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# A cross-country analysis of total factor productivity using micro-level data

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ABSTRACT

Total factor productivity (TFP) is a crucial measure of efficiency and thus an important tool for policy-makers. However, research on comparison of TFP performances using micro-level data across developing countries has been limited due to the unavailability of homogenous data sources. This study aims to fill this crucial gap by using a data set which has been collected through a large body of surveys conducted across 69 developing countries following the same methodology. The homogenous nature of the data and the diverse set of questions included in the surveys provide unique opportunity to compare average productivity performances of firms across a large set of characteristics and business environment factors. The analysis performed here provides the groundwork for testing various stylized facts about TFP and its related factors such as exporting, innovation, access to finance, foreign ownership, and regulations across developing countries.



## 1. Introduction

Since the seminal work of Solow (1957), Total Factor Productivity (TFP) has been regarded to play a major role in generating and predicting growth. TFP is defined as the portion of output not explained by the amount of inputs used in production. Its value represents how efficiently and intensely the inputs are utilized in production. Numerous studies using macro level data have shown that the differences in countries' growth patterns and income levels are associated with the differences in their productivity levels. Hsieh and Klenow (2010) and Jones and Romer (2010) find that differences in measured TFP explain more than half of the cross-country differences in output per worker. Prescott (1998) provides evidence on how physical and intangible capital cannot account for these cross-country differences.

Once the importance of TFP was established, the study of growth and development evolved into explaining the productivity differences across countries. For this purpose, the Penn World Tables (PWT) has been used as a source for reliable data for such macro-level, cross-country analysis. Hall and Jones (1999) and more recently Imrohoroğlu and Üngör (2016) have performed cross-country comparison with PWT. Yet, measuring TFP at the country level does exhibit disadvantages since it cannot account for firm-level heterogeneity.

The development of theoretical microeconomic models establishing the importance of TFP combined with the availability of rich firm level datasets allowed researchers to investigate the reasons behind vast dispersion in productivity performances across firms. Some early examples of firm-level productivity analyses are Bailey et al. (1992) and Bartelsman and Dhrymes (1998) for U.S. manufacturers and Roberts and Tybout (1996) for a number of developing countries. While firm-level TFP studies surveying developed countries are commonplace (Bartlesman and Doms, 2000), comprehensive comparisons of TFP across a large set of emerging economies have been limited due to the lack of a homogeneous data source.

The availability of microdata has not substantially altered the existing methods used for measuring productivity. However it has stimulated development of some innovative solutions to old empirical problems. If the interest is only to produce productivity, Bartelsman and Doms (2000) suggest that it is best not to take a dogmatic stance on methodology but rather to explore the

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sensitivity of productivity measures to variations in methodology. We follow their approach in this paper to the extent possible. TFP can be calculated using a wide variety of methods and the comparative advantage of each measure depends on the particular question at hand and the particular availability of the data.

In this study we assume that TFP is the unobserved firm-specific effect that is recovered from an estimated production function as the difference between actual and predicted output. We use various forms of Cobb-Douglas production function in the estimations. This approach raises econometric issues regarding the possible bias of coefficients on input variables due to simultaneity bias. The concern is that the productivity of the firm itself affects the input decisions, introducing correlation between the plant effect and the input coefficients. If there is simultaneity bias, simply running OLS might lead to biased estimates of the input coefficients. This issue could lead to sum of all factor coefficients deviate from one in the estimations.

Alternative approaches have been introduced to remedy the simultaneity problem most commonly known by Olley and Pakes (1996) which was used in microdata by Pavcnik (1998) and then further modified by Levinsohn and Petrin (2003). The novelty of these studies is that they use observable micro-level information to correct for the simultaneity bias and account for self-selection of exiting producers. Another alternative is using fixed-effect regressions. However, we could not perform any of these alternative approaches with cross-sectional data. In all these alternative specifications we need at least two periods of data for each firm.

Another popular method for computing a productivity with sectoral data was through estimating cost function and factor demand equations which was developed following Nadiri (1970). The main advantage of using this method is that the estimated parameters are not biased because of simultaneity of productivity and factor demand. However, the advantages over directly estimating production functions are questionable because identification of the factor demand equations requires variation in factor prices, which are not available at the micro level.

Being aware of the limitations of the empirical methodology implemented, we intend to perform a comprehensive cross-country analysis of TFP performances of manufacturing firms in 69 emerging economies. We also investigate how productivities vary across firms' characteristics such as size and age. The analysis shows high levels of heterogeneity in productivity levels across firms. Among countries with large samples of at least 200 manufacturing firms and surveyed after 2006, Brazil and Turkey emerge as the most productive countries. The surveys include questions that can help analyze a rich set of characteristics across which cross-country TFP comparisons can be made. Some of these characteristics are size, age, ownership of the firm, export orientation, financial access, gender of the owner, industry of operation as well as various investment climate obstacles.

We utilize the World Bank's Enterprise Surveys data which supplies firm-level data on a wide range of topics pertaining to the investment climate and firm operations. An additional advantage of the Enterprise Surveys is that all surveys included in this study were collected under a common global sampling methodology, yielding representative samples of private sector firms. Just like the PWT, we intend to produce a productivity database. However, our effort uses a large set of developing countries and provides estimates of firm level TFP levels in order to perform a cross-country analysis. Panel data is also available which provides a unique opportunity to study the evolution of productivity over time. Enterprise Surveys also include a large set of questions regarding the business environment, which is invaluable to gauge the impact of business climate and regulation onto firm productivities.

The paper is organized as follows; Section 2 discusses the Enterprise Surveys data and relevant variables. Section 3 outlines the estimation procedure used to calculate TFP. Section 4 discusses the results and compares productivities across countries, industries, and firm groups. Lastly, section 5 suggests areas for further research and concludes.

## 2. Data

The data used for the TFP analysis covers 69 countries from a rich set of emerging economies and the data is collected through the Enterprise Analysis Unit of the World Bank.[1] The sample includes countries where there are a sufficient number of manufacturing firms to conduct the analysis and where surveys followed a harmonized global sampling methodology. Although the surveys include firms from service sectors, the productivity analysis is conducted only for the firms in manufacturing sector. In some small countries, Indicator Surveys are conducted instead of the Enterprise Surveys.[2] These surveys include fewer questions than the full survey and have a smaller scope, thus productivity cannot be computed for firms in these countries. The economies where Indicator Survey is conducted are stratified into two groups: manufacturing and rest of the non-agricultural economy, with 75 interviews allocated to each group. In all remaining countries, the sample size changes between 150 and 1320 depending on the size of the economy.

In the surveys, a random sample of manufacturing firms is selected that is representative of the economy. The sample of firms is stratified by sector, size, and geographic region. Each firm is assigned a probability weight so that the inferences derived from the sample are representative for the all economy. In all the analysis performed in this study we use these probability weights.

Data used for the analysis is cross-sectional. Enterprise Surveys are collected in staggered waves by region.[3] In Latin America and Caribbean (LCR) region, surveys were conducted in 2010. Only Brazil was surveyed separately in 2009. In Eastern Europe and Central Asia (ECA) region, firms were surveyed in 2008 and 2009. Two exceptions in this region were Bulgaria and Croatia which were surveyed in 2007. The Sub-Saharan Africa (SSA) region yields the largest number of countries and most of them were surveyed in 2006 or 2007. East and South Asia region covers eight countries (ASIA). As the countries in the region are quite populous and diverse there has not been a regional survey roll-out. The countries were surveyed between 2006 and 2009. Surveys from the Middle East and North Africa (MNA) region are similar to East and South Asia. Four countries from this region were surveyed between 2006 and 2009. For the analysis, we separate the countries into two groups by the year of survey; 29 countries were surveyed in 2006 and 2007; and 40 countries were surveyed more recently between 2008 and 2010.

TFP is measured only for manufacturing firms. Industries are classified by major 2-digit manufacturing industries according to ISIC rev 3.1 classification (Table 3). Food industry has the largest coverage in the dataset, covering over 20 percent of the sample. Garments is the second largest industry. Some of the industries

[1] Enterprise Surveys restricts the universe of firms with at least 5 employees. Some sectors are excluded from the survey, such as agriculture and mining. The data used in this study as well as the methodology used in data collection and sample construction are available at www.enterprisesurveys.org.

[2] Indicator surveys are conducted in countries that have below 15 Billion USD Gross National Income.

[3] The survey coverage is in fact much larger than the 69 countries. In this study, we restricted the sample to countries that were surveyed between 2006 and 2009 so that reasonable cross-country comparisons could be made. Many new surveys where TFP could be estimated have been conducted since 2009.

were grouped together based on the similarities in the type of activity and factor intensity. The group "Other Manufacturing" is a residual category that includes all firms that are outside the six major industry groups and this residual grouping includes almost 30 percent of firms. The concentration of firms in six major industry groups is the result of a sample design, used in most countries, where selected industries were targeted to facilitate industry-level analysis.

The principle variables used to compute TFP include firms' annual sales ($Y$), labor costs ($L$), the replacement value of machinery, vehicles and equipment ($K$), cost of raw and intermediate materials ($M$), and the cost of electricity and fuel ($E$). Firms that had missing values for any of these variables are excluded from the analysis.[4] Data such as sales, costs, and the number of employees refer to the last *complete* fiscal year, not necessarily the year the survey was conducted. Hence data from LCR region refers to expenditures and sales in 2009. In ECA region, even though surveys were conducted in both 2009 and 2008, all data refers to the 2007 fiscal year.

In the analysis, we control for outliers on output (annual sales), labor costs, replacement costs of capital, costs of materials, material-output ratio, capital-output ratio, and labor cost-output ratio. Values that are three standard deviations above or below the mean values in each country are dropped from the analysis. In total, roughly 6469 firms are dropped since they had at least one outlier flag regarding data on the inputs or because they were missing key input data necessary to compute TFP.[5]

Moreover, countries for which *Y, K, L,* and *M* variables are available for less than 50 percent of the sample are dropped. Sixteen countries were excluded due to this restriction.[6] Fig. 1 shows that roughly a quarter of all countries have less than 50 percent response rate in the necessary variables. From the original sample of 26,256 firms in 69 countries, a remaining 19,787 firms with sufficient data are included in the TFP analysis. The regional distribution of firms is presented in Table 1 and the list of countries included in the analysis is presented in Table 2.

## 3. Estimating firm-level total factor productivity

TFP is commonly used as a measure to rank firms on their performance. A firm is considered to be more productive if it can produce more output from the same inputs. To measure TFP, we utilize the neoclassical production function. In doing so, we use both parametric and non-parametric estimation methods. The pioneering work on measuring TFP with firm-level data are presented by Baily et al. (1992) and Bartelsman and Dhrymes (1998) using data from U.S. Census of Manufacturers. Later, Roberts and Tybout (1996) conduct TFP analysis for a number of developing countries. Following the methods presented in their work, we estimate firm level TFPs separately for each country. In our estimations, we control for 2-digit industry effects as industries are likely to vary in the technology they use. In all specifications, we assume that all firms in a country face the same technology and thus restrict the input coefficients to be the same across industries. This assumption could be strong for some industries. However, estimating the equations for each industry could be problematic since the sample size for some industries is quite small. In the last section, for some of the countries where the sample size is large enough, we perform the TFP analysis at the industry level.

In our first parametric specification, we use the Cobb-Douglas production function shown in equation (1) below;

$$Y_{it} = A_{it} K_{it}^{\alpha} L_{it}^{\beta} M_{it}^{\phi} \tag{1}$$

Here, $Y$ is output measured as annual real sales, $K$ is the replacement cost of capital, $L$ is annual labor costs, $M$ is cost of intermediate goods, and $A$ is the TFP term. We call this specification as YAKLM. The parameters $\alpha$, $\beta$, and $\phi$ are the output elasticities of capital, labor and intermediate goods respectively. In estimating the production function, the log of output is regressed on the log of input factors. Hence the coefficients represent the elasticity of output with respect to each input factor. The log of TFP is the residual term from estimating the log transformation of this production function presented in equation (2). A higher estimated TFP value is associated with higher productivity.

$$\log \widehat{A}_{it} = \log Y_{it} - \widehat{\alpha} \log K_{it} - \widehat{\beta} \log L_{it} - \widehat{\phi} \log M_{it} \tag{2}$$

The second production function specification adds energy costs to equation (1) and is denoted as YAKLEM.[7] Although inclusion of energy costs provides a more complete view of the production process as well as a better measure of the residual than the YAKLM model, data coverage drops significantly for some countries due to missing observations. Alternatively, the YAKL specification includes only two production factors: labor and capital.[8] We also use value added as the dependent variable instead of total sales. Value added is calculated by subtracting intermediate goods cost and energy costs from total value of sales ($VA$=$Y$-$M$-$E$). This specification is called VAKL.[9] Constant returns to scale and perfect competition in the input and product markets are the critical assumptions considered for these production function specifications.

As a fifth specification, we introduce a transcendental logarithmic (*trans*-log) three-input production function (Squires (1987); Pascoe and Robinson (1998)) given in equation (3). The first equation shows the functional form of the *trans*-log specification. The second equation is obtained by taking the logarithm of the both sides of the first equation.

*Trans*-log production function is a commonly used generalization of Cobb-Douglas production function. Unlike the standard Cobb-Douglas production function, *trans*-log specification does not impose assumptions about constant elasticities of production factors or elasticities of substitution. This nature allows it to have increasing or decreasing returns to scale and possible interactions between factor inputs. The *trans*-log production function allows transforming from a linear relationship between the output and the production factors to a non-linear one yet including the possibility of a linear relationship. On the other hand, this flexibility of the functional form produces a side effect. The elasticities of substitution are not monotonic or globally convex as in Cobb-Douglas model. Moreover, the elasticities of substitution are harder to interpret in this functional form. The productivity measure is estimated as follows:

[4] Data imputation methods such as multiple imputations (MI), maximum likelihood estimation (MLE), and mean substitution were not applied in the analysis.

[5] This is the number of firms excluded from the calculation of TFP using the YAKLM specification which will be introduced in the next section. The exact number of firms excluded when computing TFP using the alternative specifications (YAKL or YAKLEM) vary.

[6] In order of least coverage, the countries removed due to less than 50% coverage of data: Panama 2010, Albania 2007, Burkina Faso 2009, Algeria 2007, Bolivia 2010, Ukraine 2008, Romania 2009, Philippines 2009, Poland 2009, Yemen 2010, Slovakia 2009, Russia 2009, Venezuela 2010, Uruguay 2010, Armenia 2009, Bosnia and Herzegovina 2009.

[7] The estimation equation is $\log A_{it} = \log Y_{it} - \widehat{\alpha} \log K_{it} - \widehat{\beta} \log L_{it} - \widehat{\lambda} \log E_{it} - \widehat{\phi} \log M_{it}$.

[8] The estimation equation is $\log A_{it} = \log Y_{it} - \widehat{\alpha} \log K_{it} - \widehat{\beta} \log L_{it}$.

[9] The estimation equation is $\log A_{it} = \log VA_{it} - \widehat{\alpha} \log K_{it} - \widehat{\beta} \log L_{it}$.

$$Y = A\prod_{i=1}^{3} X_i^{\alpha_i} \prod_{i=1}^{3} X_i^{1/2\left[\sum_{j=1}^{3}\beta_{ij}\log(X_j)\right]}$$

$$\begin{aligned}\log A_{it} = {} & \log Y_{it} - \widehat{\alpha}_K \log K_{it} - \widehat{\alpha}_L \log L_{it} - \widehat{\alpha}_M \log M_{it} \\ & - \frac{1}{2}\widehat{\alpha}_{KK}(\log K_{it})^2 - \frac{1}{2}\widehat{\alpha}_{LL}(\log L_{it})^2 - \frac{1}{2}\widehat{\alpha}_{MM}(\log M_{it})^2 \\ & - \widehat{\alpha}_{KL}(\log K_{it}{*}\log L_{it}) - \widehat{\alpha}_{KM}(\log K_{it}{*}\log M_{it}) \\ & - \widehat{\alpha}_{LM}(\log L_{it}{*}\log M_{it})\end{aligned} \tag{3}$$

The sixth and last specification uses a non-parametric approach first established by Hall (1990) as presented in equation (4).[10] In this method, the output elasticity of each input factor is calculated as the share of that input's cost relative to the total cost. The total annual cost of capital ($rK$) is depreciated by 15 percent.[11] Total annual labor cost is denoted as $wL$, and the total cost of intermediate materials is denoted as $pM$. For each country, cost shares for capital, labor, and material are computed according to equation (4). Once the output elasticities are calculated, TFP is calculated as the residual similar to equation (2).[12]

$$\widehat{\alpha} = \frac{rK}{rK + wL + pM}, \widehat{\beta} = \frac{wL}{rK + wL + pM}, \widehat{\phi} = \frac{pM}{rK + wL + pM} \tag{4}$$

Using all six specifications presented above, we estimate TFP in the next section. First, we show how countries differ in the output elasticities of the factors they employ in production process. Then we present and compare aggregate productivity levels across countries. We also compare firms with different size level, trade activity, and industry. Lastly, we compare productivity across 2-digit industry groupings within countries and show how they are likely to differ in input elasticities and productivities.

## 4. Estimation results

The number of observations used in the estimation of the YAKLM production function for each country is presented in Table 2.[13] For most of the analyses that follow, we present results for the YAKLM specification as this is the most commonly used specification in the literature. The table also shows the percentage of firms for which TFP could be calculated with the YAKLM specification.

All monetary values are originally recorded in nominal local current currencies. For the analysis, all monetary values are converted into US dollars and then deflated using a GDP deflator to be presented in 2000 constant USD. The source for the exchange rates and the GDP deflators is the World Development Indicators from World Bank. Alternatively we also convert the values in local currencies to real terms using the producer price index (PPI) which is obtained from IMF. PPI is constructed using the prices received by domestic producers and services hence it measures the price change from the perspective of the seller. On the other hand, GDP deflator has a broader coverage of the economic activity as it includes prices of all goods and services bought by consumers, firms, and government. For the purpose of our analysis, PPI is a better index to deflate firms' outputs and measure TFP. However, PPI data is available for only 29 countries. Due to this limitation, we base the analysis on values deflated by the GDP deflator. Comparison of productivities calculated for YAKLM specification using both GDP deflator and PPI for the countries with at least 200 observations is presented in Fig. 2.[14] The graph shows that TFP measures obtained from using either price index yields similar results.

### 4.1. Factor elasticities

Based on macro-level datasets, Gollin (2002) shows that factor shares adjusted for self-employment income and sectoral composition are remarkably constant across both time and countries and that the capital shares cluster around 0.30. However micro-evidence provides more diverse results.

The coefficients obtained from the estimation using Cobb-Douglas production function can be interpreted as input factor elasticities. These coefficients show how responsive sales are to changes in the levels of each input factor used in the production. Factor elasticities that are estimated using two of the specifications: YAKLM and Solow residual are presented in Table 4. In the YAKLM specification, elasticity of capital is lower than the elasticity of labor and materials in all 67 countries. [15] In this specification, average elasticity values for all 67 countries are 0.09, 0.48, and 0.55 for capital, labor, and material in respective order. The elasticity values for the ten countries with the largest sample sizes are presented in Fig. 3.

A common finding based on the factor elasticities of other specifications show that as we add new factors for production, shares of the existing factors decrease. This is expected; as when omitted, the contribution of intermediate goods (M) is distributed among the remaining factors of K, L or A (TFP). Similarly when energy (E) is included to the specification, the share of capital continues to decrease. The reason for declining factor share of capital or labor is that when omitted from the econometric specification we are imposing an implausible restriction in terms of the elasticity of output with respect to Material (or Energy). At micro-level, the high factor elasticity for intermediate goods show that in fact the use of these goods is very important in production.

Using firm level data from Colombia for 1982–1998, and using the YAKLEM specification, Eslava et al. (2004) find factor elasticities to be 0.08, 0.24, 0.12, and 0.59 in respective order for capital, labor, energy, and materials. Our estimation results for the YAKLEM specification from 2010 Columbian data yields 0.09, 0.40, 0.02, and 0.61 as factor elasticities in respective order. Although the elasticity levels are quite comparable, the slight difference could stem from the fact that Eslava et al. (2004) estimate production function at industry level rather than country level as we do. Hallward-Driemeier (2002) find these elasticities in the same order as 0.15, 0.30, 0.24 and 0.31 for Malaysia using firm level data between 1996 and 1998. In our results for 2009 Malaysian data, these values are 0.03, 0.49, 0.09, and 0.50 in respective order. Differences in these

[10] Parametric statistical tests assume that data comes from a type of probability distribution and makes inferences about the parameters of the distribution. Hence, the relationship between variables can be estimated through linear regressions. On the other hand, non-parametric statistical tests do not make the assumption that the data follows some distribution. Therefore, the relationship between variables has to be treated either through nonlinear regressions or other non-parametric methods.

[11] See Van Biesebroeck (2007), Escribano et al., (2009) for the choice of 15% as the depreciation rate.

[12] The original Solow Residual (Solow (1957)) uses revenue shares rather than cost shares and requires an assumption of perfect competition in product markets. On the other hand, the cost-based Solow Residual is robust to imperfect competition (see Hall (1990)).

[13] Number of observations used in other specifications is available upon request.

[14] Other countries are excluded only for expositional purposes. Analysis with both deflators yields similar results for all 29 countries.

[15] 67 out of 69 countries have all positive elasticities. Honduras and Guinea Bissau have negative estimated elasticities.

elasticities could stem from the changes in the time period studies or differences in the definition of capital between the two studies. In our study the value of capital stock is measured by the replacement cost of machinery, vehicles and equipment. The factor elasticities across the 67 countries in YAKLEM specification are 0.06, 0.50, 0.06, and 0.51 in respective order. In these related studies, the factor elasticities of materials and labor are calculated to be much higher than the elasticities of capital or energy.

### 4.2. TFP analysis across countries

The average productivities are calculated using sampling weights. Thus, they illustrate the productivity levels of an average firm in each country. The YAKLM, *Trans*-log, and Solow residual specifications present the most diverse estimation methods by their structure. TFP estimates from the YAKLM specification are highly correlated with estimates calculated using the *trans*-log specification which is presented in Table 5. Non-parametric estimation method of the Solow residual is correlated less strongly with the TFP values from the parametric estimation methods.[16]

First, we compare the countries that were surveyed between 2008 and 2010 using the YAKLM specification. Fig. 4 presents the average TFP values for YAKLM, YAKLEM, and *Trans*-log specifications for large countries. Large countries are those with at least 200 firms available to estimate TFP under the YAKLM specification. Among the 13 large countries, Brazil, Turkey, and Indonesia have consistently high average TFP levels under these three specifications. The same TFP comparison is performed for the countries that are surveyed earlier in 2006 or 2007. Fig. 5 shows TFP performances of large countries that were surveyed in 2006 and 2007 wave. Among these countries, Jordan, Ethiopia and Pakistan exhibit high productivity levels.

Average TFP measures and their rankings across 69 countries under all specifications are presented in Table 6. For the majority of countries, there is a close correlation between the rankings of average TFP measures across all six specifications. The TFP values on the table should be compared with care as the survey was conducted in different years across the regions. As noted before, most of the Africa region was surveyed in 2006 or 2007. ECA and Asia regions were mostly surveyed in 2008 and 2009. LCR region was surveyed in 2010. On average, ECA 2008/9 has an average productivity of 1.44, higher than the 1.21 and 1.08 average among LCR2010 countries and SSA2006/7 countries.

In the Sub-Saharan Africa region, 21 of the 25 countries included in our analysis were surveyed in 2006 or 2007. Among these countries, Ethiopia emerged as the most productive country in the region, followed by Namibia and Botswana. Mauritania ranks the lowest in four out of five specifications. Additionally, there are four Sub-Saharan African countries surveyed in 2009: Cameroon, Ivory Coast, Madagascar, and Mauritius. The most productive country in this group is Cameroon, with the largest average TFP measure calculated using all specifications except for the value-added specification.

In Asia region, there are five countries that were surveyed in 2009, which are Indonesia, Mongolia, Nepal, Philippines, and Vietnam. Indonesia is the most productive country in the region with a TFP level of 1.38 under the YAKLM specification. However, under the YAKL and VAKL specifications, Indonesia ranks second and India ranks as the most productive country.

Among the countries included in the analysis from the ECA region only Bulgaria and Croatia were surveyed in 2007. Calculating TFP using the YAKLM specification, the three most productive countries in ECA are Kyrgyzstan, Moldova, and Uzbekistan. The country with the lowest productivity level calculated using the YAKLM specification is Latvia. Under the YAKL and VAKL specifications, Georgia has the lowest TFP in ECA. Notice that there are only two large ECA countries with over 200 observations to calculate TFP, Turkey and Bulgaria. Most of the ECA countries offer small samples to compute TFP, which can lead to imprecise elasticity estimates.

In LCR region, Brazil is the only country that was surveyed in 2009. Brazil also exhibits the highest average TFP levels under all specifications except for the Solow method where it ranks second behind Chile. Among the fourteen countries from LCR region included in the study, Jamaica ranks the lowest productivity under all six specifications. While there are fewer countries in the LCR region, the sample sizes per country are higher than in ECA.

The coverage of countries in the MNA region show high variation which makes it difficult to make a regional comparison; each country was surveyed in a different year.

### 4.3. TFP analysis by firm groups

In this section we analyze average TFP across firm groups such as firm size and industry groupings. The survey questionnaires allow us various other ways to compare TFP such as firm age, trade orientation of the firm, ownership status, financial access and various other investment climate factors. We restrict our analysis to two sets of characteristics and leave additional analysis across other firm characteristics to future research.

#### 4.3.1. By firm size

Theoretical and empirical literature on productivity recognize size as a major source of heterogeneity in firms' performance. There are various arguments about the impact of firm size on productivity and growth. On one hand, many studies have emphasized that large firms could be more efficient in production using arguments such as better access to technology, learning, dealing with uncertainty and selection process (Nelson and Winter (1982), Jovanovic (1982), Hopenhayn (1992), and Ericson and Pakes (1995). On the other hand, it is emphasized that small firms could be more efficient because they have flexible, non-hierarchical structures (Audretsch, 2002).

In this study, TFP levels of firms are compared at different size groups measured in employment levels. The survey includes a question asking the number of permanent, full-time workers employed by the firm in the last fiscal year. Size groups are defined as: Small: $\leq$20 employees, Medium: 21–99 employees, and Large: $\geq$ 100 employees.

Focusing on the set of countries surveyed between 2008 and 2010, the employment distribution of the sample is for the most part evenly distributed across three-size groups. There are some exceptions; Indonesia shows a relatively high proportion of small-size firms (50%), the Kyrgyzstan sample is comprised of 60 percent medium-sized firms, and in Bolivia, 47 percent of the sample is large firms.

Fig. 6 shows the results of average productivity estimates for the large countries surveyed between 2008 and 2010.[17] The graph shows that an average small firm is more productive than medium-size and large-size firms. Comparing TFP values across countries

[16] In addition to the standard Pearson correlations presented in Table 5, we also look at Spearman rank correlations. The correlation coefficients which are available upon request are quite similar to the ones presented in Table 5.

[17] Results are presented only for those countries that had at least 200 firms for which TFP could be estimated. TFP estimates were made for countries with at least 30 firms in each size category.

reveals that an average small firm in Brazil is more productive than small firms in any of the other countries included in the analysis.

Turning to the countries surveyed between 2006 and 2007, distribution of employment in these countries is less evenly distributed across size groups than in countries surveyed between 2008 and 2010. In particular, small firms dominate the sample in these earlier surveys. In seven out of 30 countries surveyed between 2006 and 2007, at least 70 percent of the sample is comprised of small firms.

Fig. 7 displays the average productivity estimates for twelve large countries surveyed between 2006 and 2007 by firm size.[18] Similar to findings from the 2008–2010 surveys, the average productivities of small firms are often higher than medium-size and large-size firms. Only in Morocco, Malaysia and Jordon, small firms do not have the highest TFP.

Our findings are consistent with research that has found that small firms do not suffer crippling disadvantages from scale inefficiencies. In fact, small firms may seek to participate in businesses where scales efficiency does not reap large cost savings (Tybout, 2000). Using firm-level data from Bangladesh, Fernandes (2008) also finds that small manufacturing firms are more productive than large manufacturing firms.

#### 4.3.2. By industry

Manufacturing industries, as listed in Table 3, are likely to utilize different production technologies. Hence, separate TFP estimations at the industry level are desirable. Furthermore, analyzing differences in productivity at the industry level could be informative in understanding differences in firm performances and it could also reveal information about comparative advantages of different countries.

Table 7 lists the average TFP levels estimated for each industry. Regressions were conducted only when there were at least 30 firms in the industry. There is an uneven distribution of countries with at least 30 firms in each industry. Survey samples are selected based on the distribution of firm population in the country. As countries vary in the industries that they have large firm population, the samples also differ. Commonly, food and garments industries have large presence in most of the countries surveyed followed by fabricated metals and chemicals. There are 43 countries that have at least 30 firms in the food industry. On the other hand, there are only nine countries in which non-metallic and basic metals industry has at least 30 firms.

The most productive countries across the different industries are concentrated in a few large countries, namely Brazil and Turkey. Egypt also ranks well in some industries, being the third most productive country in Textiles and Chemicals. In the six industries excluding the residual industry grouping, Brazil is the most productive in all but the non-metallic and basic metals industry. Looking at countries that rank second globally, most are located in Asia. Latin America is host to some of the lowest productive firms; Uruguay in Food, Colombia in Textiles and Fabricated Metals, and Chile in Garments.

Industry level estimates of TFP results are compared only for those countries with at least 30 observations in each selected industry: food, garment, and chemicals. These three industries were chosen due to their relatively higher coverage across regions. Among the countries surveyed between 2008 and 2010, Brazilian firms have the highest average TFP in both the garment and chemical industries (Fig. 8). Among the countries that were surveyed in 2006 and 2007, only six countries had at least 30 firms in each of these industries (Fig. 9). Moroccan firms exhibit the highest productivities in both food and chemicals, while Bulgarian firms exhibit the highest productivities in the Garment industry.

### 4.4. Decomposition of aggregate TFP

There are two factors that would lead to a high aggregate productivity level in a country. All firms in the country can be productive and/or output can be reallocated toward more productive firms. How much productivity gain would be obtained from reshuffling of resources from less to more productive firms can be determined through aggregate productivity decomposition. Following the decomposition methodology introduced by Olley and Pakes (1996), aggregate TFP can be decomposed into an unweighted simple average firm productivity and a cross-term measuring the covariance between firms' shares in the total output and their TFP values. The covariance term shows the extent to which firms with higher than average productivities have a higher than average market share. The decomposition can be formulated as follows:

$$TFP_c = \overline{TFP}_c + \sum \left(\theta_{ic} - \overline{\theta}_c\right)\left(TFP_{ic} - \overline{TFP}_c\right) \quad (5)$$

In equation (5), $TFP_c$ denotes aggregate weighted TFP in country $c$. The variable $\overline{TFP}_c$ denotes the cross-sectional simple average of productivity measures across all firms in the country. $TFP_{ic}$ represents the productivity of firm $i$ in country $c$. The variable $\theta_{ic}$ is the share of firm $i$'s output in total output and $\overline{\theta}_c$, is the cross-sectional simple average of $\theta_{ic}$.

Although the Olley-Pakes decomposition does not account for the effects of entry and exit on aggregate productivity and the evolution of firm productivities, it is less dominated by measurement errors or transitory shocks. Moreover, cross-sectional differences in productivity are more persistent than over-time changes.[19] The decomposition of aggregate TFP is presented in Table 8.

Only in Hungary and Czech Republic, the cross term is positive and higher than the average productivity which shows that aggregate productivity in these countries is largely accounted for by the allocation of activity to more productive firms. There are some countries where the cross-term is negative such as Argentine, Mexico, Bulgaria, Kazakhstan. This shows that output is disproportionally located in low productive firms and small firms are more productive than large firms. For the remaining group of countries like Indonesia, Turkey, Brazil, Chile the cross term is positive but smaller than the average term. This implies that large firms are more productive than the small ones. This finding is in accordance with the results from Foster et al., (2001). They perform the same analysis using data from United States and also find only a marginal contribution of the cross term to the aggregate productivity.

## 5. Conclusion

This paper discusses the measurement of TFP using a detailed firm level dataset from a large set of developing countries collected using a unique methodology by the World Bank. The surveys were conducted at 93 countries. Due to data limitations, the analysis was performed on 69 countries. Valuable results were reached at a descriptive level but the data yields potential to study a range of issues. Very little is known about TFP of manufacturing firms in lesser developing countries, especially from a comparative basis.

[18] Results are presented only for those countries that had at least 200 firms for which TFP could be estimated. TFP estimates were made for countries with at least 30 firms in each size category.

[19] See Eslava et al. (2004) for further discussion of Olley - Pakes decomposition.

From a policy perspective this is quite important and valuable. The analysis allows us to compare average TFP performances across a rich set of developing countries and help perform benchmark analysis. In addition, it allows us to identify productivity differences across firms confirming the large heterogeneity that aggregate measures of growth accounting cannot capture.

There are a number of ways that TFP can be compared based on the data set used in this research. Here, we analyzed average TFP across countries, firm size and industry. However, there are numerous other classifications that may be of interest such as comparing TFP by export orientation of firm, gender of firm managers or owners, degree of foreign ownership, firm age, or innovation capacity of firm. There is a large literature on the positive relationship between exporting, innovation, and productivity among the other characteristics listed above. However the stylized-facts established in these literature are not tested enough using large set of developing countries. The analysis provided here provides the ground work for testing how the strong relationship between certain firm and industry characteristics and productivity change across countries. A comparison of productivities in developed and emerging economies would also fill a gap in the literature.

It is also important to ascertain why certain types of firms outperform others. Observed productivity is a consequence of firm characteristics as well as the external business environment. There is a large literature also that focuses on the policies that would improve business environment so that productivity can be improved. For example, Atesagaoglu et al. (2017) show that the informal sector that was present in Turkey had negatively impacted both the level and growth of TFP especially between 1980 and 2014. The data allows for the analysis of the relationship between the business environment and firm-level productivity. Firm-level data allows us to investigate the reasons behind the vast dispersion in productivity performances across firms. For example, do more productive firms have more access to finance, do they get more impacted by graft, or do they suffer more from business regulations? Understanding these relationships and providing cross-country comparisons can allow for specific policies to increase productivity and generate growth.

Finally, Enterprise Surveys makes efforts to track and survey firms over time, yielding a large and useful panel data set in many regions of the world. Thus, the average TFP measure estimated could be replicated in the following rounds of surveys to analyze evolution of productivity. Although the analysis conducted in this study does not introduce a novel methodology to compute productivity, it provides a useful tool to perform cross-country TFP analysis for a rich set of developing countries all of which were surveyed using a common questionnaire following the same methodology. There lies the main contribution of the study.

## Appendix A. Figures

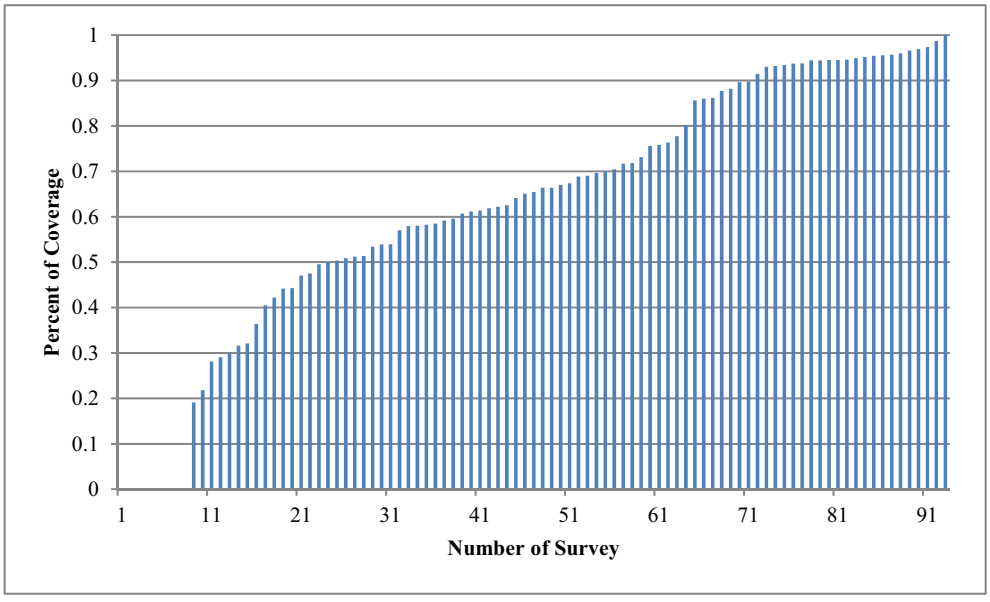


**Fig. 1.** Distribution of Data Coverage across Countries.

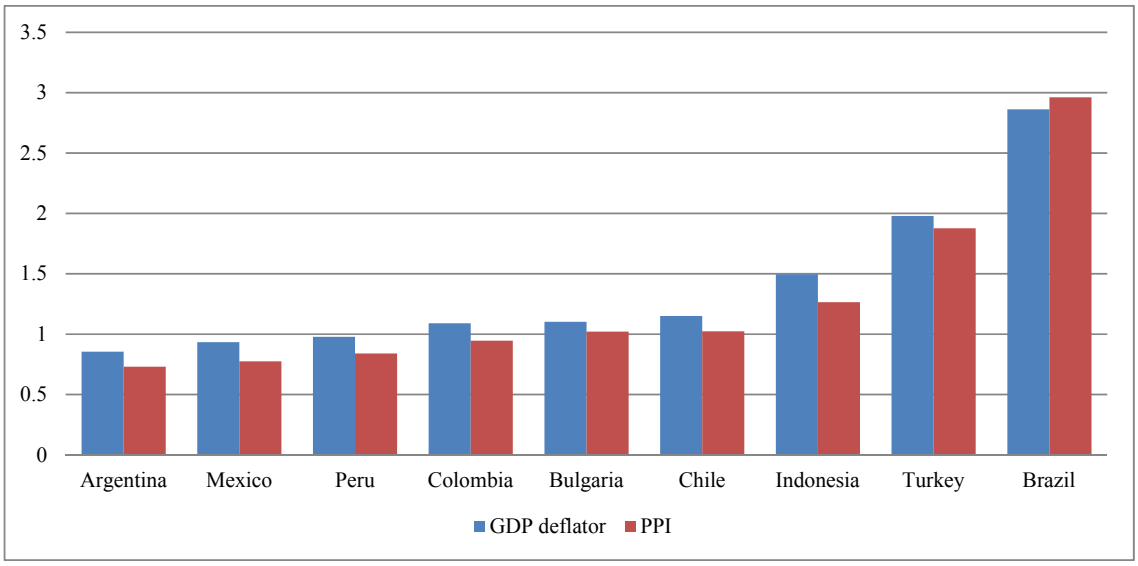


**Fig. 2.** Average TFP Measures, YAKLM specification with GDP Deflator or PPI.

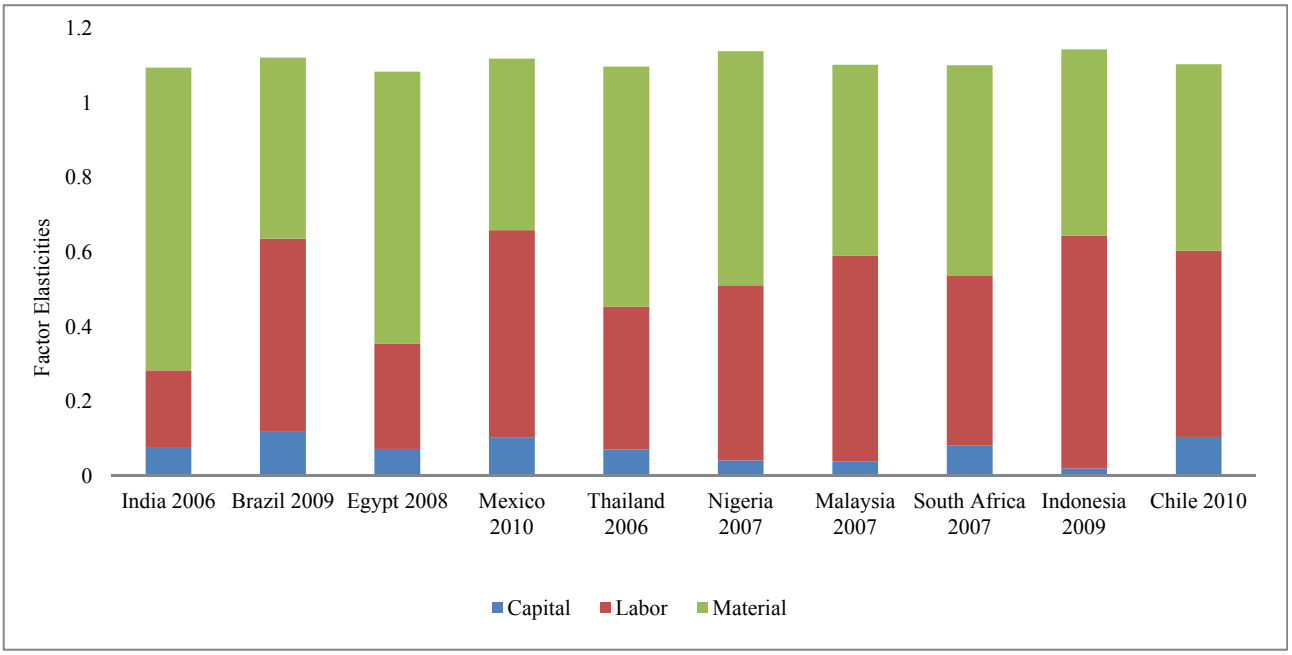


**Fig. 3.** Factor Shares for YAKLM Specification, Selected Countries with Large Samples.

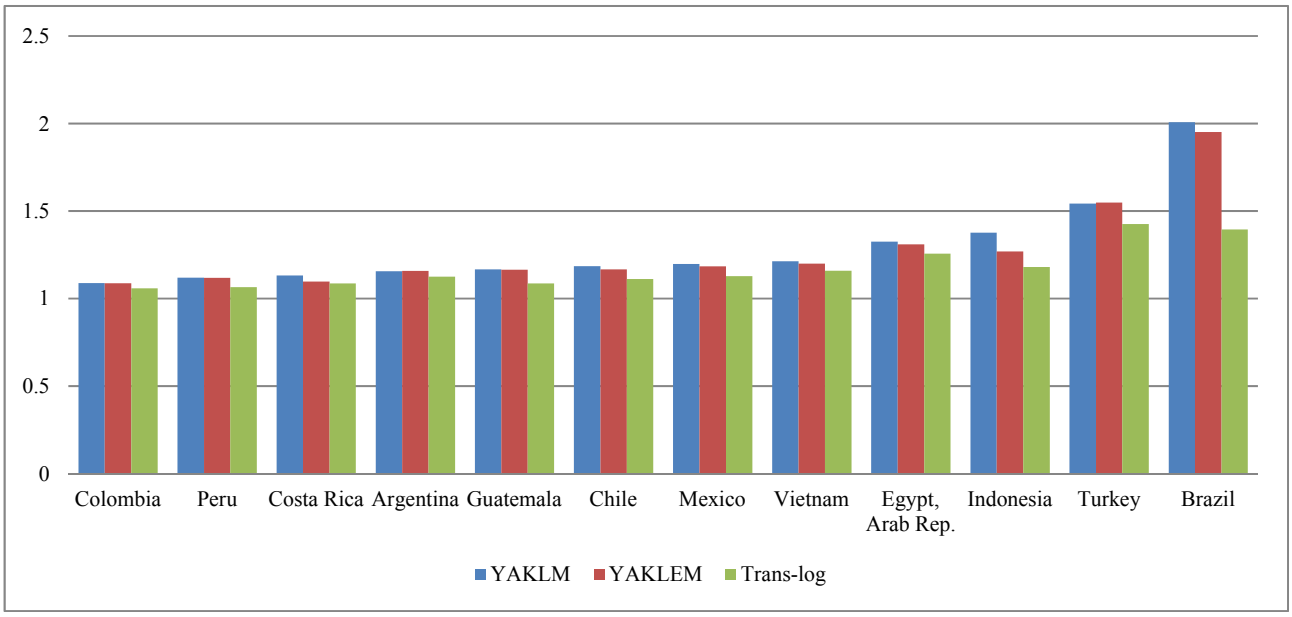


**Fig. 4.** Comparison of Average TFP, Selected Large Countries 2008-10.

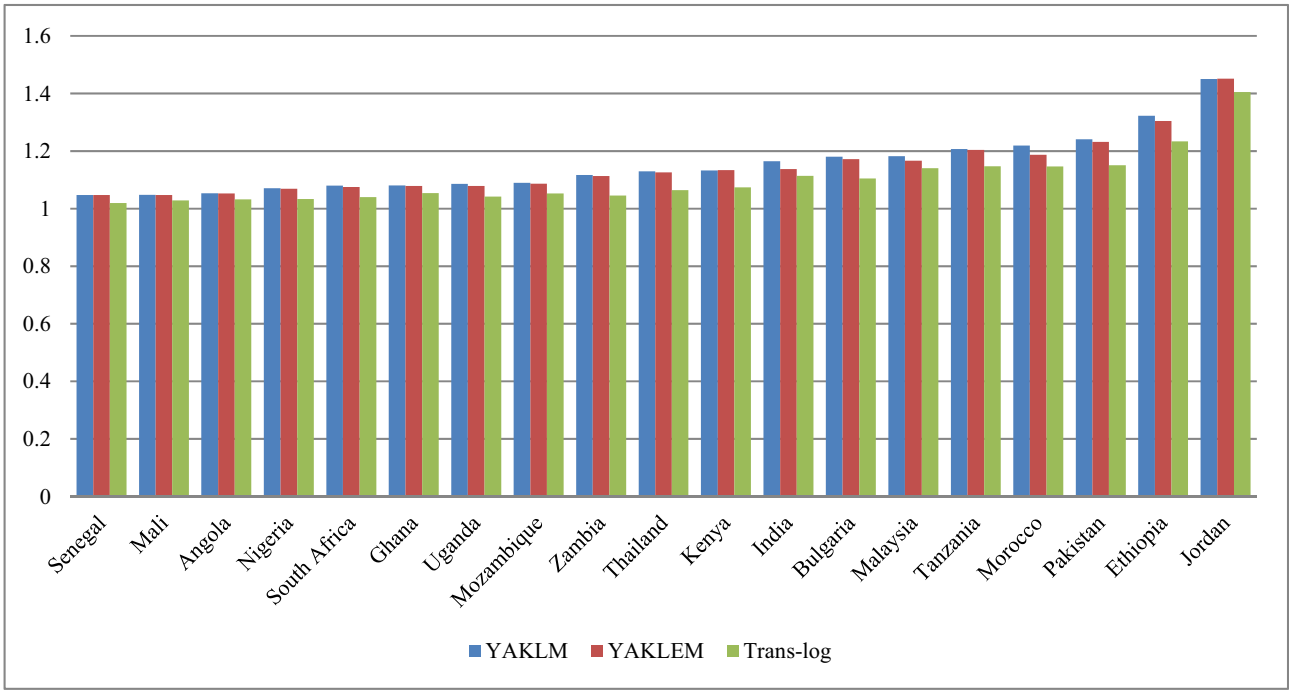


**Fig. 5.** Comparison of Average TFP, Large Sample Countries Surveyed in 2006 or 2007.

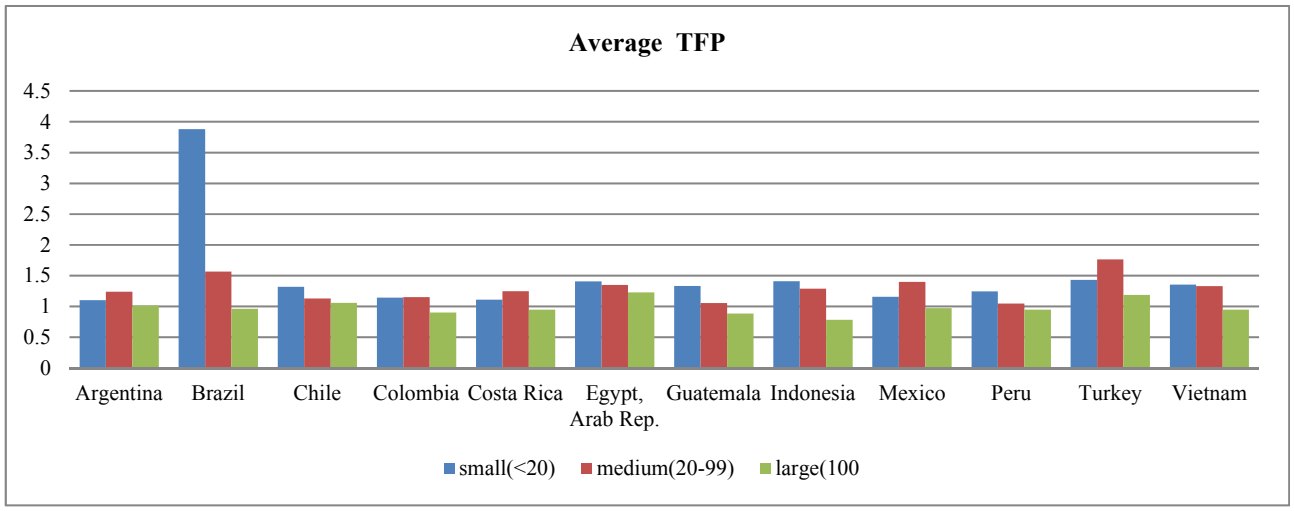


**Fig. 6.** Average productivity by firm size, selected large economies 2008-10.

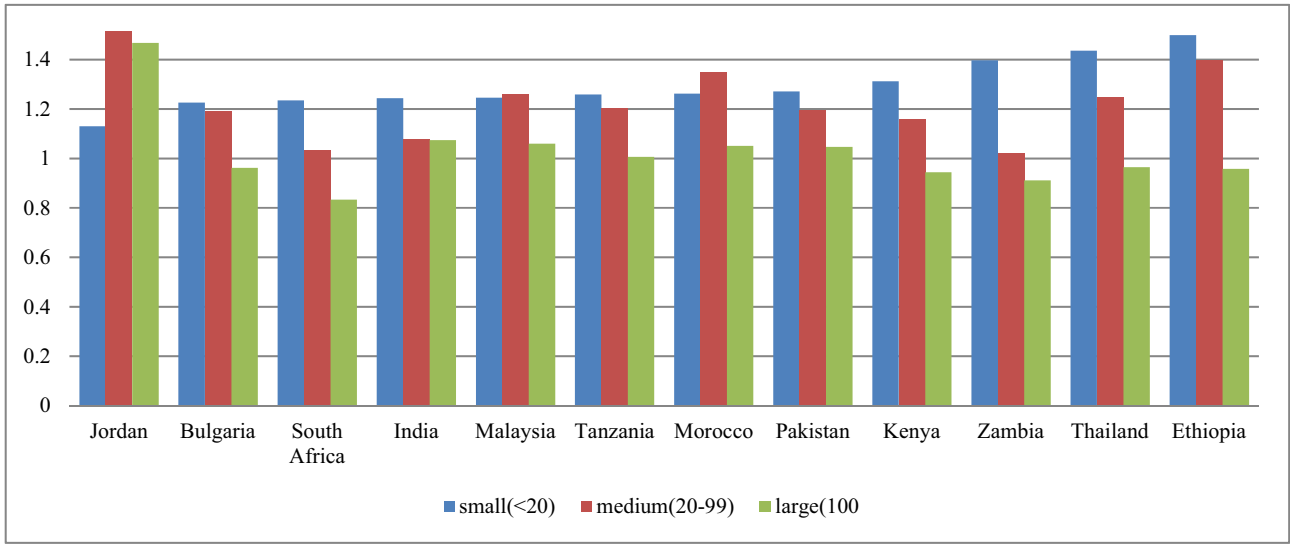


**Fig. 7.** Average productivity by firm size, selected large economies 2006/07.

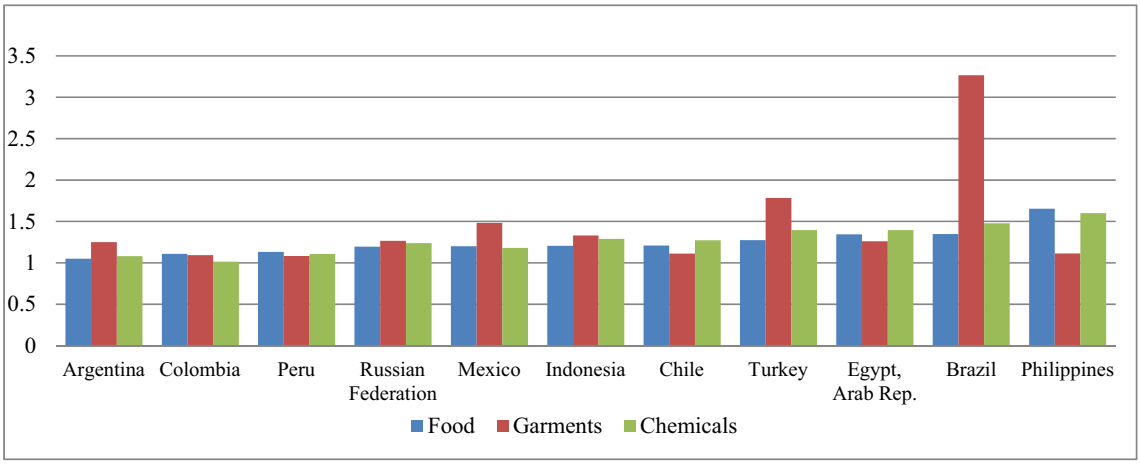


**Fig. 8.** Average productivity by industry, selected large economies 2008-10.

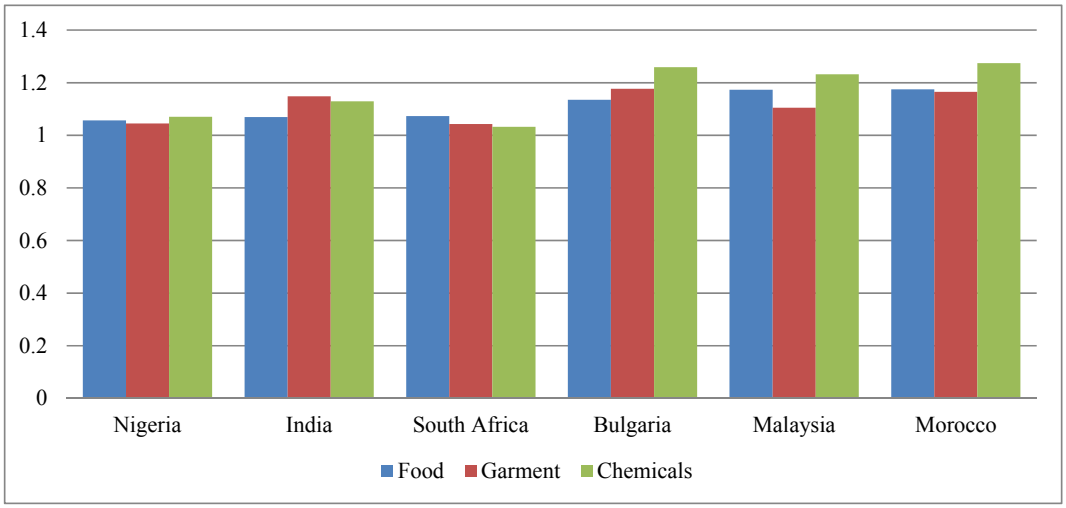


**Fig. 9.** Average productivity by industry, selected large economies 2006/7.

## Appendix B. Tables

**Table 1**
Sample by Region.

| | # Countries | # Manufacturing Firms | # Firms in analysis |
|---|---|---|---|
| Sub-Saharan Africa (SSA) | 25 | 6179 | 5592 |
| Asia | 8 | 7383 | 5077 |
| Eastern Europe and Central Europe (ECA) | 18 | 3408 | 2158 |
| Latin America and the Caribbean (LCR) | 14 | 6963 | 5049 |
| Middle East and North Africa (MNA) | 4 | 2323 | 1911 |
| Total | 69 | 26,256 | 19,787 |

Source: Enterprise Surveys.
Notes: East Asia and Pacific (EAP) and South Asia (SA) regions are grouped together and represented as Asia. The number of firms in analysis is based on the number of manufacturing firms where TFP could be calculated using the YAKLM specification (See Equation (1)).

**Table 2**
Sample Coverage by Country. Number of Observations used to calculate TFP with YAKLM specification and % of Coverage.

| Country | # of Firms | # Firms in Analysis | % of Total Sample |
|---|---|---|---|
| Sub-Saharan Africa (2006-7) | | | |
| Angola 2006 | 215 | 203 | 1.0% |
| Botswana 2006 | 114 | 106 | 0.5% |
| Burundi 2006 | 102 | 102 | 0.5% |
| Cameroon 2009 | 116 | 59 | 0.3% |
| Cotedivoire 2009 | 169 | 110 | 0.6% |
| Drc 2006 | 149 | 143 | 0.7% |
| Ethiopia 2006 | 360 | 239 | 1.2% |
| Ghana 2007 | 292 | 276 | 1.4% |
| Guinea 2006 | 135 | 129 | 0.7% |
| Guineabissau 2006 | 50 | 43 | 0.2% |
| Kenya 2007 | 396 | 377 | 1.9% |
| Madagascar 2009 | 203 | 121 | 0.6% |
| Mali 2007 | 301 | 288 | 1.5% |
| Mauritania 2006 | 80 | 75 | 0.4% |

**Table 2** (*continued*)

| Country | # of Firms | # Firms in Analysis | % of Total Sample |
|---|---|---|---|
| Mauritius 2009 | 150 | 105 | 0.5% |
| Mozambique 2007 | 341 | 322 | 1.6% |
| Namibia 2006 | 106 | 95 | 0.5% |
| Nigeria 2007 | 948 | 923 | 4.7% |
| Rwanda 2006 | 59 | 57 | 0.3% |
| Senegal 2007 | 259 | 245 | 1.2% |
| Southafrica 2007 | 680 | 659 | 3.3% |
| Swaziland 2006 | 70 | 64 | 0.3% |
| Tanzania 2006 | 273 | 258 | 1.3% |
| Uganda 2006 | 307 | 293 | 1.5% |
| Zambia 2007 | 304 | 300 | 1.5% |
| East Asia and the Pacific, and South Asia | | | |
| Indonesia 2009 | 1176 | 592 | 3.0% |
| Malaysia 2007 | 1115 | 682 | 3.4% |
| Mongolia 2009 | 132 | 123 | 0.6% |
| Thailand 2006 | 1043 | 990 | 5.0% |
| Vietnam 2009 | 778 | 569 | 2.9% |
| India 2006 | 2218 | 1452 | 7.3% |
| Nepal 2009 | 137 | 123 | 0.6% |
| Pakistan 2007 | 784 | 546 | 2.8% |
| Eastern Europe and Central Asia | | | |
| Azerbaijan 2009 | 120 | 91 | 0.5% |
| Belarus 2008 | 84 | 43 | 0.2% |
| Bulgaria 2007 | 538 | 379 | 1.9% |
| Croatia 2007 | 345 | 186 | 0.9% |
| Czech 2009 | 94 | 55 | 0.3% |
| Estonia 2009 | 90 | 62 | 0.3% |
| Fyrom 2009 | 115 | 67 | 0.3% |
| Georgia 2008 | 121 | 69 | 0.3% |
| Hungary 2009 | 103 | 74 | 0.4% |
| Kazakhstan 2009 | 181 | 105 | 0.5% |
| Kyrgyzstan 2009 | 92 | 59 | 0.3% |
| Latvia 2009 | 89 | 54 | 0.3% |
| Lithuania 2009 | 97 | 65 | 0.3% |
| Moldova 2009 | 110 | 97 | 0.5% |
| Serbia 2009 | 132 | 113 | 0.6% |
| Tajikistan 2008 | 116 | 62 | 0.3% |
| Turkey 2008 | 860 | 464 | 2.3% |
| Uzbekistan 2008 | 121 | 113 | 0.6% |
| Latin America and the Caribbean | | | |
| Argentina 2010 | 791 | 468 | 2.4% |
| Brazil 2009 | 1339 | 1041 | 5.3% |
| Chile 2010 | 775 | 586 | 3.0% |
| Colombia 2010 | 705 | 538 | 2.7% |
| Costarica 2010 | 326 | 200 | 1.0% |

(*continued on next page*)

**Table 2** (*continued*)

| Country | # of Firms | # Firms in Analysis | % of Total Sample |
|---|---|---|---|
| Ecuador 2010 | 120 | 86 | 0.4% |
| Elsalvador 2010 | 125 | 83 | 0.4% |
| Guatemala 2010 | 355 | 222 | 1.1% |
| Honduras 2010 | 150 | 77 | 0.4% |
| Jamaica 2010 | 121 | 97 | 0.5% |
| Mexico 2010 | 1152 | 993 | 5.0% |
| Nicaragua 2010 | 126 | 73 | 0.4% |
| Paraguay 2010 | 118 | 73 | 0.4% |
| Peru 2010 | 760 | 512 | 2.6% |
| Middle East and North Africa | | | |
| Egypt 2008 | 1156 | 1014 | 5.1% |
| Jordan 2006 | 352 | 219 | 1.1% |
| Morocco 2007 | 466 | 437 | 2.2% |
| Syria 2009 | 349 | 241 | 1.2% |

Source: Enterprise Surveys.
Notes: Only manufacturing firms are present. Only the newest global survey from each country is used. Moreover, each country must have at least 30 percent of firms where TFP can be calculated.

**Table 3**
Industries Groupings

| ISIC Code | Two-digit Industry | Total Number | Percentage |
|---|---|---|---|
| 15 | Food | 3992 | 20.2 |
| 17 | Textile | 1559 | 7.9 |
| 18 | Garment | 2750 | 13.9 |
| 24 | Chemicals | 1526 | 7.7 |
| 26, 27 | Non-Metallic & Basic Metals | 1254 | 6.3 |
| 28, 29 | Fabricated Metal & Machinery | 2646 | 13.4 |
| _ | Other Manufacturing | 6060 | 30.6 |
| | | 19,787 | |

Source: Enterprise Surveys.
Notes: The number of firms in analysis is based on the number of manufacturing firms where TFP could be calculated using the YAKLM specification (See Equation (1)).

**Table 4**
Factor shares calculated with different specifications

| Country | YAKLM | | | Solow | | |
|---|---|---|---|---|---|---|
| | Capital | Labor | Material | Capital | Labor | Material |
| Angola 2006 | 0.05 | 0.62 | 0.45 | 0.06 | 0.38 | 0.56 |
| Argentina 2010 | 0.05 | 0.57 | 0.48 | 0.04 | 0.29 | 0.68 |
| Azerbaijan 2009 | 0.06 | 0.54 | 0.51 | 0.07 | 0.22 | 0.72 |
| Belarus 2008 | 0.17 | 0.72 | 0.27 | 0.08 | 0.17 | 0.75 |
| Botswana 2006 | 0.01 | 0.65 | 0.47 | 0.08 | 0.22 | 0.70 |
| Brazil 2009 | 0.12 | 0.52 | 0.49 | 0.07 | 0.27 | 0.67 |
| Bulgaria 2007 | 0.14 | 0.49 | 0.49 | 0.05 | 0.18 | 0.77 |
| Burundi 2006 | 0.01 | 0.72 | 0.42 | 0.04 | 0.16 | 0.80 |
| Cameroon 2009 | 0.12 | 0.64 | 0.37 | 0.62 | 0.15 | 0.24 |
| Chile 2010 | 0.10 | 0.50 | 0.50 | 0.86 | 0.03 | 0.11 |
| Colombia 2010 | 0.09 | 0.41 | 0.61 | 0.05 | 0.19 | 0.76 |
| Costarica 2010 | 0.02 | 0.53 | 0.55 | 0.08 | 0.22 | 0.70 |
| Cotedivoire 2009 | 0.21 | 0.58 | 0.39 | 0.10 | 0.44 | 0.46 |
| Croatia 2007 | 0.35 | 0.30 | 0.43 | 0.04 | 0.29 | 0.67 |
| Czech 2009 | 0.30 | 0.01 | 0.78 | 0.07 | 0.15 | 0.78 |
| Drc 2006 | 0.12 | 0.40 | 0.61 | 0.05 | 0.11 | 0.84 |
| Ecuador 2010 | 0.01 | 0.65 | 0.46 | 0.03 | 0.23 | 0.74 |
| Egypt 2008 | 0.07 | 0.28 | 0.73 | 0.18 | 0.14 | 0.68 |
| Elsalvador 2010 | 0.05 | 0.56 | 0.50 | 0.04 | 0.16 | 0.80 |
| Estonia 2009 | 0.04 | 0.62 | 0.46 | 0.08 | 0.29 | 0.63 |

**Table 4** (*continued*)

| Country | YAKLM | | | Solow | | |
|---|---|---|---|---|---|---|
| | Capital | Labor | Material | Capital | Labor | Material |
| Ethiopia 2006 | 0.10 | 0.34 | 0.65 | 0.77 | 0.05 | 0.18 |
| Fyrom 2009 | 0.16 | 0.69 | 0.29 | 0.05 | 0.20 | 0.75 |
| Georgia 2008 | 0.02 | 0.61 | 0.50 | 0.06 | 0.37 | 0.57 |
| Ghana 2007 | 0.01 | 0.45 | 0.60 | 0.14 | 0.16 | 0.70 |
| Guatemala 2010 | 0.17 | 0.55 | 0.41 | 0.05 | 0.18 | 0.77 |
| Guinea 2006 | 0.01 | 0.45 | 0.69 | 0.39 | 0.13 | 0.48 |
| Guineabissau 2006 | −0.03 | 0.49 | 0.66 | 0.20 | 0.29 | 0.52 |
| Honduras 2010 | 0.32 | 0.83 | −0.12 | 0.03 | 0.43 | 0.54 |
| Hungary 2009 | 0.07 | 0.30 | 0.73 | 0.02 | 0.12 | 0.86 |
| India 2006 | 0.07 | 0.21 | 0.81 | 0.02 | 0.10 | 0.88 |
| Indonesia 2009 | 0.02 | 0.62 | 0.50 | 0.01 | 0.16 | 0.83 |
| Jamaica 2010 | 0.00 | 0.42 | 0.67 | 0.03 | 0.07 | 0.91 |
| Jordan 2006 | 0.23 | 0.50 | 0.40 | 0.07 | 0.22 | 0.71 |
| Kazakhstan 2009 | 0.07 | 0.38 | 0.68 | 0.03 | 0.16 | 0.81 |
| Kenya 2007 | 0.17 | 0.34 | 0.59 | 0.07 | 0.15 | 0.78 |
| Kyrgyzstan 2009 | 0.12 | 0.33 | 0.74 | 0.42 | 0.15 | 0.43 |
| Latvia 2009 | 0.04 | 0.36 | 0.70 | 0.05 | 0.26 | 0.69 |
| Lithuania 2009 | 0.02 | 0.82 | 0.28 | 0.07 | 0.27 | 0.66 |
| Madagascar 2009 | 0.02 | 0.74 | 0.39 | 0.04 | 0.26 | 0.70 |
| Malaysia 2007 | 0.04 | 0.55 | 0.51 | 0.03 | 0.10 | 0.86 |
| Mali 2007 | 0.05 | 0.43 | 0.64 | 0.02 | 0.12 | 0.86 |
| Mauritania 2006 | 0.00 | 0.28 | 0.79 | 0.04 | 0.07 | 0.89 |
| Mauritius 2009 | 0.24 | 0.50 | 0.41 | 0.06 | 0.30 | 0.64 |
| Mexico 2010 | 0.10 | 0.56 | 0.46 | 0.10 | 0.21 | 0.69 |
| Moldova 2009 | 0.04 | 0.71 | 0.44 | 0.07 | 0.24 | 0.69 |
| Mongolia 2009 | 0.05 | 0.68 | 0.41 | 0.08 | 0.15 | 0.77 |
| Morocco 2007 | 0.08 | 0.59 | 0.43 | 0.05 | 0.18 | 0.77 |
| Mozambique 2007 | 0.02 | 0.51 | 0.59 | 0.01 | 0.01 | 0.98 |
| Namibia 2006 | 0.24 | 0.35 | 0.53 | 0.04 | 0.24 | 0.72 |
| Nepal 2009 | 0.04 | 0.58 | 0.48 | 0.01 | 0.05 | 0.94 |
| Nicaragua 2010 | 0.17 | 0.47 | 0.51 | 0.04 | 0.41 | 0.55 |
| Nigeria 2007 | 0.04 | 0.47 | 0.63 | 0.07 | 0.22 | 0.71 |
| Pakistan 2007 | 0.05 | 0.52 | 0.54 | 0.01 | 0.07 | 0.92 |
| Paraguay 2010 | 0.15 | 0.37 | 0.59 | 0.05 | 0.29 | 0.67 |
| Peru 2010 | 0.09 | 0.34 | 0.68 | 0.08 | 0.18 | 0.74 |
| Rwanda 2006 | 0.02 | 0.41 | 0.68 | 0.02 | 0.16 | 0.82 |
| Senegal 2007 | 0.03 | 0.42 | 0.67 | 0.02 | 0.13 | 0.86 |
| Serbia 2009 | 0.14 | 0.47 | 0.53 | 0.08 | 0.22 | 0.70 |
| Southafrica 2007 | 0.08 | 0.46 | 0.57 | 0.05 | 0.25 | 0.70 |
| Swaziland 2006 | 0.13 | 0.51 | 0.47 | 0.02 | 0.38 | 0.60 |
| Syria 2009 | 0.07 | 0.31 | 0.71 | 0.05 | 0.34 | 0.61 |
| Tajikistan 2008 | 0.07 | 0.32 | 0.70 | 0.11 | 0.16 | 0.73 |
| Tanzania 2006 | 0.04 | 0.55 | 0.55 | 0.05 | 0.11 | 0.84 |
| Thailand 2006 | 0.07 | 0.38 | 0.64 | 0.03 | 0.09 | 0.88 |
| Turkey 2008 | 0.11 | 0.44 | 0.55 | 0.05 | 0.16 | 0.79 |
| Uganda 2006 | 0.07 | 0.35 | 0.69 | 0.05 | 0.12 | 0.84 |
| Uzbekistan 2008 | 0.19 | 0.55 | 0.44 | 0.09 | 0.32 | 0.59 |
| Vietnam 2009 | 0.16 | 0.43 | 0.53 | 0.04 | 0.16 | 0.80 |
| Zambia 2007 | 0.12 | 0.26 | 0.71 | 0.08 | 0.18 | 0.74 |

Source: Enterprise Surveys.

**Table 5**
Correlation between different TFP Measures.

| | YAKLM | YAKLEM | YAKL | VAKL | Translog |
|---|---|---|---|---|---|
| YAKLEM | 0.970 | 1.000 | | | |
| YAKL | 0.828 | 0.803 | 1.000 | | |
| VAKL | 0.854 | 0.822 | 0.906 | 1.000 | |
| Translog | 0.939 | 0.897 | 0.808 | 0.877 | 1.000 |
| Solow | 0.664 | 0.615 | 0.504 | 0.521 | 0.667 |

*significant at 1%

**Table 6**
Average TFP Estimates and Country Rankings with All Specifications.

| | YAKLM | Rank | YAKLEM | Rank | YAKL | Rank | VAKL | Rank | *Trans*-log | Rank | Solow | Rank |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sub-Saharan Africa (2006-7) | | | | | | | | | | | | |
| Angola 2006 | 1.05 | 18 | 1.05 | 17 | 1.11 | 21 | 1.10 | 21 | 1.03 | 17 | 3.60 | 9 |
| Botswana 2006 | 1.22 | 3 | 1.20 | 3 | 1.34 | 10 | 1.51 | 4 | 1.16 | 3 | 4.44 | 7 |
| Burundi 2006 | 1.13 | 7 | 1.11 | 8 | 1.24 | 16 | 1.17 | 17 | 1.05 | 8 | 5.01 | 5 |
| Drc 2006 | 1.08 | 13 | 1.08 | 11 | 1.31 | 12 | 1.23 | 14 | 1.04 | 13 | 2.89 | 18 |
| Ethiopia 2006 | 1.32 | 1 | 1.30 | 1 | 2.09 | 1 | 1.66 | 1 | 1.23 | 1 | 6.42 | 2 |
| Ghana 2007 | 1.08 | 12 | 1.08 | 13 | 1.38 | 7 | 1.32 | 7 | 1.05 | 6 | 3.63 | 8 |
| Guinea 2006 | 1.06 | 16 | 1.05 | 18 | 1.56 | 2 | 1.31 | 9 | 1.04 | 15 | 6.98 | 1 |
| Guineabissau 2006 | 1.06 | 17 | 1.06 | 16 | 1.23 | 17 | 1.25 | 13 | 1.01 | 20 | 3.46 | 12 |
| Kenya 2007 | 1.13 | 6 | 1.13 | 6 | 1.35 | 9 | 1.36 | 5 | 1.07 | 5 | 3.48 | 11 |
| Mali 2007 | 1.05 | 19 | 1.05 | 20 | 1.28 | 14 | 1.19 | 16 | 1.03 | 18 | 3.36 | 13 |
| Mauritania 2006 | 1.03 | 21 | 1.02 | 21 | 1.15 | 19 | 1.15 | 18 | 1.01 | 21 | 1.89 | 21 |
| Mozambique 2007 | 1.09 | 9 | 1.09 | 9 | 1.29 | 13 | 1.26 | 12 | 1.05 | 7 | 3.25 | 14 |
| Namibia 2006 | 1.31 | 2 | 1.27 | 2 | 1.51 | 4 | 1.61 | 2 | 1.18 | 2 | 5.29 | 4 |
| Nigeria 2007 | 1.07 | 15 | 1.07 | 15 | 1.26 | 15 | 1.22 | 15 | 1.03 | 16 | 3.59 | 10 |
| Rwanda 2006 | 1.09 | 11 | 1.09 | 10 | 1.37 | 8 | 1.34 | 6 | 1.05 | 9 | 2.94 | 17 |
| Senegal 2007 | 1.05 | 20 | 1.05 | 19 | 1.22 | 18 | 1.15 | 19 | 1.02 | 19 | 2.71 | 20 |
| Southafrica 2007 | 1.08 | 14 | 1.08 | 14 | 1.14 | 20 | 1.13 | 20 | 1.04 | 14 | 3.20 | 15 |
| Swaziland 2006 | 1.16 | 5 | 1.15 | 5 | 1.41 | 5 | 1.29 | 11 | 1.04 | 11 | 5.33 | 3 |
| Tanzania 2006 | 1.21 | 4 | 1.20 | 4 | 1.52 | 3 | 1.58 | 3 | 1.15 | 4 | 4.78 | 6 |
| Uganda 2006 | 1.09 | 10 | 1.08 | 12 | 1.38 | 6 | 1.30 | 10 | 1.04 | 12 | 2.85 | 19 |
| Zambia 2007 | 1.12 | 8 | 1.11 | 7 | 1.33 | 11 | 1.31 | 8 | 1.05 | 10 | 3.11 | 16 |
| Sub-Saharan Africa (2009) | | | | | | | | | | | | |
| Cameroon 2009 | 1.65 | 1 | 1.38 | 1 | 1.83 | 1 | 1.73 | 2 | 1.44 | 1 | 17.32 | 1 |
| Cotedivoire 2009 | 1.33 | 3 | 1.33 | 2 | 1.56 | 2 | 2.04 | 1 | 1.23 | 2 | 7.72 | 2 |
| Madagascar 2009 | 1.23 | 4 | 1.16 | 4 | 1.34 | 4 | 1.37 | 4 | 1.16 | 3 | 5.24 | 4 |
| Mauritius 2009 | 1.33 | 2 | 1.32 | 3 | 1.45 | 3 | 1.48 | 3 | 1.12 | 4 | 5.78 | 3 |
| East and South Asia | | | | | | | | | | | | |
| Indonesia 2009 | 1.38 | 1 | 1.27 | 1 | 2.02 | 2 | 1.62 | 2 | 1.18 | 1 | 4.83 | 1 |
| Malaysia 2007 | 1.18 | 4 | 1.17 | 4 | 1.54 | 5 | 1.58 | 4 | 1.14 | 4 | 3.37 | 5 |
| Mongolia 2009 | 1.15 | 6 | 1.12 | 8 | 1.32 | 7 | 1.28 | 8 | 1.08 | 7 | 3.91 | 4 |
| Thailand 2006 | 1.13 | 7 | 1.13 | 6 | 1.58 | 4 | 1.41 | 7 | 1.06 | 8 | 2.78 | 6 |
| Vietnam 2009 | 1.21 | 3 | 1.20 | 3 | 1.54 | 6 | 1.61 | 3 | 1.16 | 2 | 4.01 | 3 |
| India 2006 | 1.16 | 5 | 1.14 | 5 | 2.05 | 1 | 1.74 | 1 | 1.11 | 5 | 2.56 | 7 |
| Nepal 2009 | 1.13 | 8 | 1.12 | 7 | 1.27 | 8 | 1.42 | 6 | 1.09 | 6 | 2.42 | 8 |
| Pakistan 2007 | 1.24 | 2 | 1.23 | 2 | 1.64 | 3 | 1.54 | 5 | 1.15 | 3 | 4.04 | 2 |
| Eastern Europe and Central Asia | | | | | | | | | | | | |
| Azerbaijan 2009 | 1.12 | 17 | 1.12 | 17 | 1.35 | 16 | 1.32 | 17 | 1.06 | 17 | 3.71 | 15 |
| Belarus 2008 | 1.40 | 8 | 1.43 | 8 | 1.45 | 12 | 1.82 | 11 | 1.12 | 14 | 8.11 | 5 |
| Bulgaria 2007 | 1.18 | 15 | 1.17 | 15 | 1.42 | 14 | 1.43 | 16 | 1.10 | 16 | 4.35 | 12 |
| Croatia 2007 | 1.23 | 12 | 1.23 | 12 | 1.36 | 15 | 1.65 | 12 | 1.18 | 9 | 4.96 | 11 |
| Czech 2009 | 1.58 | 4 | 1.49 | 5 | 11.29 | 1 | 16.89 | 1 | 1.33 | 6 | 7.37 | 6 |
| Estonia 2009 | 1.48 | 7 | 1.47 | 7 | 1.71 | 9 | 2.19 | 8 | 1.29 | 7 | 6.50 | 7 |
| Fyrom 2009 | 1.29 | 11 | 1.30 | 10 | 1.62 | 10 | 1.62 | 13 | 1.17 | 11 | 9.06 | 3 |
| Georgia 2008 | 1.16 | 16 | 1.16 | 16 | 1.30 | 18 | 1.30 | 18 | 1.11 | 15 | 3.63 | 16 |
| Hungary 2009 | 1.30 | 9 | 1.30 | 9 | 1.89 | 7 | 2.74 | 4 | 1.28 | 8 | 3.71 | 14 |
| Kazakhstan 2009 | 1.30 | 10 | 1.26 | 11 | 1.89 | 6 | 1.82 | 10 | 1.14 | 13 | 3.74 | 13 |
| Kyrgyzstan 2009 | 2.69 | 1 | 2.27 | 1 | 3.22 | 2 | 4.51 | 2 | 1.66 | 1 | 9.81 | 1 |
| Latvia 2009 | 1.09 | 18 | 1.08 | 18 | 1.45 | 13 | 1.54 | 14 | 1.04 | 18 | 3.55 | 17 |
| Lithuania 2009 | 1.21 | 13 | 1.21 | 13 | 1.31 | 17 | 1.50 | 15 | 1.17 | 10 | 6.07 | 8 |
| Moldova 2009 | 1.86 | 2 | 1.69 | 3 | 1.93 | 5 | 2.34 | 6 | 1.58 | 2 | 9.11 | 2 |
| Serbia 2009 | 1.56 | 5 | 1.48 | 6 | 1.83 | 8 | 2.30 | 7 | 1.37 | 5 | 5.47 | 9 |
| Tajikistan 2008 | 1.21 | 14 | 1.20 | 14 | 1.55 | 11 | 1.87 | 9 | 1.15 | 12 | 2.97 | 18 |
| Turkey 2008 | 1.54 | 6 | 1.55 | 4 | 1.99 | 4 | 2.73 | 5 | 1.43 | 3 | 5.41 | 10 |
| Uzbekistan 2008 | 1.77 | 3 | 1.78 | 2 | 2.30 | 3 | 4.15 | 3 | 1.39 | 4 | 8.54 | 4 |
| Latin America and the Caribbean | | | | | | | | | | | | |
| Argentina2010 | 1.16 | 8 | 1.16 | 8 | 1.32 | 7 | 1.36 | 8 | 1.13 | 4 | 3.88 | 9 |
| Brazil 2009 | 2.01 | 1 | 1.95 | 1 | 2.29 | 1 | 2.48 | 1 | 1.39 | 1 | 6.76 | 2 |
| Chile 2010 | 1.18 | 4 | 1.17 | 4 | 1.33 | 6 | 1.41 | 6 | 1.11 | 5 | 13.19 | 1 |
| Colombia 2010 | 1.09 | 13 | 1.09 | 13 | 1.41 | 3 | 1.27 | 12 | 1.06 | 13 | 3.77 | 10 |
| Costarica 2010 | 1.13 | 10 | 1.10 | 12 | 1.25 | 10 | 1.25 | 13 | 1.09 | 10 | 3.13 | 13 |
| Ecuador 2010 | 1.16 | 7 | 1.16 | 7 | 1.31 | 8 | 1.30 | 11 | 1.09 | 7 | 4.44 | 5 |
| Elsalvador 2010 | 1.14 | 9 | 1.12 | 10 | 1.25 | 11 | 1.40 | 7 | 1.09 | 8 | 3.41 | 12 |
| Guatemala 2010 | 1.17 | 5 | 1.16 | 5 | 1.24 | 12 | 1.32 | 9 | 1.09 | 9 | 3.90 | 8 |
| Honduras 2010 | 1.16 | 6 | 1.16 | 6 | 1.17 | 13 | 1.61 | 3 | 1.10 | 6 | 5.56 | 4 |
| Jamaica 2010 | 1.02 | 14 | 1.02 | 14 | 1.07 | 14 | 1.06 | 14 | 1.01 | 14 | 2.45 | 14 |
| Mexico 2010 | 1.20 | 3 | 1.18 | 2 | 1.36 | 4 | 1.43 | 4 | 1.13 | 3 | 4.13 | 7 |
| Nicaragua 2010 | 1.22 | 2 | 1.18 | 3 | 1.36 | 5 | 1.82 | 2 | 1.18 | 2 | 6.43 | 3 |
| Paraguay 2010 | 1.13 | 11 | 1.13 | 9 | 1.30 | 9 | 1.31 | 10 | 1.08 | 11 | 4.15 | 6 |
| Peru 2010 | 1.12 | 12 | 1.12 | 11 | 1.53 | 2 | 1.42 | 5 | 1.07 | 12 | 3.50 | 11 |
| Middle East and North Africa | | | | | | | | | | | | |
| Egypt 2008 | 1.32 | 2 | 1.31 | 2 | 2.43 | 1 | 2.52 | 1 | 1.26 | 2 | 3.54 | 4 |
| Jordan 2006 | 1.45 | 1 | 1.45 | 1 | 1.78 | 3 | 2.09 | 3 | 1.40 | 1 | 6.61 | 1 |
| Morocco 2007 | 1.22 | 4 | 1.19 | 4 | 1.49 | 4 | 1.47 | 4 | 1.15 | 4 | 5.03 | 2 |
| Syria 2009 | 1.29 | 3 | 1.24 | 3 | 2.10 | 2 | 2.25 | 2 | 1.17 | 3 | 4.41 | 3 |

Source: Enterprise Surveys.

**Table 7**
Industry Level Regressions, Average TFP.

| | Food | Textile | Garment | Chemicals | Non-Metallic & Basic Metals | Fabricated Metal & Machinery | Other |
|---|---|---|---|---|---|---|---|
| Sub-Saharan Africa | | | | | | | |
| Angola | 1.05 | | | | | | 1.05 |
| Botswana | | | | | | | 1.16 |
| Burundi | | | | | | | 1.12 |
| Congo, Dem. Rep. | 1.09 | | | | | | 1.05 |
| Cote d'Ivoire | | | | | | | 1.39 |
| Ethiopia | | | | | | | 1.32 |
| Ghana | 1.07 | | 1.19 | | | | 1.15 |
| Guinea | | | 1.07 | | | | 1.07 |
| Kenya | 1.11 | | 1.14 | | | 1.08 | 1.11 |
| Madagascar | | | | | | | 1.10 |
| Mali | 1.06 | | 1.04 | | | | |
| Mauritius | 1.39 | | | | | | |
| Mozambique | 1.06 | | 1.05 | | | 1.15 | 1.09 |
| Namibia | | | | | | | 1.23 |
| Nigeria | 1.10 | | 1.07 | 1.12 | 1.07 | 1.05 | 1.11 |
| Senegal | 1.12 | | 1.04 | | | | 1.09 |
| South Africa | 1.10 | | 1.07 | 1.02 | | 1.04 | 1.01 |
| Tanzania | 1.33 | | 1.21 | | | | 1.18 |
| Uganda | 1.11 | | | | | 1.10 | 1.09 |
| Zambia | 1.14 | | 1.13 | | | 1.05 | 1.21 |
| East and South Asia | | | | | | | |
| Indonesia | 1.15 | 1.19 | 1.20 | 0.99 | 1.37 | | 1.41 |
| Malaysia | 1.18 | | 1.10 | 1.25 | | 1.08 | 1.20 |
| Mongolia | 1.27 | | | | | | 1.23 |
| Philippines | 1.82 | | 1.13 | 1.66 | 1.15 | | 1.47 |
| Thailand | 1.11 | 1.11 | 1.12 | | | 1.10 | 1.14 |
| Vietnam | 1.20 | 1.18 | 1.22 | | 0.88 | 1.34 | 1.42 |
| India | 1.11 | 1.18 | 1.16 | 1.15 | 1.11 | 1.11 | 1.20 |
| Nepal | | | | | | | 1.67 |
| Pakistan | 1.76 | 1.30 | | 1.25 | 1.54 | 1.09 | 1.42 |
| Eastern Europe & Central Asia | | | | | | | |
| Azerbaijan | 1.11 | | | | | | |
| Bulgaria | 1.11 | | 1.22 | 1.24 | | 1.09 | 1.22 |
| Croatia | 1.04 | | | | | 1.12 | |
| Estonia | | | | | | | 1.35 |
| Georgia | 1.62 | | | | | | |
| Kazakhstan | | | | | | | 1.40 |
| Lithuania | | | | | | | 1.05 |
| Moldova | 1.31 | | | | | | |
| Russian Federation | 1.15 | | 1.25 | 1.16 | | 1.45 | |
| Serbia | | | | | | | 1.26 |
| Turkey | 1.32 | 1.40 | 1.35 | 1.25 | 1.96 | 1.53 | 2.18 |
| Ukraine | 1.32 | | 1.39 | | | 1.24 | |
| Latin America and the Caribbean | | | | | | | |
| Argentina | 0.96 | 1.32 | 1.17 | 1.01 | | 1.14 | 0.85 |
| Brazil | 2.12 | 2.52 | 1.96 | 3.39 | | 2.05 | 1.65 |
| Chile | 1.15 | 1.21 | 0.97 | 1.38 | | 1.23 | 1.08 |
| Colombia | 1.11 | 1.08 | 1.30 | 1.11 | | 1.04 | 1.08 |
| Costa Rica | 1.29 | | | | | 1.11 | 1.05 |
| Guatemala | 1.06 | 1.31 | | | | | 1.16 |
| Jamaica | 1.01 | | | | | | 1.01 |
| Mexico | 1.04 | | 1.22 | 1.19 | 0.98 | 1.17 | 1.09 |
| Nicaragua | | | | | | | 1.20 |
| Peru | 1.20 | 1.10 | 1.00 | 1.16 | | 1.23 | 0.95 |
| Uruguay | 0.80 | | | | | | 1.33 |
| Middle East and North Africa | | | | | | | |
| Algeria | 1.34 | | | | | | |
| Egypt, Arab Rep. | 1.34 | 1.36 | 1.26 | 1.40 | 1.33 | 1.30 | 1.32 |
| Jordan | | | | | | | 1.47 |
| Morocco | 1.17 | 1.12 | 1.18 | 1.33 | | | 1.27 |
| Syrian Arab Republic | 1.37 | | 1.21 | 1.26 | | | 1.24 |

Source: Enterprise Surveys.
Notes: Industry level TFP is computed only for cases where there are at least 30 firms in an industry and country.

**Table 8**
Olley-Pakes Decomposition of Aggregate TFP

| Country Name | Aggregate TFP (Weighted) | Simple Average | Cross-Term |
|---|---|---|---|
| Argentina | 0.729 | 1.043 | −0.314 |
| Mexico | 0.773 | 1.152 | −0.379 |
| Latvia | 0.799 | 1.029 | −0.230 |
| Peru | 0.840 | 1.108 | −0.268 |
| Paraguay | 0.896 | 1.120 | −0.224 |
| Belarus | 0.959 | 1.686 | −0.728 |
| Bulgaria | 1.021 | 1.200 | −0.179 |
| Ecuador | 1.068 | 1.140 | −0.072 |
| Lithuania | 1.084 | 1.125 | −0.040 |
| Kazakhstan | 1.112 | 1.286 | −0.173 |
| Chile | 1.258 | 1.215 | 0.043 |
| Colombia | 1.299 | 1.086 | 0.214 |
| Georgia | 1.308 | 1.397 | −0.089 |
| Croatia | 1.326 | 1.063 | 0.262 |
| Indonesia | 1.609 | 1.367 | 0.241 |
| Turkey | 1.876 | 1.575 | 0.301 |
| Estonia | 2.047 | 1.540 | 0.507 |
| Brazil | 2.963 | 2.353 | 0.609 |
| Kyrgyz Republic | 3.171 | 2.704 | 0.467 |
| Czech Republic | 5.666 | 1.861 | 3.804 |
| Hungary | 8.892 | 1.616 | 7.277 |

Source: Enterprise Surveys.
Notes: Aggregate TFP = Simple average + cross term.

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