Technological Progress and Scientific Indicators: A Panel Data Analysis

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Abstract

Total factor productivity (TFP) is generally interpreted to be a proxy for technological advancement. In this paper we use stochastic frontier analysis to decompose the growth in TFP into three components: technological progress, scale effect and change in technical efficiency. Then, we conduct a comprehensive panel data analysis using the technological progress component of the TFP growth and several scientific and technological indicators using data from 160 countries over the period from 1960 to 2009. Our results generally show that the technological progress component of the TFP growth properly reflects certain dimensions of actual scientific and technological progress. However, we also find that this result is somewhat sensitive to different econometric specifications and assumptions.

Keywords: Total factor productivity; Technological Progress; Stochastic Frontier Analysis; Panel Data

JEL Classification Numbers: C23; O30; 047.

1 Introduction

Since the 19th century, various economies enjoyed the blessings of persistent economic growth brought by industrial revolution. Thereafter, economists spent a significant amount of time to understand the driving forces behind this sustained economic growth.[1] Moreover, as well known, a distinguishing method for this endeavour was developed by Solow (1957) to investigate the main source of growth of the US economy for the first half of the 20th century, also applied to other economies and episodes later on. In this seminal work, Solow used an aggregate production function including physical capital, labor, as well as a time-varying parameter aiming to capture "technical change". Under the assumption that the input factors are paid their marginal productivities he demonstrated that 87.5% of the growth in the GDP per capita can be attributed to growth in technological progress. Notice that, Solow defined technical change as "any kind of shift in the production function". Accordingly, technological inventions, slowdowns, speed-ups, improvements in the education of the labor force etc. might appear as an indicator of technical change. (Also see Solow, 1956 on this.) The so-called "Solow residual" has started to be referred to as the "total factor productivity" (TFP) thereafter. Since then the TFP has been widely used to account for both long term growth and cross country income differences. (See for example Prescott (1998), Hall and Jones (1999), Caselli (2005) or Hsieh and Klenow (2010) among many various others.)

Even though generally, the TFP is assumed to be a proxy for technical or technological advancement, given that a functional form for the production function is assumed and estimated (such as a Cobb-Douglas one) one can observe that the TFP arising from such a function, might actually include many other things such as potentially omitted inputs, measurement errors, aggregation errors, excess returns and scale effects, technology and efficiency effects etc. Therefore, it is crucial to understand the exact nature of the TFP, separate one effect from another and how each of these effects is related to technological and scientific advancement. Unfortunately, the literature so far failed to generate a consensus

[1]Among many others Griliches (1996) provides an excellent review of this literature.

regarding the measurement and the decomposition of TFP. This is also one of the reasons why Solow (1957) mentions earlier that the term “technical change” is used as a short-hand expression for any kind of shift in the production function. Similarly, Nadiri (1970) avoids making a precise TFP decomposition but mentions that it included scale effects as well as “specific embodiment of technical know-how in the form of better organizational structures, new equipment, better skills etc.”. In a similar fashion, Abramovitz (1962) and Jorgenson and Griliches (1967) also use similar terms when referring to the TFP. On the other hand, Lipsey and Carlaw (2000, 2003 and 2004) argue that the TFP is not a measure of technological change but instead includes excess returns, externalities and “free lunches” of technological change due to the fact that any cost incurred in the implementation of technological change is rewarded by a normal return of the change. Hulten (2000) agrees with Lipsey and Carlaw’s view that as long as the R&D costs (including implementation costs) are not excluded from factor input costs, TFP cannot be a measure of technical change.[2]

Evident from the different views and the number of cited papers above, the discussion and the existence of of an ambiguity on what the TFP includes and measures led to an extensive literature on the decomposition of TFP. Generally,TFP is decomposed into three different components: technology, efficiency and “neglected unconventional inputs”. To address one specific dimension in this literature and to understand to what extent the TFP can be used as a proxy for technological advancement, in this paper we empirically investigate the relationship between the growth in the “technology” component of TFP and several scientific and technological indicators. We ask, whether some (if any) aggregate scientific and technological indicators are significanty associated with the growth in the technology component of the TFP. To this end, first we use the stochastic frontier analysis to decompose the growth in TFP into three components: technological progress, scale effect and change in technical efficiency. Then, we conduct a comprehensive panel data analysis between the technological progress component of the TFP and several scientific and technological

[2]Also see Farrell (1957),Nishimizu and Page (1982), Bauer (1990) and Fare et al. (1994), and more recently Kumbhakar (2000), for similar arguments.

indicators using data from 160 countries over the period from 1960 to 2009. Our results generally show that the technological progress component of the TFP series properly reflects actual technological progress. However, we also find that this result is sensitive to different empirical specifications and assumptions. Nevertheless, our analysis indicates that three specific scientific indicators, namely number of scientific articles, patent application and trademark application are significantly correlated with technological progress in a robust manner.

Several methods have been proposed in the literature for the decomposition of the TFP. One such method is based on a nonparametric approach relying on data envelopment analysis within the framework of linear programming. Another method is based on a parametric approach which has three variants with respect to the determination of the error component: deterministic, probabilistic and stochastic error structure. This difference with respect to the error component is imposed to the model in order to determine the possible locations of the cross-sectional units (mostly countries) with respect to their production frontiers. Among these three variants, stochastic frontier approach for cross sectional data is the most recent one which is independently pioneered by Aigner et al. (1977) and Meeusen and van den Broeck (1977). Since then, this approach has been improved by many researchers to include panel data cases and various specifications regarding the error structure such as distribution and evolution of inefficiency with respect to time. (See Kumbhakar and Lovell (2003) for an excellent review of the literature.) Stochastic frontiers analysis also varies with respect to the assumption of the evolution of the inefficiency with respect to time. While former models have implemented time invariant inefficiency models such as Schmidt and Sickles (1984) and Battese and Coelli (1988), more recent models such as Lee and Schmidt (1993), Kumbhakar (1990) and Battese and Coelli (1995), have allowed the variation of inefficiency along with time. Panel data version of the stochastic frontier analysis is based on the well-known panel data analysis with fixed or random effect models. One common feature of the aforementioned models is that the intercept term is the same across time and units and the efficiency of the entities is captured by the intercept term. However, intercept terms may also include unmeasured time-invariant and firm-specific heterogeneity which may amplify the differences across the entities and lead to biased estimates. To overcome this drawback Greene (2005a, 2005b) uses different intercept terms for each entity and unmeasured firm-specific heterogeneity. In this paper we use time-varying inefficiency models, particularly the one used by Lee and Schmidt (1993) and Battese and Coelli (1992 and 1995) as well as Greene's (2005, 2005b) "true fixed effect" and "true random effect" models with their different error term distribution alternatives. Moreover, we also expect to draw a conclusion about the sensitivity of our main results with respect to different models or different distribution assumptions within the same model.

Our paper is unique in the literature in using a large panel dataset to investigate the relationship between technological progress component of the TFP and various scientific indicators. Moreover, our finding that the three indicators (number of articles, patent applications and trademark applications) significantly correlate with technological progress is also a novel and unique finding, which also has several policy recommendations for policy-makers.

The rest of the paper is organized as follows: In the next section we discuss the econometric methodology we use in our analysis. Then, in the third section, we give a full description of our dataset. In section four, we present our estimation results. Finally, in the last section we provide some concluding remarks and a discussion.

2 Methodology

In order to decompose the TFP series and separate the technological progress from other components of the growth in TFP, we conduct a decomposition analysis similar to several time varying inefficiency models, including Battese and Coelli (1992 and 1995), Lee and Schmidt (1993) Greene (2005a). To this end, we use a translog production function, widely employed in the literature. The main advantage of such a production function is that it needs very few assumptions to justify. (especially compared to the Cobb-Douglas production function) There is vast evidence in the literature (Kumbhakar and Wang, 2005, Hamit-Haggar, 2011 and Pires and Garcia, 2012) regarding the translog's advantages over the Cobb-Douglas production function. Moreover, with the help of the translog formulation, we are also able to decompose the TFP into scale effect, too, which is not possible in the standard Cobb-Douglas type due to presumption of the returns to scale. Therefore, once we decompose the TFP by using translog production function, we end up with a more refined measure of technological progress.

The general form of the production frontier function is given below, where y is the actual output level, $f(k,l,t)$ is the production frontier(potential production level with full efficiency), $\exp(-u)$ is the technical inefficiency level, and $\exp(v)$ represents the random shocks:

$$y_{it} = f(k,l,t)\exp(-u)\exp(v)\ , \quad u \geq 0 \tag{1}$$

The logarithmic form of the stochastic frontier, consisting of $f(k,l,t)$ and $exp(v)$, is denoted by the following:

$$\begin{aligned} \ln y_{it} + u_{it} = \beta_0 + \beta_t t + \beta_k \ln k_{it} + \beta_l \ln l_{it} + 0.5[\beta_{tt}t^2 + \beta_{kk}(\ln k_{it})^2 + \beta_{ll}(\ln l_{it})^2] \\ + \beta_{tk} t \ln k_{it} + \beta_{tl} t \ln l_{it} + \beta_{kl} \ln k_{it} \ln l_{it} + v_{it}, \end{aligned} \tag{2}$$

where l_t is labor, k_t is capital, t is time trend, and βs are the coefficients to estimate. The random error term, $\exp(v)$, captures the measurement errors and exogenous shocks and is assumed to be independent and identically distributed with zero mean and constant variance, σ_v. The inefficiency parameter $\exp(u)$, provides the connection between the frontier and the actual production level of the relevant entity. In other words, it represents technical inefficiency, that is, the distance of actual output level from the potential one. In the literature, exponential, truncated normal and half normal distribution are generally assumed for the distribution of this term. (Pires and Garcia, 2012)

Other than the error component, the production function consists of three key variables and their interaction terms with other variables including the interaction with themselves. Therefore, the relevant coefficients must be carefully interpreted. For output elasticities of the inputs, the partial derivatives with respect to inputs have to be taken. Specifically, the output elasticity of capital and labor are given as follows:

$$\frac{\partial \ln f(.)}{\partial \ln k} = \beta_k + \beta_{kk} \ln k_{it} + t\beta_{tk} + \beta_{kl} \ln l_{it} \tag{3}$$

$$\frac{\partial \ln f(.)}{\partial \ln l} = \beta_l + \beta_{ll} \ln l_{it} + t\beta_{tl} + \beta_{kl} \ln k_{it} \tag{4}$$

In our setup, we, first, ascribe the output growth into three factors which are efficiency change, input growths including the scale effects and the technological progress.

$$\frac{\dot{y}}{y} = \frac{\partial \ln f(k,l,t)}{\partial t} + \epsilon_k g_k + \epsilon_l g_l - \frac{\partial u}{\partial t}, \tag{5}$$

where ϵ_k and ϵ_l are output elasticity for capital and labor, respectively. Since there is no assumption regarding the returns to scale of the translog production function, we cannot interpret them as shares of inputs, yet. Therefore, we need to extract the scale effect from the input growth. Scale effect is obtained by the following:

$$\text{Scale effect} = (\epsilon_k + \epsilon_l - 1)(\frac{\epsilon_k}{\epsilon_k + \epsilon_l} g_k + \frac{\epsilon_l}{\epsilon_k + \epsilon_l} g_l), \tag{6}$$

where $\frac{\epsilon_k}{\epsilon_k+\epsilon_l}$ and $\frac{\epsilon_l}{\epsilon_k+\epsilon_l}$ denote shares of capital and labor in the scale effect, respectively.[3] After necessary refinements and some algebraic manipulations, the TFP growth is decomposed into the following three factors:

[3]Notice that, in a standard Cobb-Douglas production function, obviously, there is no room for this refinement.

i. Technological progress: $\frac{\partial \ln f(k,l,t)}{\partial t} = \beta_t + \beta_{tt} t + \beta_{tk} \ln k_{it} + \beta_{tl} \ln l_{it}$

ii. Scale effect: $(\epsilon_k + \epsilon_l - 1)(\frac{\epsilon_k}{\epsilon_k+\epsilon_l} g_k + \frac{\epsilon_l}{\epsilon_k+\epsilon_l} g_l)$

iii. Change in technical efficiency: $-\dot{u} = -\frac{\partial u}{\partial t}$.

Having accomplished the refinement, the growth output can then be divided into growth in inputs and TFP growth decomposed into change in efficiency, technological progress and scale effect.

$$g_{TFP} = \frac{\partial \ln f(k,l,t)}{\partial t} + (\epsilon_k + \epsilon_l - 1)(\frac{\epsilon_k}{\epsilon_k + \epsilon_l} g_k + \frac{\epsilon_l}{\epsilon_k + \epsilon_l} g_l) + -\dot{u} \tag{7}$$

Although these three factors collectively constitute the TFP, their effects on the production frontier are different. An increase in the technological progress and scale effect shift the frontier outwards while the change in technical efficiency changes only the position of the production entity with respect to the relevant frontier, without changing the position of the frontier. Based on this mechanism, any improvement of the TFP increases the actual output level, but we cannot be sure that the potential output level of the country is increased since the improvement of the TFP may stem, merely, from the efficiency increase, which is embodied in TFP, too.

Once we decompose the growth in the TFP, in the second part of the analysis, we use the technological progress component of it and make it subject to an econometric analysis to analyze its relationship with different scientific and technological indicators. To this end, using panel data we regress the decomposed technological progress ($\text{TP}_{i,t}$) on these different indicators (S) one by one. The regression model is of the following form:

$$TP_{i,t} = \beta_0 + \beta_1 S_{i,t} + \beta_i \sum_{i=2}^{n} X_{i,t} + \gamma_t + \theta_i + \epsilon_{i,t} \tag{8}$$

Here, for country i and year t γ_t and θ_i denote period (year) and country fixed-effects and $\epsilon_{i,t}$ is the error term. Finally, $X_{i,t}$ denote the control variables. As we will explain in more detail in the next section, we use real GDP per capita, government spending as % of GDP, trade openness and school enrolment ratio as control variables. Nevertheless, in our regressions, we will especially examine the sign and the level of the estimated value of β_1.

Moreover, we also run some regressions using the GMM estimator developed by Arellano and Bond (1991). In addition to the previous specification, here we also use one-period lagged values of the dependent variables among the independent variables. Using this estimator also helps us to address potential endogeneity and mean reverting dynamics.[4]

3 Data

In our empirical analysis, to understand how robust the relationship between the technological progress and scientific-technological indicators are to the inclusion of various control variables, we will use various control variables in our regressions, in addition to the indicators.

We use per capita real GDP in constant USD (rgdpl), secondary school enrollment ratio (school), total government spending as a ratio to GDP (kg) and trade openness (openk) defined as the ratio of the sum of exports and imports to GDP as control variables in our regressions. These variables are the most widely used control variables in growth regressions and we hypothesize that they might also potentially explain variation in technological progress. Ex-ante, we expect that countries with a higher schooling rate, per capita income and are more open to international trade open to have a higher rate of technological progress.

We obtained the series used in the empirical analysis from several different sources. The PWT 7.0 is used in order to obtain GDP, population, labor, openness and investment series for 160 countries over the period from 1950 to 2009. Next, we have employed the widely used perpetual inventory method to construct a series for the capital stock. [5]

[4]At this point, we should also yield that there might exist a possibility for the existence of a two-way causality between the dependent (TP) and the control variables. To address this we have run several regressions using lagged dependent variables as instruments for their levels, as well as some systems estimations hypothesizing two-way causality between the variables and obtained qualitatively similar results. These are available upon request from the corresponding author.

[5]The formula used for the calculation of the capital series is the well-known perpetual inventory method.

Once we decompose the TFP using the above-mentioned methodology, we employ panel data techniques to understand the relationship between scientific and technological indicators and the growth in technological progress. To this end, we regress technological progress on nine different indicators one by one, along with other control variables. These indicators are obtained from the World Bank Development Indicators (WDI). Since the series in the WDI are only available for the period after 1960, at the end, we have a panel dataset for 160 countries from the period from 1960 to 2009. In all the regressions reported in the next section, we use 5 year-averaged data of all the variables in order to overcome the effects of the business cycles and measurement errors.

Table 1 provides descriptive statistics of the components of the TFP as well as the control variables using five-year averaged data from 1960 to 2009 for 169 countries. Here, when we report the TFP growth and its components we report series obtained using the true fixed model with exponential distribution of inefficiency a la Greene's (2005a) and the one following Lee and Schmidt (1993).

Moreover, as for the scientific and technological indictors we use the following list variables from the WDI in our regressions:

- **articles**: Number of scientific and technical journal and engineering articles in several fields such as physics, biology, and space sciences

- **techpop**: Number of technicians in R&D and equivalent staff per million of population. These people's work primarily necessitates technical knowledge and experience in engineering, physical or social sciences.

- **hitech_exp**: It is the ratio of amount of high technology export to the amount of manufactured export. High technology exports are exported products that is produced

Accordingly, the initial year's capital-output ratio for any country i is calculated with the following formula $\frac{K_0}{Y_0} = \frac{I/Y}{g_y+\delta}$ where g_y is the average growth rate of GDP in the period of interest. δ is the depreciation rate and I/Y is the average investment-to-GDP ratio in the period of interest. In these calculations we have assumed that $\delta = 0.08$. Once the initial year's capital-output ratio is calculated, the rest of the capital stock series is obtained with $K_{t+1} = K_t(1-\delta) + I_t$.

by using R&D intensely such as computers, aerospace and pharmaceuticals.

- **hitech_gdp**: The ratio of high technology export to GDP.

- **patentapp**: The number of patent applications made by residents and non-residents in a given year.

- **tmapp**: The number of trademark applications made by residents and non-residents in a given year.

- **roy_gdp**: The ratio of sum of payments and receipts of royalty to GDP.

- **rdgdp**: The ratio of expenditures for research and development, including public and private research and development expenditure, to GDP

- **rdpop**: Researchers in R&D per million of population. Researchers are people primarily engaged in the creation of new knowledge, products, methods etc.

Figures 1, 2, and 3 jointly aim to illustrate the observed plain correlations between three different indicators and technological progress component of the growth in TFP. Here we report the time-series averages (from 1960 to 2009) of each country in our dataset. We deliberately illustrate the relationship between technological progress component of the TFP (on the y-axis) and only three specific scientific indicators, as these indicators are the only ones having a significant correlation with technological progress. These indicators are the number of scientific articles, patent applications and trademark applications. (all expressed in per-capita) The existence of a significant correlation between technological progress and these indicators indicates that these indicators have the potential to account for the cross-county and time-series variation in this specific component of the TFP. Nevertheless, observing a significant correlation is not enough to establish a robust relationship. That is why we will further investigate the robustness of this relationship with various regressions. In the next section we will show that these significant correlations will survive various econometric specifications and inclusion of control variables.

4 Estimation and Results

As mentioned before, the coefficients attained by the stochastic frontier analysis cannot be interpreted directly in terms of output elasticities of inputs. However, the signs of these coefficients embody some important information about the marginal effects of the corresponding variable. The results[6] are presented in Table 2. All the coefficients except β_{kl} and β_{kk}, which represents for the capital-labor interaction and capital square, respectively, are significant at the 1 % level of significance. β_t and β_{tt} are the coefficients of the neutral part of the technology, that is, the cause of the parallel shifts in the frontier. Along with the neutral part of the technological progress, there is also a non-neutral part. The positive sign of β_{kt} indicates the presence of capital-biased technological progress. The negativity of β_{tl} shows that technological progress is labor saving and technological progress of labor intense countries are less than the capital intense countries. The negative sign of β_k is somewhat puzzling, but we need to recall that the coefficients cannot be directly interpreted as elasticities and the effect of capital on production is not reflected only by β_k. Therefore, in order to identify the effect of capital on the production, the interactions with time, labor and capital itself must also be taken into consideration.

For output elasticities, some algebraic manipulation in the translog production function is needed. We are able to calculate elasticities for each year taking the partial derivatives with respect to the inputs. The average values of output elasticities , returns to scales, technological progress, and growths for each of the 160 countries are presented in appendix.(See Table 7.)

For the second part of the analysis, we conduct an econometric analysis using nine different decomposition models including Battese and Coelli (1992 and 1995), Lee and Schmidt (1993) and Greene (2005a). However, due to space constraints, we only present full results of two among these nine and only present summary findings of the remaining seven. The

[6] The decomposition analysis and the consecutive panel data analysis are conducted by using STATA. For the implementation of different decomposition models we particularly benefited from Belotti et al. (2012).

first of these two is Greene's (2005) "true fixed effect" model with exponential distribution of inefficiency term. The second one is the result of the same analysis accomplished by using technological progress output of Lee and Schmidt (1993) decomposition model. In both tables, each column represents a fixed effect regression where dependent variable is the decomposed technological progress and the independent variables are one of the technology and science indicators, four control variables and the year dummies.

The results of the regressions using the "true fixed effect" model with exponentially distributed inefficiency and indicators are presented[7] in Table 3.Each column of the table replicates the same analysis; the only difference is the indicator used in the right hand side. We observe from the table that the statistically significant indicators are scientific and technological journal articles, patent, and trademark applications and number of researchers engaged in R&D per million of the population. The insignificant scientific and technological indicators are high technology exports as a percentage of GDP, high technology exports as a percentage of the total exports, total royalty to GDP ratio, R&D expenditure to GDP ratio and number of technicians in R&D per million of the population.

In order to check whether the insignificance of some indicators stem from econometric specification, we conduct several robustness checks and try different econometric specifications, different control variables and run the regression equation with stratified data. However, our results do not change qualitatively in these estimations.[8]

In Table 4 we present the results of the same analysis performed for the technological progress obtained through Lee and Schmidt (1993) decomposition model. and next, in Table 5, we report estimations results using the GMM estimator in the dynamic panel data setting.

According to Table 4, scientific indicators which are significantly correlated with technological progress are number of articles, number of technicians, patent applications, trademark applications and researchers in R&D. However, according to the results in Table 5, the only

[7]Notice that the number of observations in the regressions is a lot lower than the number observations given in Table 1 for each variable. This is due to the 5-year averaging of the data.

[8]These results are available upon request from the corresponding author.

significant coefficients are of articles, patent and trademark applications. This difference in both tables indicate that the results very much depend on the econometric specification and type of estimator used in the analysis. Considering the difference in results, in Table 6 we summarize[9] signs of the coefficients (if significant) obtained through estimations with the 10 different models. (Insignificant coefficients are denoted by 0.) We observe from Table 6 that the coefficients of the variables articles, patentapp and tmapp are consistently significant and have the expected sign. That is, number of scientific articles, number of patent applications and number of trademark applications are consistently positively correlated with the technological progress component of the growth in TFP. The remaining six scientific and technological indicators do not produce any consistently significant coefficient. We should also notice that these results are also in line with what we observe from Figures 1, 2 and 3.

5 Conclusion

In this paper we investigated the relationship between the growth in TFP and actual technological and scientific progress. To accomplish this, we employed the stochastic frontier analysis to decompose growth in TFP into three components: technological progress, scale effect and change in technical efficiency. Then, we conducted a comprehensive panel data analysis using the technological progress component of the TFP and several scientific and technological indicators using data from 160 countries over the period from 1960 to 2009. Our results indicate that among several technological and scientific indicators, number of scientific articles, number of patent applications and number of trademark applications are consistently positively correlated with the technological progress component of the growth in TFP. These results shed light on possible dimensions that technological and scientific policy should be focused on.

Finally, we would notice that we do not allow for the possibility of international leakages

[9]Due to space constraints, we do not report full regression results using all the specification but only summarise their main results in Table 6. These regressions are available upon request from the corresponding author.

in the current paper. It might be very well true that productivity growth of each country is affected not only by the traditional internal factors but also by the international leakages. We leave such an analysis to future research.

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Appendix: Figures and Tables

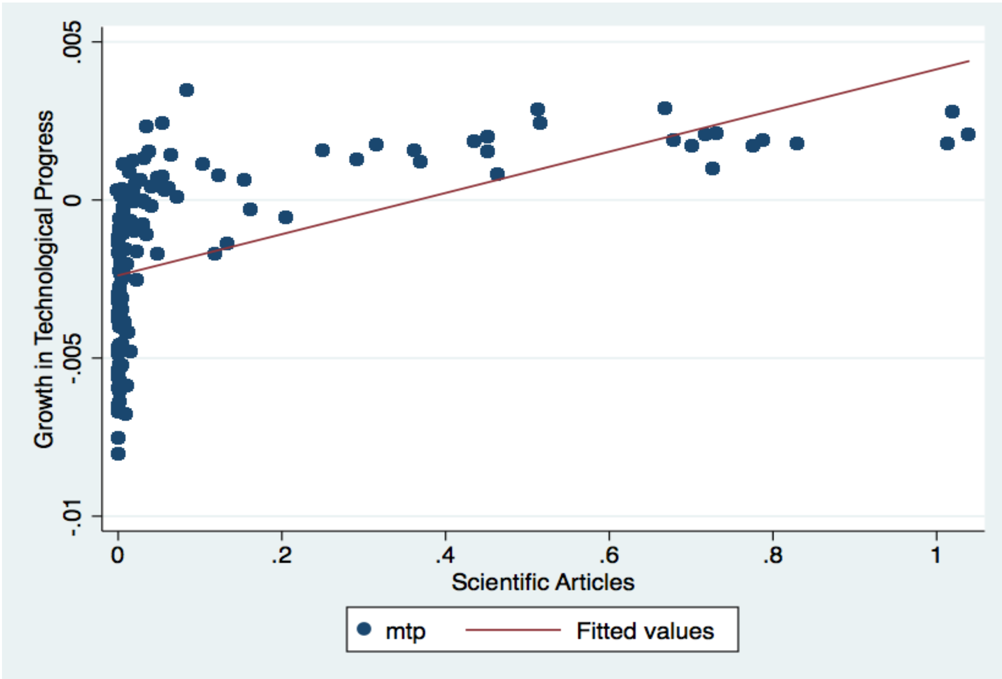

Figure 1: Technological Progress and Scientific Articles

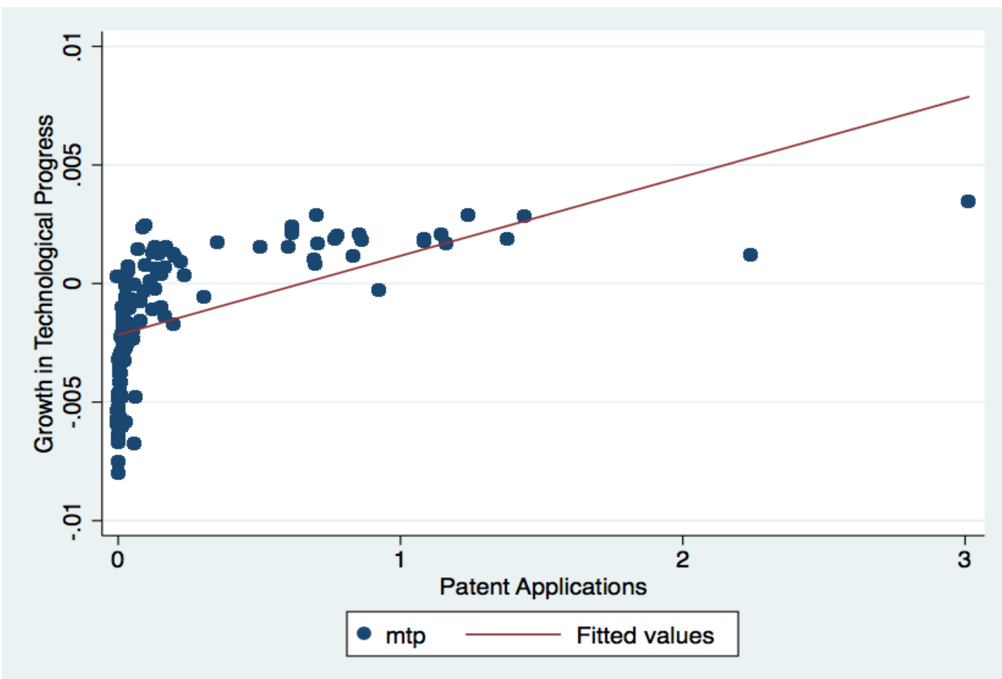

Figure 2: Technological Progress and Patent Applications

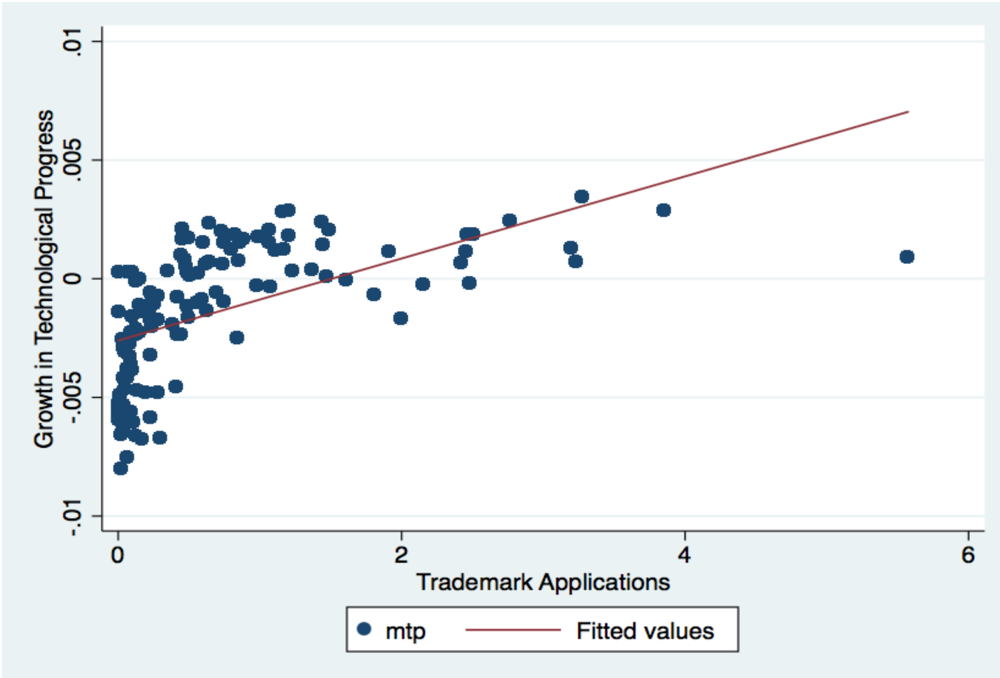

Figure 3: Technological Progress and Trademark Applications

Table 1: Descriptive Statistics of TFP Components and Control Variables

	tfp growth		tech. progress		scale effect		eff. change		
	tfee	fels	tfee	fels	tfee	fels	tfee	fels	
Obs	7000	7000	7141	7141	7000	7000	7000	7000	
Mean	0.001	-0.001	0.006	-0.0004	-0.006	0.000	0.001	0.000	
Std. Dev	0.037	0.006	0.002	0.000	0.008	0.001	0.0352	0.006	
Min	-0.562	-0.138	-0.0001	-0.001	-0.238	-0.007	-0.578	-0.137	
Max	0.399	0.087	0.013	0.001	0.0432	0.029	0.382	0.0871	
	articles	techpop	hitech_exp	hitech_gdp	patentapp	tmapp	roy_gdp	rdgdp	rdpop
Obs	3823	1567	2394	1864	3706	3917	2731	1539	1781
Mean	3854.1	557.5	9.78	0.0162	11136.7	13612.3	0.00384	0.9591	1889.88
Std. Dev.	17245	587.64	12.76	0.0447	43220.52	39076.64	0.00985	0.9486	1770.942
Min	0	2.464297	0	0	0	0	4.54e-09	0.00614	5.9694
Max	212883	3775.15	83.64	0.505	456321	793729	0.16455	4.804	8007.53
	rgdpl	school	openk	kg					
Obs	7645	6640	7645	7645					
Mean	8367.15	61.25	68.43	10.83					
Std. Dev.	11307.8	28.61	49.23	7.27					
Min	117.6	1.48	2.32	0.277					
Max	159144.5	99.94	443.18	58.59					

tfee=Greene's (2005a) true fixed model with exponential distribution of inefficiency. fels= Lee and Schmidt (1993) model. rgdpl=per capita income. school=secondary school enrollment rate. openk=openness at constant prices. kg=government expenditure share in GDP

Table 2: Translog Production Function Estimation: True Fixed Effect with Exponentially Distributed Inefficiency

Dependent variable: $\ln y$

	Coefficient	p-value	Confidence Interval	
β_t	0.13	0.00	0.06	0.19
β_k	-0.84	0.00	-1.29	-0.40
β_l	3.25	0.00	2.52	3.98
β_{tk}	0.001	0.00	0.0005	0.0018
β_{tl}	-0.002	0.00	-0.003	-0.001
β_{kl}	-0.01	0.17	-0.02	0.003
β_{tt}	-0.00003	0.00	-0.00005	-0.00001
β_{kk}	0.003	0.18	-0.001	0.008
β_{ll}	0.02	0.00	0.01	0.03
Observations per group:				
min	20			
ave	51			
max	60			

Table 3: Regression of Technological progress on Indicators, True Fixed Effect

Dependent variable: Technological progress

	articles	techpop	hitech_exp	hitech_gdp	patentapp	tmapp	roy_gdp	rdgdp	rdpop
Indicator	1.7e-08	-2.5e-08	5.9e-07	-0.00086	2.1e-09	2.2e-09	-0.00178	0.00004	6.3e-08
	(0.000)	(0.747)	(0.804)	(0.353)	(0.001)	(0.029)	(0.250)	(0.463)	(0.011)
rgdpl	-1.4e-09	-1.4e-08	8.9e-10	-3.7e-09	1.4e-08	3.5e-08	2.5e-08	-8.4e-09	-1.2e-08
	(0.413)	(0.011)	(0.581)	(0.397)	(0.000)	(0.000)	(0.000)	(0.099)	(0.016)
kg	3.3e-06	-0.00001	0.00002	0.00003	-9.4e-06	-3.4e-06	0.00002	-0.00002	-0.00001
	(0.457)	(0.332)	(0.001)	(0.000)	(0.213)	(0.617)	(0.037)	(0.053)	(0.371)
openk	2.8e-06	3.3e-06	1.9e-06	2.4e-06	8.4e-07	1.3e-06	-7.9e-07	2.3e-06	2.6e-06
	(0.001)	(0.000)	(0.015)	(0.011)	(0.247)	(0.038)	(0.270)	(0.007)	(0.001)
school	-4.9e-06	1.9e-06	-7.3e-06	-2.6e-06	2.9e-06	1.6e-06	6.8e-08	-5.1e-06	-3.9e-06
	(0.009)	(0.603)	(0.000)	(0.220)	(0.218)	(0.488)	(0.970)	(0.080)	(0.176)
R-sq.	0.903	0.941	0.912	0.906	0.922	0.922	0.939	0.925	0.940
Obs.	765	314	479	373	742	784	547	308	357

In all regressions a constant, country and time dummies are included but their coefficients are not reported.
Values in parentheses denote p values.

Table 4: Regression of Technological progress on Indicators, Lee and Schmidt Model

Dependent variable: Technological Progress

	articles	techpop	hitech_exp	hitech_gdp	patentapp	tmapp	roy_gdp	rdgdp	rdpop
Indicator	5.4e-8	2.9e-08	1.9e-07	0.00005	3.5e-10	6.2e-10	0.00062	9.8e-06	1.1e-08
	(0.02)	(0.047)	(0.583)	(0.701)	(0.000)	(0.000)	(0.033)	(0.158)	(0.003)
rgdpl	1.9e-09	2.7e-09	1.4e-09	7.9e-11	1.1e-11	-2.8e-10	4.2e-10	1.9e-09	2.0e-09
	(0.000)	(0.017)	(0.012)	(0.919)	(0.983)	(0.707)	(0.611)	(0.012)	(0.006)
kg	-9.2e-07	-2.4e-06	-3.5e-06	-3.3e-07	-1.6e-06	-7.7e-07	1.4e-06	-3.1e-06	3.2e-07
	(0.253)	(0.649)	(0.087)	(0.776)	(0.143)	(0.465)	(0.459)	(0.300)	(0.918)
openk	-1.3e-07	-8.0e-08	-3.0e-08	1.1e-07	2.7e-07	3.3e-07	-3.0e-07	-1.9e-07	-1.4e-07
	(0.368	(0.700)	(0.825)	(0.512)	(0.020)	(0.002)	(0.054)	(0.156)	(0.316)
school	1.4e-06	1.2e-06	1.2e-06	8.9e-07	1.4e-06	1.4e-06	9.9e-07	5.6e-07	9.3e-07
	(0.000)	(0.070)	(0.001)	(0.012)	(0.000)	(0.000)	(0.007)	(0.221)	(0.047)
R-sq.	0.310	0.339	0.264	0.166	0.391	0.411	0.228	0.243	0.358
Obs.	765	314	479	373	742	784	547	308	357

In all regressions a constant, country and time dummies are included but their coefficients are not reported. Values in parenthesis denote p values.

Table 5: Regression of Technological progress on Indicators, Arellano and Bond Estimator

Dependent variable: Technological Progress

	articles	techpop	hitech_exp	hitech_gdp	patentapp	tmapp	roy_gdp	rdgdp	rdpop
Indicator	7.4e-11	2.5e-07	1.6e-07	0.0001	3.5e-10	6.2e-10	0.0038	7.1e-05	1.8e-06
	(0.041)	(0.234)	(0.293)	(0.321)	(0.011)	(0.021)	(0.187)	(0.158)	(0.20)
rgdpl	1.9e-08	2.5e-09	1.3e-07	7.5e-10	1.0e-10	-2.6e-10	3.5e-10	2.9-10	2.6e-10
	(0.000)	(0.027)	(0.012)	(0.301)	(0.412)	(0.392)	(0.533)	(0.045)	(0.021)
kg	-7.2e-07	-2.5e-06	-2.3e-05	-2.9e-06	-2.7e-06	-5.4e-06	2.3e-06	-2.9e-06	3.1e-06
	(0.253)	(0.649)	(0.077)	(0.601)	(0.217)	(0.335)	(0.389)	(0.290)	(0.641)
openk	-1.2e-07	-6.1e-07	-2.9e-06	1.1e-06	2.7e-07	2.9e-05	-2.0e-05	-1.8e-07	-1.4e-07
	(0.368)	(0.100)	(0.715)	(0.444)	(0.010)	(0.003)	(0.064)	(0.056)	(0.116)
school	1.4e-06	1.2e-06	1.6e-06	8.6e-07	1.2e-06	1.3e-05	9.9e-07	4.3e-07	8.2e-07
	(0.000)	(0.060)	(0.05)	(0.021)	(0.000)	(0.000)	(0.119)	(0.321)	(0.051)
Obs.	465	146	191	182	465	466	279	101	99
J-Test	0.24	0.32	0.04	0.19	0.41	0.49	0.09	0.18	0.05

In all regressions a constant, lagged dependent variable, country and time dummies are included but their coefficients are not reported. Values in parenthesis denote p values. J-Test reports the p-values of the Hansen's test for exogeneity of instruments.

Table 6: Signs and Significance of Indicators with respect to Models

	tfee	tfeh	tfet	tree	treh	tret	fels	bc95	bc92	gmm
articles	+	+	+	+	+	+	+	+	+	+
techpop	0	0	0	0	0	0	+	-	0	0
hitech_exp	0	0	0	0	0	0	0	0	0	0
hitech_gdp	0	0	0	0	0	0	0	0	0	0
patentapp	+	+	+	+	+	+	+	+	+	+
tmapp	+	+	+	+	+	+	+	+	+	+
roy_gdp	0	0	0	0	-	-	+	-	0	0
rdgdp	0	0	0	0	0	0	0	0	0	0
rdpop	+	+	0	0	0	0	+	0	+	0

tfee=True fixed effect with exponential distribution, tfeh=True fixed effect with half-normal distribution, tfet=True fixed effect with truncated-normal distribution, tree=True random effect with exponential distribution, treh=True random effect with half-normal distribution, tret=True random effect with truncated-normal distribution, fels= Lee and Schmidt (1993) model, bc95= Battese and Coelli (1995) model, bc92=Battese and Coelli (1992) model. gmm= Arellano and Bond (1991) GMM estimator. The threshold level for significance is 0.1. Plus(minus) signs indicates that relevant indicator has positive(negative) significant estimate in fixed effect panel data regression. And zeros denotes that the indicator coefficient estimate is insignificant regardless of its sign.

Table 7: Output Elasticity, Efficiency and Growth Accounting with respect to True Fixed Effect

country	eff	ϵ_k	ϵ_l	RTS	g_{tfp}	Δeff	se	avetp	random
Albania	0.87	0.681	0.140	0.82	0.0035	0.0012	-0.0045	0.0069	-0.0089
Algeria	0.89	0.680	0.195	0.87	0.0020	-0.0002	-0.0040	0.0063	-0.0290
Angola	0.85	0.675	0.183	0.86	0.0027	0.0012	-0.0037	0.0053	-0.0082
Argentina	0.90	0.674	0.228	0.90	0.0037	0.0003	-0.0023	0.0057	-0.0173
Australia	0.92	0.680	0.201	0.88	0.0021	-0.0003	-0.0044	0.0069	-0.0247
Austria	0.91	0.681	0.181	0.86	0.0036	0.0004	-0.0041	0.0074	-0.0111
Bahamas	0.85	0.693	0.053	0.75	-0.0057	-0.0063	-0.0092	0.0099	-0.0253
Bahrain	0.85	0.697	0.064	0.76	-0.0004	0.0006	-0.0109	0.0100	-0.0575
Bangladesh	0.91	0.658	0.281	0.94	-0.0011	-0.0013	-0.0022	0.0024	-0.0291
Belgium	0.92	0.682	0.185	0.87	0.0034	-0.0006	-0.0034	0.0074	-0.0103
Belize	0.89	0.688	0.041	0.73	0.0000	0.0014	-0.0112	0.0099	-0.0285
Benin	0.90	0.666	0.173	0.84	0.0005	0.0006	-0.0058	0.0057	-0.0272
Bhutan	0.88	0.680	0.081	0.76	-0.0038	0.0037	-0.0157	0.0082	-0.0256
Bolivia	0.91	0.667	0.183	0.85	0.0031	0.0000	-0.0031	0.0063	-0.0209
Botswana	0.85	0.676	0.119	0.79	-0.0032	0.0082	-0.0191	0.0077	-0.0366
Brazil	0.90	0.668	0.276	0.94	0.0039	0.0023	-0.0025	0.0041	-0.0339
Brunei	0.68	0.693	0.048	0.74	-0.0062	-0.0067	-0.0095	0.0101	-0.0474
Bulgaria	0.90	0.680	0.180	0.86	0.0055	0.0028	-0.0031	0.0058	0.0037
Burkina Faso	0.89	0.659	0.205	0.86	0.0013	0.0010	-0.0041	0.0044	-0.0193
Burundi	0.88	0.653	0.201	0.85	-0.0015	-0.0003	-0.0050	0.0038	-0.0272
Cambodia	0.82	0.663	0.203	0.87	-0.0003	0.0002	-0.0043	0.0039	-0.0201
Cameroon	0.89	0.668	0.197	0.86	0.0011	0.0004	-0.0045	0.0052	-0.0247
Canada	0.91	0.679	0.219	0.90	0.0006	-0.0020	-0.0037	0.0063	-0.0265
Cape Verde	0.88	0.678	0.074	0.75	-0.0002	0.0013	-0.0105	0.0090	-0.0198
C. African Republic	0.91	0.660	0.171	0.83	0.0028	-0.0004	-0.0020	0.0052	-0.0199
Chad	0.89	0.658	0.193	0.85	-0.0043	-0.0026	-0.0062	0.0045	-0.0254
Chile	0.87	0.674	0.192	0.87	0.0027	0.0011	-0.0049	0.0066	-0.0229
China	0.78	0.654	0.367	1.00	0.0088	0.0071	0.0011	0.0006	-0.0277
Colombia	0.91	0.670	0.221	0.89	0.0022	0.0011	-0.0045	0.0056	-0.0298
Comoros	0.90	0.671	0.097	0.77	0.0021	0.0012	-0.0069	0.0079	-0.0284
Costa Rica	0.88	0.674	0.143	0.82	-0.0015	0.0000	-0.0094	0.0078	-0.0370
Cote Divore	0.90	0.664	0.199	0.86	0.0015	0.0023	-0.0056	0.0048	-0.0349
Cyprus	0.85	0.680	0.105	0.79	0.0033	0.0029	-0.0088	0.0093	-0.0146
Dem.Rep. of Congo	0.78	0.656	0.247	0.90	-0.0049	-0.0071	-0.0015	0.0038	-0.0199
Denmark	0.90	0.680	0.172	0.85	0.0008	-0.0027	-0.0040	0.0076	-0.0125
Dominican Republic	0.90	0.670	0.177	0.85	0.0009	0.0023	-0.0079	0.0066	-0.0313
Ecuador	0.90	0.675	0.180	0.86	0.0028	0.0014	-0.0056	0.0069	-0.0273
Egypt	0.87	0.664	0.243	0.91	0.0038	0.0034	-0.0042	0.0045	-0.0249

Table 7: continued

country	eff	ϵ_k	ϵ_l	RTS	g_{tfp}	Δeff	se	avetp	random
El Salvador	0.87	0.670	0.166	0.84	0.0002	-0.0010	-0.0057	0.0069	-0.0261
Equatorial Guinea	0.84	0.665	0.096	0.76	-0.0141	0.0068	-0.0283	0.0074	-0.0096
Ethiopia	0.88	0.652	0.267	0.92	0.0021	0.0019	-0.0028	0.0030	-0.0227
Fiji	0.91	0.679	0.095	0.77	0.0008	-0.0002	-0.0075	0.0086	-0.0239
Finland	0.91	0.681	0.170	0.85	0.0043	0.0008	-0.0041	0.0076	-0.0090
France	0.92	0.677	0.246	0.92	0.0043	0.0009	-0.0021	0.0055	-0.0139
Gabon	0.83	0.684	0.104	0.79	-0.0009	-0.0001	-0.0096	0.0088	-0.0255
Gambia	0.88	0.661	0.133	0.79	-0.0029	0.0002	-0.0093	0.0062	-0.0294
Germany	0.92	0.687	0.241	0.93	0.0033	-0.0003	-0.0012	0.0049	-0.0098
Ghana	0.83	0.666	0.209	0.87	0.0037	0.0026	-0.0039	0.0051	-0.0172
Greece	0.91	0.680	0.185	0.86	0.0044	0.0017	-0.0044	0.0071	-0.0126
Guatemala	0.91	0.671	0.181	0.85	0.0010	0.0001	-0.0057	0.0066	-0.0298
Guinea	0.89	0.661	0.193	0.85	-0.0038	-0.0042	-0.0043	0.0048	-0.0264
Guinea-Bissau	0.85	0.664	0.130	0.79	0.0026	0.0013	-0.0051	0.0065	0.0019
Guyana	0.80	0.685	0.092	0.78	0.0066	0.0006	-0.0023	0.0083	-0.0042
Haiti	0.84	0.664	0.189	0.85	-0.0020	-0.0042	-0.0028	0.0050	-0.0196
Honduras	0.90	0.670	0.162	0.83	-0.0008	-0.0012	-0.0066	0.0070	-0.0325
Hong Kong	0.89	0.684	0.163	0.85	0.0028	0.0052	-0.0097	0.0073	-0.0287
Hungary	0.91	0.684	0.179	0.86	0.0030	-0.0006	-0.0025	0.0061	-0.0002
Iceland	0.91	0.687	0.065	0.75	-0.0012	-0.0014	-0.0104	0.0107	-0.0191
India	0.91	0.655	0.346	1.00	0.0042	0.0029	0.0000	0.0014	-0.0250
Indonesia	0.89	0.665	0.288	0.95	0.0042	0.0038	-0.0023	0.0027	-0.0308
Iran	0.75	0.676	0.225	0.90	0.0029	0.0024	-0.0050	0.0056	-0.0324
Ireland	0.90	0.680	0.154	0.83	0.0022	0.0003	-0.0060	0.0080	-0.0146
Israel	0.90	0.681	0.150	0.83	0.0018	0.0029	-0.0093	0.0083	-0.0347
Italy	0.91	0.678	0.244	0.92	0.0047	0.0012	-0.0021	0.0057	-0.0106
Jamaica	0.89	0.678	0.143	0.82	0.0013	-0.0015	-0.0051	0.0079	-0.0169
Japan	0.89	0.676	0.274	0.95	0.0052	0.0024	-0.0019	0.0047	-0.0219
Jordan	0.80	0.680	0.124	0.80	-0.0023	0.0013	-0.0119	0.0084	-0.0465
Kenya	0.91	0.659	0.229	0.89	0.0008	0.0003	-0.0039	0.0044	-0.0318
Korea Republic	0.89	0.674	0.231	0.90	0.0019	0.0027	-0.0060	0.0053	-0.0368
Kuwait	0.89	0.700	0.102	0.80	-0.0252	-0.0251	-0.0080	0.0080	-0.0217
Laos	0.87	0.663	0.177	0.84	-0.0038	0.0018	-0.0100	0.0045	-0.0308
Lebanon	0.68	0.695	0.116	0.81	-0.0021	-0.0084	-0.0023	0.0086	0.0049
Lesotho	0.81	0.665	0.143	0.81	-0.0028	-0.0001	-0.0089	0.0063	-0.0201
Liberia	0.67	0.671	0.142	0.81	-0.0014	-0.0085	0.0012	0.0060	0.0007
Libya	0.89	0.693	0.128	0.82	0.0037	-0.0004	-0.0027	0.0068	-0.0317
Luxembourg	0.90	0.688	0.080	0.77	0.0027	0.0004	-0.0081	0.0104	-0.0174
Macao	0.88	0.692	0.063	0.75	-0.0034	0.0034	-0.0163	0.0096	-0.0306
Madagascar	0.90	0.661	0.212	0.87	0.0011	0.0001	-0.0032	0.0043	-0.0252
Malawi	0.88	0.663	0.200	0.86	0.0024	0.0025	-0.0052	0.0052	-0.0216
Malaysia	0.90	0.673	0.203	0.88	0.0020	0.0040	-0.0078	0.0059	-0.0359
Maldives	0.83	0.682	0.048	0.73	-0.0070	0.0071	-0.0232	0.0091	-0.0422

Table 7: continued

country	eff	ϵ_k	ϵ_l	RTS	g_{tfp}	Δeff	se	avetp	random
Mali	0.91	0.664	0.184	0.85	0.0012	0.0008	-0.0047	0.0052	-0.0182
Malta	0.89	0.691	0.062	0.75	0.0013	0.0029	-0.0111	0.0096	-0.0106
Mauritania	0.87	0.671	0.139	0.81	0.0019	0.0027	-0.0076	0.0069	-0.0214
Mauritus	0.89	0.676	0.114	0.79	0.0015	0.0003	-0.0074	0.0087	-0.0213
Mexico	0.91	0.673	0.244	0.92	0.0010	-0.0006	-0.0037	0.0053	-0.0358
Mongolia	0.88	0.679	0.135	0.81	0.0019	0.0020	-0.0069	0.0068	-0.0229
Morocco	0.86	0.668	0.214	0.88	0.0024	0.0019	-0.0051	0.0056	-0.0270
Mozambique	0.88	0.653	0.229	0.88	0.0010	0.0018	-0.0040	0.0032	-0.0201
Namibia	0.90	0.680	0.109	0.79	0.0006	0.0000	-0.0077	0.0084	-0.0289
Nepal	0.88	0.661	0.222	0.88	-0.0030	-0.0023	-0.0046	0.0040	-0.0292
Netherlands	0.92	0.681	0.198	0.88	0.0036	0.0002	-0.0035	0.0070	-0.0177
New Zealand	0.91	0.681	0.151	0.83	0.0015	-0.0017	-0.0049	0.0081	-0.0231
Nicaragua	0.79	0.673	0.148	0.82	-0.0027	-0.0039	-0.0063	0.0076	-0.0314
Niger	0.86	0.664	0.184	0.85	0.0015	-0.0003	-0.0033	0.0052	-0.0233
Nigeria	0.79	0.654	0.272	0.93	0.0028	0.0022	-0.0024	0.0030	-0.0235
Norway	0.91	0.684	0.158	0.84	0.0043	0.0007	-0.0046	0.0082	-0.0130
Oman	0.89	0.690	0.104	0.79	-0.0036	0.0026	-0.0146	0.0084	-0.0446
Pakistan	0.91	0.662	0.267	0.93	0.0033	0.0025	-0.0030	0.0038	-0.0282
Panama	0.90	0.672	0.141	0.81	0.0010	0.0024	-0.0091	0.0077	-0.0277
Paraguay	0.87	0.669	0.163	0.83	-0.0001	-0.0002	-0.0067	0.0068	-0.0314
Paupa New Guinea	0.90	0.667	0.165	0.83	0.0012	0.0030	-0.0077	0.0059	-0.0229
Peru	0.89	0.673	0.209	0.88	0.0037	0.0013	-0.0038	0.0062	-0.0235
Philippines	0.90	0.663	0.256	0.92	0.0032	0.0024	-0.0034	0.0041	-0.0285
Poland	0.90	0.680	0.224	0.90	0.0038	0.0014	-0.0023	0.0047	-0.0064
Portugal	0.90	0.676	0.194	0.87	0.0018	0.0000	-0.0049	0.0067	-0.0165
Qatar	0.91	0.700	0.071	0.77	-0.0067	0.0039	-0.0194	0.0088	-0.0407
Republic of Congo	0.86	0.670	0.144	0.81	0.0011	0.0033	-0.0088	0.0067	-0.0314
Romania	0.85	0.675	0.221	0.90	0.0076	0.0055	-0.0031	0.0052	-0.0046
Rwanda	0.85	0.657	0.197	0.85	-0.0001	0.0000	-0.0044	0.0043	-0.0180
Saudi Arabia	0.91	0.695	0.170	0.87	0.0000	-0.0003	-0.0057	0.0060	-0.0415
Senegal	0.90	0.664	0.189	0.85	-0.0033	-0.0034	-0.0050	0.0051	-0.0304
Sierra Leone	0.86	0.662	0.172	0.83	-0.0010	-0.0017	-0.0045	0.0052	-0.0181
Singapore	0.86	0.687	0.139	0.83	0.0017	0.0049	-0.0113	0.0082	-0.0307
Solomon Islands	0.89	0.681	0.050	0.73	0.0007	0.0013	-0.0096	0.0091	-0.0253
South Africa	0.91	0.674	0.218	0.89	0.0027	0.0005	-0.0038	0.0060	-0.0284
Spain	0.91	0.677	0.231	0.91	0.0036	0.0013	-0.0036	0.0059	-0.0206
Sri Lanka	0.87	0.665	0.215	0.88	0.0032	0.0023	-0.0044	0.0053	-0.0179
Sudan	0.87	0.663	0.221	0.88	-0.0055	-0.0031	-0.0058	0.0034	-0.0335
Suriname	0.84	0.690	0.067	0.76	-0.0046	-0.0072	-0.0066	0.0093	-0.0101
Swaziland	0.90	0.679	0.096	0.78	-0.0009	0.0037	-0.0124	0.0078	-0.0294
Sweden	0.92	0.680	0.187	0.87	0.0037	-0.0004	-0.0029	0.0071	-0.0110
Switzerland	0.89	0.683	0.178	0.86	0.0027	-0.0016	-0.0034	0.0077	-0.0163
Syria	0.89	0.673	0.179	0.85	0.0004	0.0019	-0.0075	0.0060	-0.0351

Table 7: continued

country	eff	ϵ_k	ϵ_l	RTS	g_{tfp}	Δeff	se	avetp	random
Taiwan	0.90	0.671	0.211	0.88	0.0027	0.0051	-0.0082	0.0058	-0.0341
Tanzania	0.90	0.659	0.238	0.90	0.0010	0.0020	-0.0044	0.0034	-0.0286
Thailand	0.89	0.665	0.258	0.92	0.0035	0.0031	-0.0039	0.0043	-0.0287
Togo	0.84	0.668	0.160	0.83	0.0009	0.0000	-0.0052	0.0061	-0.0313
Trinidad and Tobago	0.82	0.680	0.114	0.79	0.0040	0.0032	-0.0082	0.0090	-0.0139
Tunisia	0.89	0.680	0.164	0.84	0.0034	0.0027	-0.0062	0.0070	-0.0208
Turkey	0.91	0.667	0.250	0.92	0.0033	0.0025	-0.0037	0.0046	-0.0215
Uganda	0.90	0.653	0.232	0.88	0.0003	0.0008	-0.0044	0.0039	-0.0276
United Arab Emirates	0.91	0.698	0.122	0.82	-0.0025	0.0024	-0.0122	0.0074	-0.0589
United Kingdom	0.92	0.676	0.251	0.93	0.0028	-0.0008	-0.0016	0.0053	-0.0114
United States	0.91	0.677	0.291	0.97	0.0022	-0.0012	-0.0010	0.0044	-0.0219
Uruguay	0.90	0.673	0.160	0.83	0.0042	0.0000	-0.0032	0.0074	-0.0092
Venezuela	0.90	0.677	0.194	0.87	0.0024	0.0005	-0.0050	0.0069	-0.0348
Vietnam	0.89	0.663	0.262	0.93	0.0012	0.0033	-0.0045	0.0024	-0.0363
Zambia	0.83	0.666	0.186	0.85	0.0019	0.0005	-0.0043	0.0057	-0.0225
Zimbabwe	0.87	0.653	0.210	0.86	-0.0045	-0.0047	-0.0038	0.0041	-0.0229

eff= Production efficiency, ϵ_k= Output elasticity of capital, ϵ_l= Output elasticity of labor, RTS= Returns to scale, g_{tfp}= TFP growth, Δeff= Change in efficiency, se= scale effect, tp= technological progress, random= random shocks. All variables are averages over time-series.