummy variable of the North African region (*DUN*) and that of oil producing countries (*DUO*) were positive and statistically significant at



Table 2. Parameter estimates and *t*-value  
of stochastic frontier model and inefficiency effects model

Variables	Estimates	<i>t</i> -value
Stochastic frontier model		
Intercept	0.689	1.194
lnk	0.816 ***	15.248
<i>t</i>	0.006 ***	2.795
Inefficiency effects model		
Intercept	−0.011	−0.087
<i>TRD</i>	0.004 ***	2.773
<i>MAI</i>	−0.006 ***	−2.641
<i>FDI</i>	−0.035 ***	−3.071
<i>DUN</i>	0.402 ***	3.730
<i>DUO</i>	0.036 ***	6.108
<i>DUE</i>	−0.036	−0.835
Variance parameters		
$\sigma^2$	0.013 ***	7.810
$\gamma$	0.376 **	1.757
Log-likelihood	116.090	

(Note) \*, \*\*, \*\*\* indicate significant at the 10% level, 5% level, 1% level, respectively.

the 1% level. The positive sign of the location dummy (*DUN*) indicates that technical efficiency declines in North African countries (Algeria, Egypt, Morocco and Tunisia) compared with Jordan. The positive sign of the dummy of oil producing countries indicates that technical efficiency is higher in non-oil producing countries compared with an oil producing country, Algeria, in this estimation. As for the effect of EU enlargement to the SMCs, the estimated coefficient of the dummy variable (*DUE*) was found to be negative but not statistically significant. This result implies that the EU might have a positive impact on enhancing technical efficiency. However, such positive impact has not been statistically confirmed.

The estimate of variance parameters,  $\gamma$ , is positive and statistically significant at the 1% level, indicating that inefficiency effects are significant in determining the level and the variability of the countries (Table 2). Thus, the stochastic frontier inefficiency model is empirically justified. In addition, two null hypotheses for the parameters of the model are examined in Table 3 using the log-likelihood test. The first null hypothesis of no inefficiency effects was rejected. The second null hypothesis that no country-specific factor makes a significant contribution to the explanation of the inefficiency effects was also rejected.

Table 3. Tests of hypotheses for the parameters of stochastic frontier model and inefficiency effects model

Null Hypotheses	Log-likelihood ratio	d.f.	Critical Value at 5%	Decision
No inefficiency effects $\gamma = \delta_i = 0 \ (i = 0, 1, 2, \dots, 6)$	218.948	8	15.5	Reject $H_0$
No country specific effects $\delta_i = 0 \ (i = 1, 2, 3, \dots, 6)$	133.724	6	12.6	Reject $H_0$

(Note) The value of the log-likelihood function under the specification of alternative hypothesis (i.e. unrestricted model) is 49.227.

Table 4 presents the results of the estimation of each country's technical efficiency. The estimated efficiency scores indicate that there exist some technically inefficient countries, although most countries appear relatively technically efficient. The average level of technical efficiency is 79.5%, ranging from a minimum of 55.1% to a maximum of 99.2%. It is suggested that the countries in the Southern Mediterranean region are producing an average of 79.5% of their potential with the given present state of technology and input levels. This implies that those countries can increase their production by 20.5% through more efficient use of technology and production inputs. Egypt, Jordan and Tunisia were relatively efficient, with an efficiency score greater than the average; however, Morocco and Algeria appeared relatively inefficient with their scores of 77.3% and 59.1%, respectively. These results imply that the extent to which each country could increase its production is different, ranging from 8.1% to 40.9%, given their present state of technology and input levels.

4 The null hypothesis ( $H_0: \gamma = 0$ ) was tested, using the generalized log-likelihood ratio,  $\lambda$ , given by  $\lambda = -2\{L(H_0) - L(H_1)\}$ .  $L(H_0)$ ,  $L(H_1)$  denote the values of the likelihood function under the null and the alternative hypothesis, respectively.

Table 4. Technical efficiency estimates of each country

Country	Technical efficiency (%)
Algeria	59.1
Egypt	87.7
Jordan	91.9
Morocco	77.3
Tunisia	81.5
All countries (Mean efficiency)	79.5
Min. efficiency	55.1
Max efficiency	99.2

(Note) The technical efficiency estimate indicates the average score from 1980 to 2007.

The trend of technical efficiency in the five countries is presented in Figure 1. The overall trends from 1980 to 2007 indicate that the level of technical efficiency improved in Egypt, Morocco and Tunisia. Although the initial level of technical efficiency was higher than average in Egypt, it has been improving since the beginning of the 1990s. For Morocco and Tunisia, the initial efficiency score was slightly lower than the average, but both economies show a long-term improvement. Jordan's initial highest level of efficiency with an increasing trend since 1990 somewhat limits its room for improvement. The technical efficiency score of Algeria (59.1%) was the lowest and has been stagnated during the observed period. These results suggest that the level of technical efficiency of the five countries have been improving since the mid-1990s.

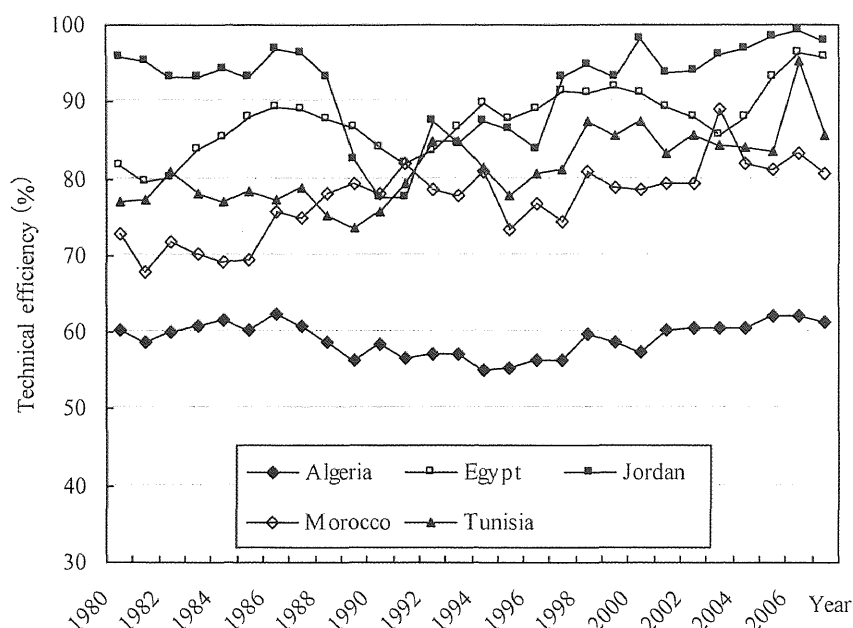


Figure 1. Changes in technical efficiency, 1980-2007

The estimation of the changes in technical efficiency and the relative contribution to productivity growth are summarised in Table 5. The average annual growth rate of technical efficiency was relatively higher at 1.77% in Egypt and 1.63% in Tunisia, although it remained at 1.09% in Morocco. The growth of technical efficiency is higher than the average in Egypt, Morocco and Tunisia, where the relative contributions to productivity growth were estimated at 33.4%, 35.5% and 23.9%, respectively, with an average of 30.5% for these three countries. These results indicate that improvements in technical efficiency have significantly contributed to the output growth in these countries. On the contrary, the improvement in technical efficiency has stagnated in Algeria and Jordan with its annual changes remaining at 0.06% and 0.09%, respectively. Compared with the results shown in Table 4 and Figure 1, the SMCs, except for Algeria, showed a relatively low level of technical efficiency but demonstrate prospects of long-term improvement.

Table 5. Changes in technical efficiency (TE) and relative contribution to productivity growth

Country	Average annual growth rate of labour productivity (%)	Average annual changes in TE (%)	Relative contribution of TE changes to labour productivity growth (%)
Algeria	−1.44	0.06	−4.5
Egypt	1.77	0.59	33.4
Jordan	−0.64	0.09	−13.7
Morocco	1.09	0.39	35.5
Tunisia	1.63	0.39	23.9

The empirical results explained in this section provide the following five implications. First, the five economies in the SMCs seem to be relatively efficient, with an average technical efficiency score of 79.5%. This implies that those countries can increase their production by 20.5% through more efficient use of technology and production inputs. Second, the technical efficiency of the five economies has been improving since the mid-1990s although its level differs by country. Third, the average relative contribution of technical efficiency to productivity growth was 30.5%. This indicates that improvement in technical efficiency significantly contributed to productivity growth. Fourth, technology imports embodied in manufacturing goods and technology transfer through FDI contributed to the improvement of technical efficiency. Fifth, the effect of the conclusion of the association agreement might be positive, but cannot be statistically confirmed. Increase in trade exchange did not have a positive impact. These results suggest that openness to international trade due to the effect of association agreement is inevitable but its effect is ambiguous for the improvement in technical efficiency. To seize the positive effect, it is important to stimulate the diffusion of technology and knowledge spillover.

While most studies on growth accounting of the economies of the SMCs have noted the stagnation of total factor productivity growth [Abu-Qarn and Abu-Bader (2007); Makdisi, Fattah and Limam (1997); Pissarides and Vegganzones-Varoudakis (2007); Devlin (2010)], this study revealed that improvements in technical efficiency have at least contributed to productivity growth. The major factor for improving technical efficiency was the import and transfer of technology through attracting FDI and encouraging technology imports within manufacturing goods. Although Nishimizu and Robinson (1984) suggested the existence of a significant correlation between export expansion and productivity growth, this study emphasises the necessity of a positive cycle of trade and investment, i.e. attracting FDI and technology imports that promote exports. However, it should be noted that relatively low rates of technological

progress coexist with improving technical efficiency. For Egypt, Morocco and Tunisia, innovation to stimulate a shift in production technology is essential to further increase productivity although the adoption of best practices has already contributed to it. On the contrary, in Algeria, a relatively low level and growth in technical efficiency might conceal the potential for stimulating technological progress. Deterioration of technical efficiency was the main cause for the lower TFP growth. In this case, more efficient use of inputs by adopting best practice techniques is necessary to further increase productivity.

#### **IV. Conclusion**

This study investigated the sources of economic growth by estimating technical efficiency of five SMCs and identifying the determinants of technical efficiency improvement, applying the stochastic frontier approach to aggregate data from 1980 to 2007. Using the five SMCs' aggregate data from 1980 to 2007 and applying the Cobb-Douglas form of the stochastic frontier, this study simultaneously estimated the production and inefficiency functions.

Empirical findings of the stochastic frontier production function indicated that the technical efficiency of production ranges from a minimum of 55.1% to a maximum of 99.2%, with an average level of technical efficiency estimated at 79.5%. This implies that the economies of the five SMCs can increase their productivity by an average of 20.5% through more efficient use of technology and production inputs. The relative contribution of technical efficiency to productivity growth was 30.5%, indicating that improvements in technical efficiency significantly contributed to productivity growth. Empirical results of the estimation of the inefficiency function indicate that the main factors contributing to the improvement of technical efficiency were technology imports within manufacturing goods and technology transfer through FDI. Although many studies criticised the insignificant total factor productivity growth in SMCs, improvements in technical efficiency at least contributed to productivity growth. It was also revealed that relatively low rates of technological progress coexist with improving technical efficiency in some countries such as Egypt, Morocco and Tunisia, and that a relatively low level and growth in technical efficiency might conceal Algeria's potential for stimulating technological progress. To further increase productivity and competitiveness, country-specific policy measures must be identified to accelerate technical efficiency and technological progress.

Levels of technical efficiency in most of the five SMCs have been improving since the mid-1990s when the Barcelona Process began. However, the conclusion of the association agreement and increase in international trade did not have a positive effect on improvement in technical efficiency. These empirical results suggest that openness to international trade is inevitable but does not promise to improve technical efficiency. It is the attraction of FDI and promotion

of technology imports that seize the positive effect through the diffusion of technology and knowledge spillover. This implication emphasises the importance of the positive cycle of trade and investment, i.e. attracting FDI and encouraging technology imports that promote exports for the SMCs to further strengthen regional integration.

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