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Productivity measurements for three countries of the Pacific Alliance and South Korea, 2008-2012

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Productivity measurements for three countries of the Pacific Alliance and South Korea, 2008-2012

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Abstract

This paper measures and compares total factor productivity changes using Hicks-Moorsteen Productivity indexes for five broad economic sectors, in South Korea and in three countries of the Pacific Alliance: Colombia, Chile and Mexico, during the period 2008-2012. We specify two models, one measuring output and inputs in levels and the other in per worker terms. We use panel data for years and countries. We find a more diverse pattern of productivity among the four countries, as well as among sectors, that the obtained from national figures (not sectoral). That is, national estimates of Total Factor Productivity veil different and interesting trends in productivity that occurs at the sectoral level and among countries.

JEL Codes: O13; O14, O33; Q16

Keywords: Hicks-Moorsteen Index, Malmquist Productivity Index, Technological Change, Sectoral analysis, Pacific Alliance, South Korea.

1. Introduction

The “Pacific Alliance” was signed by Colombia, Chile, Mexico and Peru in 2011 as a trade bloc aimed to further free trade among their members and between them and Asia. In 2014, Costa Rica began the process of joining the group. These countries represent more than 36% of Latin-American GDP (World Bank, 2015), and their population amounts to 215 million people, with an average per capita GDP of $16,500 (PPP). Behind the initiative is the example of the European Union, founded in 1991, and its success in several aspects relevant for economic development.

An important goal of the Alliance is to enter a rich and growing market as the one conformed by China, Japan, Korea, Taiwan, and others. These countries demand commodities, but also value added products. This is perceived as an opportunity by the Pacific Alliance to expand the markets for their products, beyond more traditional North American and European markets.

The Alliance expects to develop dynamic competitive advantages in order to compete in the Asian markets. Central to this effort is the increase of the productivity of its members. In this paper we aim to establish the current levels of productivity in key sectors. The measurements obtained will serve as a basis for programs of investment, innovation and increased trade. South Korea and its

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productivity are taken as reference for the measurements, because of its dynamics, as well as its current and future economic relations with the countries of the Pacific Alliance.

We were not able to find a substantial number of studies that had estimated differences in productivity among sectors (inside countries) and countries and sectors for the countries considered in the paper. Excellent exceptions are, for example, Hsiao and Park (2002), who estimated Korean and Taiwanese Productivity performance; they used three-digit matched industry levels of 15 manufacturing industries. Acemoglu and Melissa (2010) use microdata from 11 countries in the Americas, and estimate productivity differences between and within countries; they did use a decomposition of inequality (Theil index) in labor and income into three components: inequality between countries, inequality between municipalities or regions (within countries) and inequality between municipalities/regions. Note that they estimate differences in cross-country and cross-regional income per capita, using labor income as a proxy of productivity, whereas this study is interested in estimating productivity differences among countries and sectors. The importance of productivity on development has been highlighted for example by Guisan and Cancelo (2014), and the relationships between real wages, human capital and productivity is well analyzed in Guisan and Aguayo (2007), with a comparison between the EU and the USA.

Ludena (2010) estimates Agricultural Productivity Growth and Efficiency, technical change and efficiency change in Latin America and the Caribbean with data from FAO, using Malmquist Index. Ludena uses as outputs crops and livestock and five inputs (animal stock, land, fertilizer, tractors and labor); he finds "a recovery of efficiency in the last two decades". Additional to labor and fixed capital, Lee and Kim (2006) incorporated R&D capital in their estimation of productivity (this element is considered in one of our models below).

In this paper we estimate productivity growth for Colombia, Chile, Mexico and South Korea, and for five economic sectors: Agriculture, Services, Manufacturing, Mining and Construction. In order to obtain an indication on how consistent results are, we have considered four models, all of them in a panel data framework, that differ in the included variables and in how they are incorporated. Specifically, besides output, capital and labor, we considered Number of Patents (following Lee and Kim, 2006), Imported inputs, and Industrial Exports, by country and sector. We estimated Total Factor Productivity (TFP) using the Hicks- Moorsteen Index proposed by O'Donnell (2008); this allowed us to get scale efficiency. This index has the advantage over Malmquist Index that we do not need assumptions concerning optimizing behavior, structure of markets or returns to scale. Sufian (2009) uses this index in the context of financial institutions in Malaysia.

A group of results suggests the sectors in which each country has acquired productivity strengths in relation to the other three countries. Another group of results shows the performance of sectors inside each particular country. From a methodological point of view they outline, on the one hand, that more efforts are needed to build longer consistent data in the region and by economic sectors; and, on the other hand, that alternative methodologies need to be implemented in order to compare them and obtain better insights on measurements that are of ordinary use in the economies. Also, it would be of interest to study productivity at more disaggregated levels, including firm level. This will allow more detailed investment and productivity programs.

2. Methodology and data

2.1 The Hicks-Moorsteen Productivity Index

To estimate TFP with panel data, the Malmquist Index is one of the most popular used in the literature. However, this index has several disadvantages, related to unfeasible results when general technologies are used in the estimations (Briec and Kerstens, 2008). The Hicks-Moorsteen Productivity Index, proposed first by Bjurek (1996), despite being constructed from Malmquist indexes, does not have this disadvantage.

Additionally, the Hicks-Moorsteen Index has the advantage over the Malmquist Index that no assumptions are required concerning optimizing behavior, structure of markets or returns to scale (O'Donnell, 2008), is "well-defined and satisfies the determinateness property, since the underlying distance functions are always feasible" (Briec and Kerstens, 2008).

The Hicks-Moorsteen index estimates are obtained as the ratio of geometric mean of Malmquist output quantity index at a base period $t(s)$ and Malmquist input quantity index at a base period $t(s)$. In order to avoid problems with definition of a base period, the Hicks-Moorsteen is the geometric mean of this index in period t and period s, as can be seen in equation (1). Following O'Donnell (2008, 2009), the Hicks-Moorsteen Index is defined as:

$$TFP^{HM} = \left[\frac{d_O^s(Q_t,X_s)d_I^s(q_s,x_s)}{d_O^s(Q_s,X_s)d_I^s(Q_s,X_t)} \times \frac{d_O^t(Q_t,X_t)d_I^t(Q_t,X_s)}{d_O^t(Q_s,X_t)d_I^t(Q_t,X_t)}\right]^{1/2} \quad (1)$$

where t corresponds to the base period and s is the next period (i.e. $t+1$); q denotes output and x stands for inputs; $d_O^\tau(Q,X)$ and $d_I^\tau(Q,X)$ are respectively output (O) and input (I) distances functions in period τ, proposed by Shepard (1953). The Hicks-Moorsteen index is then the geometric mean of Malmquist indices between period t and period s.

The input distance function and output distance function can be defined as:

$$d_I^\tau(Q,X) = \ max\{\rho > 0: (X/\rho, Q) \in T^\tau\} \quad (2)$$

$$d_O^\tau(Q,X) = \ min\{\delta > 0: (Q, X/\delta) \in T^\tau\} \quad (3)$$

where T^τ is the production possibilities frontier in period τ. O'Donnell (2009) establishes that the input distance function "measures the largest radial contraction of the input vector that is technically feasible while holding the output vector fixed"; and that the output distance function "measures the inverse of the largest radial expansion of the output vector that is possible while holding the input vector fixed".

To interpret the results, an index greater than one means an increase in total productivity, a number less than one means a decrease. In order to facilitate the analysis, we show percent changes for each decomposition and for TFP.

The Hicks-Moorsteen index can be further decomposed in the following efficiency sub-indices:

Technical efficiency:

$$TE_{it} = \frac{Q_{it}/X_{it}}{\bar{Q}_{it}/X_{it}} = \frac{Q_{it}}{\bar{Q}_{it}} \quad (4)$$

where $\bar{Q}_{it}$ is the maximum output (Value Added produced by country i in period t), that is technically feasible when using X_t to produce a scalar multiple of Q_t. And X_{it} includes the whole of inputs used in the production process.

Technological efficiency:

$$TFPE_{it} = \frac{Q_{it}/X_{it}}{Q_{it}^{*}/X_{it}^{*}} = \frac{Q_{it}}{\bar{Q}_{it}} \quad (5)$$

where Q_{it}^{*} is the Value Added produced by country i and X_{it}^{*} are the aggregate input at the point where Total Factor Productivity is unconditionally maximized.

Scale efficiency:

$$SE_{it} = \frac{\bar{Q}_{it}/X_{it}}{\tilde{Q}_{it}/\tilde{X}_{it}} \quad (6)$$

where $\tilde{Q}_{it}$, is the Value Added produced by country i and $\tilde{X}_{it}$ are the aggregate input respectively at the point of optimal scale.

In this paper the estimates were obtained using the DPIN software by the Centre for Efficiency and Productivity Analysis (CEPA). The Hicks-Moorsteen index and its decompositions are estimated using DEA (Data Envelopment Analysis), under Variable Returns to Scale.

2.2. Model specification

We compute TFP indicators, as well as their decomposition into technical efficiency change, technological change and scale efficiency change, for five sectors in each country, and we examine their trends for 2009-2012. The sectors are Agriculture, Services, Manufacturing, Mining, and Construction. Additionally, we estimate each model assuming Constant Returns to Scale (CRS) as well as Variable Returns to Scale (VRS). However, the VRS hypothesis seems more appropriate: CRS (for example in DEA) assumes that the Decision-Making Units (DMUs) are operating at an optimal scale, an assumption that is unrealistic in the presence of financial distortions, imperfect competition, and a complex set of market regulations, as Banker, Charnes and Cooper (1984), and Cesaro, Marongiu, Arfini, Donato and Capelli (2009), have pointed out.

Two models were specified[1] for each sector and each country:

$$1.\ Y = f(K, L) \qquad (7)$$
$$2.\ \frac{Y}{L} = f\left(\frac{K}{L}, \frac{P}{L}\right) \qquad (8)$$

where *P* stands for number of Patents (as proxy for knowledge as an input).

Model 1 is the simplest two-input model and it is used here as a reference. It proposes the traditional specification that has been used in several studies to measure productivity. Its obvious shortcomings are the absence of other relevant inputs, as well as the high level of aggregation, and the assumption of constant economies of scale. Notice that even in this simplified form our sectoral analysis goes beyond the economy-wide aggregate level, which is common in the literature.

Model 2 is a version of the neoclassical production function in terms of per capita variables. Moreover, following Lee and Kim (2006), we add a new variable, the number of Patents. This tries to capture the role of Knowledge as an input to production processes, a fact that is well documented in the literature of endogenous growth (see, for example, Romer, 1986). The expression of variables in relative terms (using labor as the common variable) is intended to correct in some degree for the different size of the four economies under analysis, so that size does not affect the measurements of efficiency and technological change. With these normalizations, results are different from the model without normalization, as will be apparent in our estimates.

2.3 Data

To estimate TFP indicators, the data required are inputs and outputs for each country at a sectoral level. As output, Value Added by economic activity (at constant prices of 2008) is used. Several kinds of inputs are considered, as previously established. The capital stock is proxied by Gross Fixed Capital Formation[2], whereas the Number of Employees represents Labor; number of patents appears also in the set of data, as well as other variables as imported intermediate goods and, industrial exports (these two variables were used in some estimates, but are not reported here). The data covers five years comprised between 2008 and 2012; a wider period is desirable, but the corresponding data were not available in a comparable basis.

Data sources are the following: for Colombia, information by Departamento Administrativo Nacional de Estadística (DANE), for Chile we take data from Instituto Nacional de Estadísticas de Chile (INE), for Mexico data from Instituto Nacional de Estadística y Geografía (INEGI), and for South Korea data from Statistics Korea.

[1] We also estimated two other models using imported inputs and manufacturing exports as normalizations. Results are similar to the results of model 1 (results are available on request).
[2] Blades and Meyer-zu-Schlochtern (1997) argue that Value Added and the number of employees are flow variables, as well as Gross Fixed Capital Formation, so that this variable can be used for Capital instead of a stock variable such as the capital stock.

3. Results

3.1 Total Productivity Change, comparisons among countries by sector, 2008 - 2012

Recall that model 1 is taken as a base for comparison and it has two inputs (capital and labor, and no normalization); whereas model 2 takes into account capital and patents, both normalized by number of employees. Besides the relevance of the variables by themselves, as outlined before, one objective of this procedure is to correct for the size of the economies. The comparison of these estimations will allow us to establish the impact of the normalization on the results. Estimations of Technical Efficiency change, Technological change and Scale Efficiency change are presented in Annex 1, for each sector and country.

The first estimates (Table 1) correspond to model 1 and show Total Factor Productivity results for the five economic sectors analyzed and the four countries in the sample.

Agricultural Sector

In Agriculture (first column of Table 1) Mexico seems to be the country with the best performance regarding Total Productivity change, when a H-M Index is used in a model of two inputs, labor and capital under Variable Returns to scale. Chile, though, has an increase of 2.35% with Constant Returns to Scale, compared to Mexico with a TFP change of 1.98%. However, the estimates with VRS seem preferable for the reasons exposed in the last section. The other three countries (Chile, Colombia and Korea) show 0 or negative TFP changes assuming either CRS or VRS.

Table 1. Total Factor Productivity Change H-M indexes by Country. Non-Normalized. Geometric mean, 2009-2012

Country	Variable returns to scale				
	Agriculture	**Manufacturing**	**Mining**	**Services**	**Construction**
Chile	-0.18%	3.05%	-20.22%	0.82%	3.05%
Colombia	-0.17%	-7.92%	8.63%	-0.19%	-7.92%
Korea	-1.25%	-2.24%	-3.88%	-0.01%	-2.24%
Mexico	1.69%	3.62%	0.91%	0.14%	3.62%
Country	**Constant returns to scale**				
	Agriculture	**Manufacturing**	**Mining**	**Services**	**Construction**
Chile	2.35%	2.17%	-20.22%	0.16%	-1.62%
Colombia	0.00%	-7.92%	6.53%	-1.28%	-0.23%
Korea	-1.25%	-2.24%	-3.88%	-0.16%	-1.87%
Mexico	1.98%	3.62%	-5.75%	-0.05%	-3.05%

Now, if we consider Model 2 (capital and patents as inputs and all variables normalized by labor), the analysis of TFP in Agriculture is modified (Table 2). Mexico is no longer the leader in this sector, and its place is taken by Colombia independently of the assumption on returns to scale. Chile changes sign if VRS are substituted for CRS; meanwhile, Korea keeps consistently a negative TFP change in Agriculture in the period 2008 – 2014. As argued before, the results with the input Knowledge (Patents) and normalization seem preferable to the simpler two inputs model.

Manufacturing Sector

In the Manufacturing sector (Tables 1 and 2), both the non–normalized and the normalized estimations show that Chile has the best performance in Total Factor Productivity change, over Colombia and Korea. However, Mexico should be investigated in more depth: the H-M Index changes from positive to negative (close to 0) when the CRS assumption is changed to VRS.

Mining Sector

Within both estimates, Colombia is the leader in Total Factor Productivity change when Mining is considered (Tables 1 and 2): the index is positive and larger than the other countries figures. This is consistent with the emphasis given to Mining in Colombia during the last two decades.

Table 2. Total Factor Productivity Change H-M indexes by Country. Normalized with number of employees
Geometric mean 2009-2012

Country	Variable returns to scale				
	Agriculture	Manufacturing	Mining	Services	Construction
Chile	-1.69%	1.22%	-11.91%	7.05%	1.22%
Colombia	1.89%	-2.63%	4.90%	-1.30%	-2.63%
Korea	-0.25%	-1.77%	-3.51%	-0.77%	-1.77%
Mexico	-2.23%	-0.43%	-5.11%	3.72%	-0.43%
Country	Constant returns to scale				
	Agriculture	Manufacturing	Mining	Services	Construction
Chile	2.70%	2.17%	1.45%	7.05%	2.17%
Colombia	3.34%	-7.92%	12.81%	6.66%	-7.92%
Korea	-0.25%	-2.24%	-3.51%	-0.77%	-2.24%
Mexico	-2.23%	3.62%	-5.74%	3.72%	3.62%

Services Sector

On the one hand, Chile and Mexico present positive TPF changes in the Services Sector, especially Chile (Tables 1 and 2). On the other hand, Colombia and Korea have the lowest changes, even negative ones.

In Korea, the component that is more critical is Technological change (Annex 2): in all cases (normalized or not, CRS or VRS), this change is negative in the period under consideration. Given the inner heterogeneity of this sector, further disaggregation would be required in order to have more insights.

Construction Sector

Chile shows the best results of TFP among the countries considered. In model 2 (Table 2), its indices are 2.17% and 1.22%, whereas the other three countries have negative TFP´s. In the simple model of two inputs, also Chile presents the best performance (Table 1).

3.2 Total Productivity Change, comparisons by sector in each country, 2008 – 2012

Several estimations were performed to establish the sector with the best performance in each country. In this section we present these results. Estimations of Technical Efficiency change, Technological change and Scale Efficiency change for each country are presented in Appendix 2.

Table 3. Total Productivity Factor Change H-M indexes by sector. Non-Normalized Geometric mean 2009 – 2012

Sector	Variable returns to scale			
	Colombia	Chile	Mexico	Korea
Agriculture	-0.45%	0.38%	-0.50%	0.72%
Construction	0.59%	-0.88%	-3.23%	-3.61%
Manufacturing	-5.05%	0.62%	-3.14%	1.97%
Mining	2.80%	-2.98%	-4.13%	0.91%
Services	-3.08%	0.99%	-1.35%	2.25%
Sector	**Constant returns to scale**			
	Colombia	**Chile**	**Mexico**	**Korea**
Agriculture	-2.13%	0.11%	2.98%	0.15%
Construction	0.14%	-1.05%	-3.23%	-3.86%
Manufacturing	-2.55%	0.60%	-2.36%	3.62%
Mining	3.79%	-3.03%	-4.46%	1.97%
Services	-6.81%	1.00%	-1.24%	1.38%

Colombia

Construction and Mining are the sectors in Colombia with the highest TFP in the period 2008 – 2012. For example, their indices with Variable Returns to Scale are 7.2% and 4.42%, respectively (Table 4).

The Services sector shows a negative sign with the simple as well as the normalized model, with both Constant and Variable Returns to Scale (Tables 3 and 4). That is, we can conclude that this sector has a very poor performance regarding productivity in the period analyzed.

The case of manufacturing should be mentioned. If model 2 is used its TFP change is positive regardless of the assumption on constant or variable returns to scale. However, model 1 (non-normalized; capital and employees) gives always a negative TFP. The second model (normalized with employees; capital and patents), being more complete, seems to be preferable.

Table 4. Total Productivity Factor Change H-M indexes by sector. Normalized with number of employees
Geometric mean 2009 – 2012

Sector	Variable returns to scale			
	Colombia	Chile	Mexico	Korea
Agriculture	0,69%	0,68%	-0,25%	-0,28%
Construction	7,20%	0,72%	-3,90%	-0,62%
Manufacturing	2,89%	2,99%	-2,09%	0,26%
Mining	4,42%	-8,19%	-3,51%	-0,53%
Services	-1,30%	6,90%	-0,77%	0,38%
Sector	**Constant returns to scale**			
	Colombia	**Chile**	**Mexico**	**Korea**
Agriculture	-0,61%	0,07%	2,98%	-0,30%
Construction	7,20%	0,60%	-3,90%	-0,63%
Manufacturing	2,89%	2,53%	-2,20%	0,14%
Mining	12,81%	-10,81%	-4,77%	-1,04%
Services	-1,30%	7,07%	-0,77%	0,38%

Chile

Services and Manufacturing present positive changes of TFP in the four cases considered (a simple model and a model including Patents, on the one hand, and Constant and Variable Returns to Scale, on the other). The Mining sector had the worst performance. Again, its changes are negative with the four alternatives. Construction moves around a change of 0 in TFP.

Mexico

The results obtained for Mexico are discouraging. Only Agriculture shows a positive change of TFP and this if the assumption of Constant Returns to scale is used in the estimations (Tables 3 and 4). The other four sectors present a decrease in TFP in the analyzed period.

Korea

The model with employees, capital and Patents move around 0 in the five sectors (Table 4), for the period 2008 – 2012, Manufacturing and Services show positive TFP´s. These poor results have been found in other papers, such as OECD (2014)[3] and The Conference Board Productivity Brief (2015). If we turn to the simple model of two inputs (Table 3), only Construction show negative change; but the model more complete is the second (normalized with labor), therefore, the results more consistent with evidence found by other research is obtained with second model.

4. Conclusions and further research

The reported results on productivity allowed, on the one hand, the identification of sectors in which each of the four countries studied –Chile, Colombia, Korea and Mexico- seem to have higher indices relative to the sectors in other country. These are Agriculture and Services for Chile, Mining for Colombia, Manufacturing for South Korea and Construction for Mexico.

On the other hand, looking at the results on each individual country and its sectors, the leading sectors in Colombia are Mining and Construction; in Chile, Services and Manufacturing; in Mexico, Agriculture (if the assumption of Constant Returns to Scale is used); and in Korea, Manufacturing and Services (if the estimates are taken from the simple two sectors model).

Taken together the results on sectors among countries and of sectors inside each country, the picture obtained shows a clear leadership of Chile in Services, and of Colombia in Mining in the period 2008 - 2012. Mexico would show low dynamics in TFP, as well as Korea. Other studies have found a similar performance of Korea.

All the results are dependent of the short period of time (2008 – 2012) considered, a limitation due to the decision of having a common period for the five countries in which information by sectors were available (for an aggregate national level figures longer estimation have been performed elsewhere).

As the figures in Annex 1 (by sector) and Annex 2 (by country) show, the levels of TPF, Technical Efficiency change and Technical Change vary among countries and sectors, as well as from year to year, in such a way that could not have been predicted from national estimates. The figures also show that Technical Efficiency Change and Technical Change do not move in the same direction in a given year for the same sector and country. It is more frequent to find Technical Efficiency change than Technical Change in the sectors in which each country performs better than the others, probably because Technical change is more costly and takes more time. Change of scale of the frontier was absent in the studied period (recall our observation about the shortness of the period).

A task ahead consists in explaining why a country in some specific sectors has higher TFP changes and higher Technical Efficiency Changes or Technical Changes. The reasons should be related to macroeconomic environment, rates of interest, rates of exchange, inflation, knowledge creation and R&D, global insertion, institutions, among others. They need to be analyzed for each country and sector.

[3] According to OECD (2014), the Services Sector in South Korea is facing low productivity, putting South Korea as the OECD members with the lowest productivity level.

Another point to be studied relates to the reasons of having some years in which technical efficiency is more relevant than technical change, and some years with the opposite situation. Given the shortness of the period taken into account (for reasons presented above), it is desirable to replicate the exercises when the sectoral information becomes available for the four countries in a longer period.

Finally, it is important to analyze productivity and its components at a microeconomic level, moving on along the process of disaggregation performed in this paper. As our exercise showed, the disaggregation allows a better picture of the heterogeneity of countries and of sectors (and firms).

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ANNEX 1. ESTIMATIONS BY SECTOR

Table 5. Hicks-Moorsteen indexes Agriculture sector by Country. Non-Normalized. Geometric mean 2009-2012

Country	Constant return to scale		Variable return to scale		
	Technical efficiency change	Techonolgical change	Technical efficiency change	Techonolgical change	Scale Efficiency change
Chile	8,07%	-5,29%	0,69%	-0,86%	8,07%
Colombia	5,59%	-5,29%	0,87%	-1,03%	0,98%
Korea	5,44%	-6,34%	5,44%	-6,34%	0,00%
Mexico	7,68%	-5,29%	7,37%	-5,29%	3,38%

Table 6. Hicks-Moorsteen indexes Agriculture sector by Country. Normalized. Geometric mean 2009-2012

Country	Constant return to scale		Variable return to scale		
	Technical efficiency change	Techonolgical change	Technical efficiency change	Techonolgical change	Scale Efficiency change
Chile	6,30%	-3,38%	0,14%	-1,83%	-1,64%
Colombia	6,96%	-3,38%	3,91%	-1,95%	6,96%
Korea	4,46%	-4,51%	4,46%	-4,51%	0,00%
Mexico	-5,06%	2,98%	-5,06%	2,98%	-11,83%

Table 7. Hicks-Moorsteen indexes Manufacturing sector by Country. Non-Normalized. Geometric mean 2009-2012

Country	Constant return to scale		Variable return to scale		
	Technical efficiency change	Techonolgical change	Technical efficiency change	Techonolgical change	Scale Efficiency change
Chile	3,55%	-1,33%	6,39%	-3,14%	3,55%
Colombia	-6,68%	-1,33%	-6,68%	-1,33%	2,09%
Korea	5,84%	-7,63%	5,84%	-7,63%	0,00%
Mexico	6,98%	-3,14%	6,98%	-3,14%	0,39%

Table 8. Hicks-Moorsteen indexes Manufacturing sector by Country. Normalized. Geometric mean 2009-2012

Country	Constant return to scale		Variable return to scale		
	Technical efficiency change	Techonolgical change	Technical efficiency change	Techonolgical change	Scale Efficiency change
Chile	3,55%	-1,33%	2,53%	-1,28%	3,54%
Colombia	-6,68%	-1,33%	2,23%	-4,76%	-6,68%
Korea	5,84%	-7,63%	6,63%	-7,87%	0,00%
Mexico	6,98%	-3,14%	0,91%	-1,33%	-5,68%

Table 9. Hicks-Moorsteen indexes Mining sector by Country. Non-Normalized. Geometric mean 2009-2012

Country	Constant return to scale		Variable return to scale		
	Technical efficiency change	Techonolgical change	Technical efficiency change	Techonolgical change	Scale Efficiency change
Chile	-15,57%	-5,51%	-15,57%	-5,51%	-18,96%
Colombia	12,74%	-5,51%	14,97%	-5,51%	11,87%
Korea	1,73%	-5,51%	1,73%	-5,51%	0,00%
Mexico	-3,60%	-2,23%	6,80%	-5,51%	0,00%

Table 10. Hicks-Moorsteen indexes Mining sector by Country. Normalized. Geometric mean 2009-2012

Country	Constant return to scale	Variable return to scale

	Technical efficiency change	Techonolgical change	Technical efficiency change	Techonolgical change	Scale Efficiency change
Chile	6,53%	-4,77%	-9,12%	-3,07%	10,35%
Colombia	18,46%	-4,77%	7,58%	-2,48%	18,46%
Korea	1,33%	-4,77%	1,33%	-4,77%	0,00%
Mexico	-3,60%	-2,23%	-2,95%	-2,22%	-3,60%

Table 11. Hicks-Moorsteen indexes Services sector by Country. Non-Normalized. Geometric mean 2009-2012

Country	Constant return to scale		Variable return to scale		
	Technical efficiency change	Techonolgical change	Technical efficiency change	Techonolgical change	Scale Efficiency change
Chile	0,50%	-0,34%	1,06%	-0,24%	-0,12%
Colombia	-1,29%	0,01%	0,18%	-0,37%	-1,85%
Korea	0,75%	-0,90%	0,99%	-1,00%	0,00%
Mexico	0,29%	-0,34%	0,37%	-0,24%	-0,03%

Table 12. Hicks-Moorsteen indexes Services sector by Country. Normalized. Geometric mean 2009-2012

Country	Constant return to scale		Variable return to scale		
	Technical efficiency change	Techonolgical change	Technical efficiency change	Techonolgical change	Scale Efficiency change
Chile	8,52%	-1,36%	8,52%	-1,36%	0,84%
Colombia	8,12%	-1,36%	-1,11%	-0,19%	8,12%
Korea	2,20%	-2,90%	2,20%	-2,90%	0,00%
Mexico	3,91%	-0,19%	3,91%	-0,19%	0,52%

Table 13. Hicks-Moorsteen indexes Construction sector by Country. Non-Normalized. Geometric mean 2009-2012

Country	Constant return to scale		Variable return to scale		
	Technical efficiency change	Techonolgical change	Technical efficiency change	Techonolgical change	Scale Efficiency change

Chile	1,06%	-2,65%	6,39%	-3,14%	3,55%
Colombia	1,02%	-1,23%	-6,68%	-1,33%	2,09%
Korea	1,68%	-3,49%	5,84%	-7,63%	0,00%
Mexico	-1,26%	-1,81%	6,98%	-3,14%	0,39%

Table 14. Hicks-Moorsteen indexes Construction sector by Country. Normalized. Geometric mean 2009-2012

Country	Constant return to scale		Variable return to scale		
	Technical efficiency change	Techonolgical change	Technical efficiency change	Techonolgical change	Scale Efficiency change
Chile	3,55%	-1,33%	2,53%	-1,28%	3,54%
Colombia	-6,68%	-1,33%	2,23%	-4,76%	-6,68%
Korea	5,84%	-7,63%	6,63%	-7,87%	0,00%
Mexico	6,98%	-3,14%	0,91%	-1,33%	-5,68%

ANNEX 2. ESTIMATIONS BY COUNTRY

Table 15. Hicks-Moorsteen indexes Colombia by sector. Non-Normalized. Geometric mean 2009-2012

Sector	Constant return to scale		Variable return to scale		
	Technical efficiency change	Techonolgical change	Technical efficiency change	Techonolgical change	Scale Efficiency change
Agriculture	5,84%	-7,53%	1,27%	-1,70%	8,82%
Construction	-1,31%	1,47%	2,14%	-1,52%	5,30%
Manufacturing	-4,02%	1,53%	-3,69%	-1,41%	0,65%
Mining	0,84%	2,93%	3,16%	-0,35%	0,00%
Services	18,80%	-21,56%	-10,77%	8,63%	0,00%

Table 16. Hicks-Moorsteen indexes Colombia by sector. Normalized. Geometric mean 2009-2012

Sector	Constant return to scale	Variable return to scale

	Technical efficiency change	Techonolgical change	Technical efficiency change	Techonolgical change	Scale Efficiency change
Agriculture	8,82%	-8,66%	3,00%	-2,25%	8,82%
Construction	0,51%	6,66%	0,51%	6,66%	5,35%
Manufacturing	-3,54%	6,66%	-3,54%	6,66%	0,82%
Mining	5,77%	6,66%	6,33%	-1,79%	5,77%
Services	-0,06%	-1,24%	-0,06%	-1,24%	0,00%

Table 17. Hicks-Moorsteen indexes Chile by sector. Non-Normalized. Geometric mean 2009-2012

Sector	Constant return to scale		Variable return to scale		
	Technical efficiency change	Techonolgical change	Technical efficiency change	Techonolgical change	Scale Efficiency change
Agriculture	2,23%	-2,07%	3,51%	-3,03%	0,96%
Construction	1,34%	-2,36%	7,04%	-7,40%	0,00%
Manufacturing	3,16%	-2,48%	0,74%	-0,12%	1,61%
Mining	0,61%	-3,62%	-0,66%	-2,34%	0,00%
Services	3,87%	-2,76%	3,06%	-2,02%	3,27%

Table 18. Hicks-Moorsteen indexes Chile by sector. Normalized. Geometric mean 2009-2012

Sector	Constant return to scale		Variable return to scale		
	Technical efficiency change	Techonolgical change	Technical efficiency change	Techonolgical change	Scale Efficiency change
Agriculture	-6,02%	6,49%	-3,89%	4,74%	0,00%
Construction	6,47%	-5,51%	6,37%	-5,31%	0,00%
Manufacturing	-5,48%	8,48%	-3,58%	6,81%	0,64%
Mining	-17,51%	8,13%	-6,77%	-1,52%	0,00%
Services	-3,73%	11,22%	-0,19%	7,10%	0,00%

Table 19. Hicks-Moorsteen indexes Mexico by sector. Non-Normalized. Geometric mean 2009-2012

Sector	Constant return to scale		Variable return to scale		
	Technical efficiency change	Techonolgical change	Technical efficiency change	Techonolgical change	Scale Efficiency change

Agriculture	3,46%	-0,46%	-0,05%	-0,46%	3,17%
Construction	2,42%	-5,51%	2,42%	-5,51%	5,14%
Manufacturing	0,32%	-2,67%	2,51%	-5,51%	1,37%
Mining	1,11%	-5,51%	-3,80%	-0,35%	0,00%
Services	2,16%	-3,33%	4,41%	-5,51%	0,00%

Table 20. Hicks-Moorsteen indexes Mexico by sector. Normalized. Geometric mean 2009-2012

Sector	Constant return to scale		Variable return to scale		
	Technical efficiency change	Techonolgical change	Technical efficiency change	Techonolgical change	Scale Efficiency change
Agriculture	3,17%	-0,19%	2,16%	-2,35%	3,17%
Construction	-1,34%	-2,59%	-1,34%	-2,59%	-0,19%
Manufacturing	0,40%	-2,59%	-0,06%	-2,03%	-0,86%
Mining	-2,23%	-2,59%	-3,05%	-0,46%	-3,46%
Services	2,68%	-3,36%	2,68%	-3,36%	0,00%

Table 21. Hicks-Moorsteen indexes Korea by sector. Non-Normalized. Geometric mean 2009-2012

Sector	Constant return to scale		Variable return to scale		
	Technical efficiency change	Techonolgical change	Technical efficiency change	Techonolgical change	Scale Efficiency change
Agriculture	8,10%	-7,36%	0,50%	0,22%	-0,54%
Construction	8,16%	-11,11%	-3,83%	0,22%	0,00%
Manufacturing	-4,09%	8,04%	-0,91%	2,90%	-4,09%
Mining	-2,17%	4,23%	5,81%	-4,63%	0,00%
Services	0,47%	0,91%	7,21%	-4,63%	2,45%

Table 22. Hicks-Moorsteen indexes Korea by sector. Normalized. Geometric mean 2009-2012

Sector	Constant return to scale		Variable return to scale		
	Technical efficiency change	Techonolgical change	Technical efficiency change	Techonolgical change	Scale Efficiency change
Agriculture	0,22%	-0,51%	-0,55%	0,27%	-0,17%
Construction	0,25%	-0,88%	-0,25%	-0,36%	0,00%

Manufacturing	0,06%	0,08%	1,00%	-0,73%	-0,15%
Mining	-0,31%	-0,74%	-0,85%	0,32%	-0,31%
Services	0,11%	0,27%	1,01%	-0,63%	0,00%