

Total Factor Productivity Across the Developing World

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Total factor productivity (TFP) is a crucial measure of efficiency and thus an important indicator for policymakers. Using micro level data from manufacturing industries in 80 developing countries, this note analyzes TFP performance at the firm-level. Among the countries surveyed during the same period across multiple regions—Eastern Europe and Central Asia, Latin America, Africa, and Asia—Hungary, Peru, Ethiopia and Indonesia have the highest aggregate productivities. A comparison of average productivities in each region shows that Moldova, Nicaragua, Ethiopia and Indonesia have the highest values among the countries surveyed. This note also discusses separate estimates of TFP values obtained at the industry level. These industry-level estimates are the most useful for policymakers in that they reveal comparative advantages of specific industries within countries. In the garments and chemicals industries, Brazil has the highest average productivity among all the countries surveyed.

Introduction

In the last three decades, many studies have analyzed the relative contribution of factor inputs and technical progress to economic growth. Since the seminal work of Solow (1957), total factor productivity—defined as the efficiency with which firms turn inputs into outputs—has been considered as the major factor in generating growth. The availability of firm-level data allowed researchers to investigate the reasons behind the vast dispersion in productivity performances across firms which led to the establishment of policies that would improve productivity and eventually generate growth. Some early examples of firm-level productivity analyses are Bailey, Hulten, and Campbell (1992) and Bartelsman and Dhrymes (1998) for U.S. manufacturers and Roberts and Tybout (1996) for a number of developing countries.

Research on the comparison of productivity performances across countries has been limited due to the unavailability of a homogenous data source. This note aims to fill this gap. It uses a data set which has been collected through surveys conducted across a large number of developing countries. The homogenous nature of the data provides a unique opportunity to compare average productivity performances of firms across industries, countries and regions.

Data description

The World Bank's Enterprise Surveys¹ provide a unique source of information that can be used to measure TFP across a large set of developing countries. The data used for TFP analysis in this note cover manufacturing firms in 80 countries from different regions of the world.² All data used in this analysis were collected from surveys conducted since 2006, with the exception of India which was surveyed in 2005. The regional coverage of the countries is presented in Table 1. The table also shows the number of firms that are included in the analysis from each region.

Table 1 Number of countries in each region

Region	# of Countries	# of Firms
Sub-Saharan Africa (AFR)	25	5,582
South Asia and East Asia and Pacific (Asia)	9	5,439
Eastern Europe and Central Asia (ECA)	25	2,872
Latin America and the Caribbean (LAC)	15	5,514
Middle East and North Africa (MENA)	6	2,005
Total	80	21,412

Source: Enterprise Surveys.

Table 2 Industries included in the analysis

ISIC Code	Two-digit Industry	Percentage
15	Food	20.9
17	Textiles	8.8
18	Garments	15.2
24	Chemicals	8.4
26, 27	Non-Metallic & Basic Metals	7.2
28, 29	Fabricated Metal & Machinery	12.3
-	Other Manufacturing	27.2

Source: Enterprise Surveys.

The data cover all the major two-digit manufacturing industries according to the International Standard Industrial Classification (ISIC), revision 3.1. For this analysis some industries are combined to achieve a sufficiently large number of observations (Table 2). Industries were grouped together based on 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. 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.

Estimating total factor productivity

A Cobb-Douglas production function with three factors of production—capital, labor and intermediate goods—is used to estimate TFP.³ Firm sales are used to measure output; the replacement value of machinery, vehicles and equipment is used to measure capital; labor is assessed by the total compensation of workers including wages, salaries and bonuses; and intermediate goods are determined by the cost of raw materials and intermediate materials. TFP is estimated as the residual term of the production function.

The TFP values used in this note are compared with the values obtained from five additional production function specifications. These specifications are three variations of the Cobb-Douglas production function; a transcendental logarithmic (trans-log) production function with capital, labor and materials as input factors; and a non-parametric cost-based Solow residual method.⁴ The first variation of the Cobb-Douglas production function adds energy costs to the input factors; the second variation uses only labor and capital as input factors; and the third uses value added as the dependent variable instead of total sales. Details

of the analysis with these alternative TFP measures are discussed in Saliola and Seker (2010).⁵ That study showed that TFP estimates obtained from all specifications are positively and highly correlated with each other.

The productivity values are estimated separately for each country, while controlling for industry differences by including dummy variables for each industry group listed above. All monetary values are converted into U.S. dollars and then deflated by GDP deflator in U.S. dollars (base year 2000).⁶ For each variable used in the estimation, values that are three standard deviations away from the mean value for each country are excluded from the analysis. These outlier tests are performed at the country level. Firms that have material cost-output or labor cost-output ratios that are three standard deviations away from the mean are also excluded from the analysis.⁷ In addition, Afghanistan, Albania, Burkina Faso, Kosovo, Malawi, Niger and West Bank and Gaza were excluded since at least one of the variables required to compute TFP was not available for at least 30 percent of the manufacturing firms surveyed.

When the data is collected, each firm is assigned a sampling weight in order to allow the data to be representative at the country level.⁸ These weights are not used in the TFP analysis because the variables to measure TFP are not available for all firms included in the surveys. Hence the composition of the sample adopted in the empirical analysis to measure TFP might not reflect the actual composition of firms in the manufacturing sectors.

In the 2008–2009 sample, Indonesia has the highest aggregate productivity and Brazil has the highest average productivity.

The un-weighted sample for which TFP analysis could be performed is defined as the *productivity sample*. The data coverage issue raises the question whether the productivity sample over- or under-samples firms in certain size groups. In order to test this difference, size distribution measured in terms of employment levels in the productivity sample is compared to the distribution in the full sample obtained by using the survey weights (which is defined as the *weighted sample*). The weighted sample includes the productivity sample and the rest of the firms for which TFP could not be estimated and it is representative of the manufacturing sector in each country. In general, the distribution of the productivity sample mirrors relatively well the distribution of the weighted sample. In countries where there is a reasonable difference (more than 10 percentage points in any size group), small firms (less than 20 workers) are slightly under-sampled in the productivity sample. In a few countries like Indonesia, Nepal, Uzbekistan and Guatemala this difference is around 30 percent.

Estimation results

The coefficients obtained from the estimation using a Cobb-Douglas production function can be interpreted as input factor elasticities; they show the responsiveness of sales to changes in the levels of each input factor used in production. In the estimation of the production function, raw materials and intermediate goods have the highest elasticity in 52 of the 80 countries.⁹ In 51 countries, labor has the second highest level of elasticity after materials. The average elasticity values across countries are 0.10 for capital, 0.46 for labor, and 0.54 for materials. Figure 1 presents elasticities for select countries. The share of capital is lowest in Indonesia with a value of 0.02 which means that a 10 percent increase in capital is associated with an increase in output of just 0.2 percent. For each country, the sum of the three factor elasticities is around one. This corresponds to the assumption of the Cobb-Douglas production function.

The input factor elasticities obtained from the estimation yield comparable results to several other studies. Using firm-level data from Colombia covering the years 1982-1998 and using the same estimation method as above with four input factors—capital, labor, energy and materials—Eslava et al. (2004) find factor elasticities of 0.08, 0.24, 0.12 and 0.59. The estimation using Enterprise Surveys data for Colombia from 2006 yields the factor elasticities in respective order of 0.09, 0.48, 0.07, and 0.46. Hallward-Driemeier, Iarossi and Sokoloff (2002) calculate these elasticities as 0.15, 0.30, 0.24 and 0.31 for Malaysia using firm-level data covering 1996-1998. In our results for 2007 Malaysian data, these values are 0.03, 0.48, 0.10, and 0.51 respectively. Differences in these elasticities could be a result of changes in the time period studied or differences in the definition of capital.¹⁰

Eslava et al. (2004) estimate the production function at industry level rather than country level. This could also play a role in explaining the different elasticities.

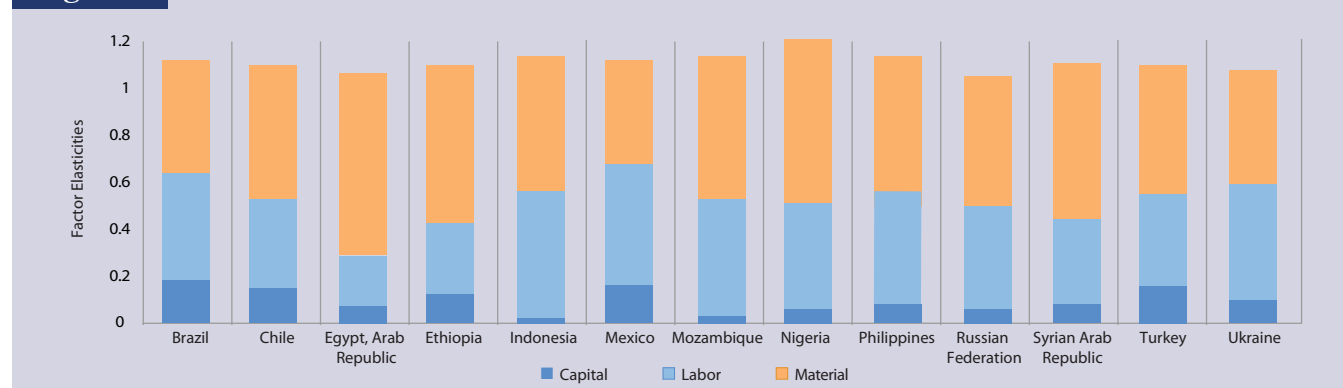
Cross-country analysis

Using the factor elasticities obtained above for each country, firm-level TFP values were computed. Firms' productivity levels are weighted by their output shares in order to compute *aggregate productivity*. Output shares are calculated as the ratio of each firm's sales to aggregate sales in the country. Hence, when weighted productivities are aggregated to compute the aggregate productivity, a firm with higher production has a larger contribution than a firm with low production. Simple *average productivities* are also presented in order to see how an average firm performs in each country.

The years in which the surveys were conducted vary in the data. This difference can contribute to variation in productivity performances across countries. For analytical purposes, countries were grouped in two cohorts—those surveyed in 2006–2007 and those surveyed in 2008–2009 (44 and 36 countries respectively). The cross-country comparison in this section uses data from countries that have relatively large sample sizes. Comparison of average and aggregate productivities shows noticeable differences across countries. A country with a high average productivity level could have quite low aggregate productivity or vice versa. This discrepancy between the two measures could be caused by the differences in the size distribution of the samples. Small sample size in a particular size group, which is more likely to be the case for large firms, could cause noticeable differences across both TFP measures. Another reason for this discrepancy is the variation in average productivity levels of firms in different size groups. If small firms are much more

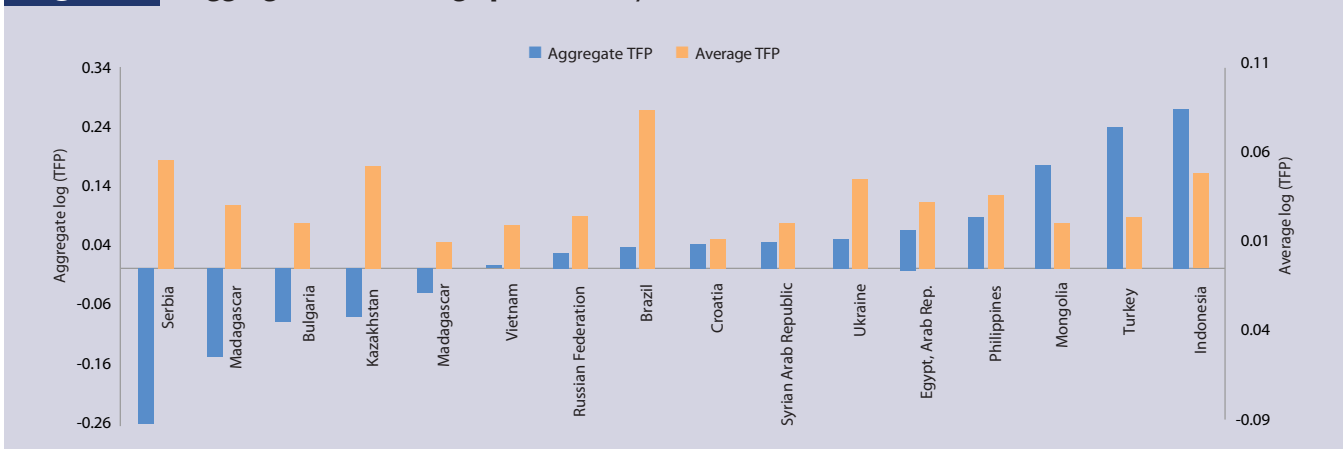
In the 2006–2007 sample, Peru has the highest aggregate productivity and Nicaragua has the highest average productivity.

Figure 1 Factor elasticities for selected countries



Source: Enterprise Surveys.

Figure 2 Aggregate and average productivity of countries in 2008–2009



Source: Enterprise Surveys.

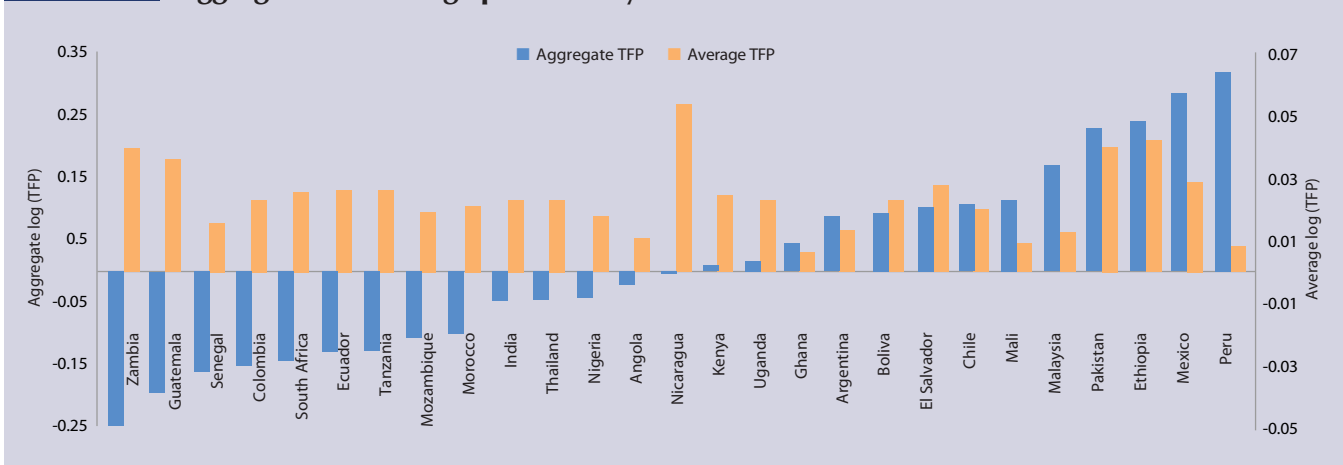
productive than large firms in a country, then this country might have high average productivity but low aggregate productivity relative to other countries.

Figure 2 shows aggregate and average productivity values in the countries that were surveyed in 2008–2009 and that had at least 100 firms for which TFP could be estimated. Among these countries, Indonesia has the highest aggregate productivity followed by Turkey. The picture is quite different for average productivity. Brazil has the highest average productivity among these countries. Serbia, which has the lowest aggregate productivity level, has an average productivity that is higher than the average productivities in Indonesia or Turkey.

The same analysis is performed for those countries that were surveyed in 2006–2007 and that had more than 200 firms for which TFP could be estimated (Figure 3).¹¹ Peru has the highest aggregate productivity among these countries. However, average productivity is among the

lowest in this country. The difference between average and aggregate productivities could be caused by how productivity is distributed among firms at different size levels. Productive large firms make a large contribution to aggregate productivity. However, this difference could also be caused by the distribution of firms in the productivity sample. For example, in Nicaragua the share of large firms in the sample is 3.5 percent (only 9 firms), one of the lowest shares in the 2006–2007 period. These large firms have very low productivities which drag the aggregate productivity to lower levels as compared to average productivity. While the firm-size distribution for Nicaragua is representative of the population (the share of large firms is 4.5 percent in the weighted sample), the small number of observations causes the big discrepancy between the two TFP measures.

Figure 3 Aggregate and average productivity of countries in 2006–2007



Source: Enterprise Surveys.

Table 3		Countries with high and low productivity levels									
ECA 2008/09		LAC 2006		AFR 2006/07		ECA 2008/09		LAC 2006		AFR 2006/07	
Mean	0.18	Mean	0.01	Mean	-0.02	Mean	0.03	Mean	0.03	Mean	0.02
High values of aggregate TFP						High values of average TFP					
Hungary	1.50	Peru	0.32	Ethiopia	0.24	Moldova	0.07	Nicaragua	0.05	Ethiopia	0.04
Romania	1.16	Mexico	0.28	Botswana	0.23	Kyrgyz Rep.	0.06	Honduras	0.05	Zambia	0.04
Uzbekistan	0.64	Chile	0.11	Mali	0.12	Serbia	0.06	Panama	0.04	Namibia	0.04
Kyrgyz Rep.	0.50	Panama	0.11	Rwanda	0.11	Kazakhstan	0.06	Guatemala	0.04	Swaziland	0.03
Georgia	0.31	El Salvador	0.10	Ghana	0.05	Macedonia, FYR	0.05	Paraguay	0.03	Burundi	0.03
Low values of aggregate TFP						Low values of average TFP					
Bulgaria	-0.09	Ecuador	-0.13	Tanzania	-0.12	Latvia	0.02	Bolivia	0.02	Rwanda	0.01
Belarus	-0.10	Colombia	-0.15	South Africa	-0.14	Azerbaijan	0.02	Colombia	0.02	Angola	0.01
Latvia	-0.11	Uruguay	-0.19	Senegal	-0.16	Croatia	0.02	Chile	0.02	Mali	0.01
Slovak Rep.	-0.19	Guatemala	-0.19	Swaziland	-0.19	Romania	0.01	Argentina	0.01	Mauritania	0.01
Serbia	-0.27	Honduras	-0.34	Zambia	-0.24	Hungary	0.01	Peru	0.01	Ghana	0.01

Source: Enterprise Surveys.

Regional analysis

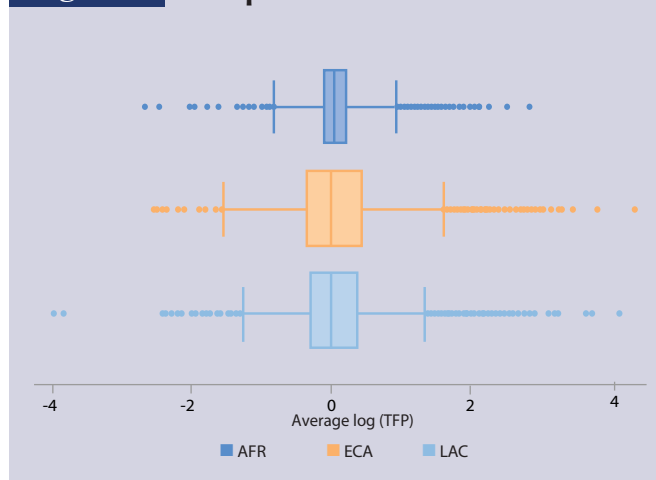
The rich coverage of data from the ECA, LAC and AFR regions allows performance of regional-level analysis (Table 3). Using all countries for which TFP could be estimated, countries are ranked according to their aggregate and average productivity levels. In the ECA region Hungary has the highest aggregate productivity which is followed by Romania and Uzbekistan. However, the ranking for average productivity is quite different. Among the large economies in the region—Ukraine, Turkey, Russia, Bulgaria and Kazakhstan—Turkey has the highest aggregate productivity level.

In the LAC region, Peru has the highest aggregate productivity, followed by Mexico. The least productive country is Honduras although average productivity in this

country is the second highest in the region. In this region all countries except Brazil were surveyed in 2006. In the AFR region, 21 of the 25 countries included in the analysis were surveyed in 2006–2007. Among these countries, Ethiopia has the highest aggregate and average productivity levels. On the other hand, Zambia has the lowest aggregate productivity but the second highest average productivity. The other four countries in this region—Cameroon, Côte d'Ivoire, Madagascar and Mauritius—were surveyed in 2009. The country with the highest aggregate productivity in this group is Côte d'Ivoire (with a TFP of 0.76) followed by Madagascar (with a TFP of -0.04).

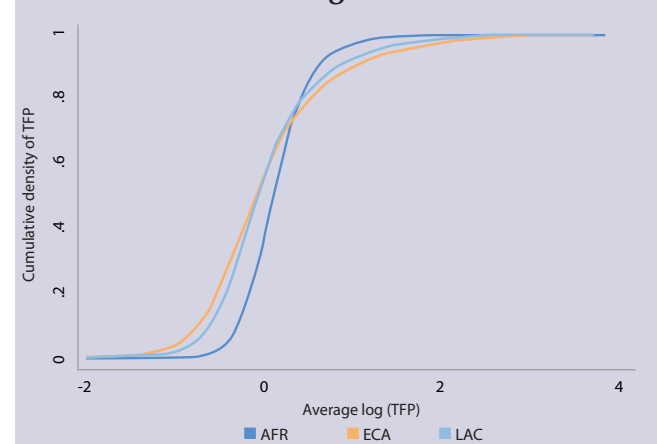
The spread of average productivity distributions shows variation across these three regions (Figure 4).¹² The dispersion in the AFR region is the smallest among the three. The standard deviation of TFP values in AFR is 0.39 whereas it is 0.64 and 0.71 in LAC and ECA respectively.

Figure 4 Box plot of TFP distribution



Source: Enterprise Surveys.

Figure 5 Cumulative density distribution in three regions



Source: Enterprise Surveys.

The difference in log productivity levels between the 5th and 95th percentiles in the AFR region is 1.2, which corresponds to a TFP ratio of 3.3.¹³ These ratios are 7.4 in LAC and 9.4 in ECA. Figure 5 shows the cumulative density of average TFP in each region.¹⁴ The graph indicates that all regions had similar average productivity. Moreover, the productivity distribution in ECA and LAC are more spread out than the distribution in the AFR region. This means that the number of firms with very high and very low productivity in these two regions is higher than the number in the AFR region.

In Asia, there are five countries surveyed in 2009—Indonesia, Mongolia, Nepal, Philippines and Vietnam. The average TFP value of these countries is 0.03. Nepal has the highest aggregate productivity level (0.38) which is followed by Indonesia (0.27). The lowest aggregate productivity is observed in Vietnam (-0.004). Comparing average productivities, Indonesia has the top ranking (0.05), followed by the Philippines (0.04).

Industry analysis

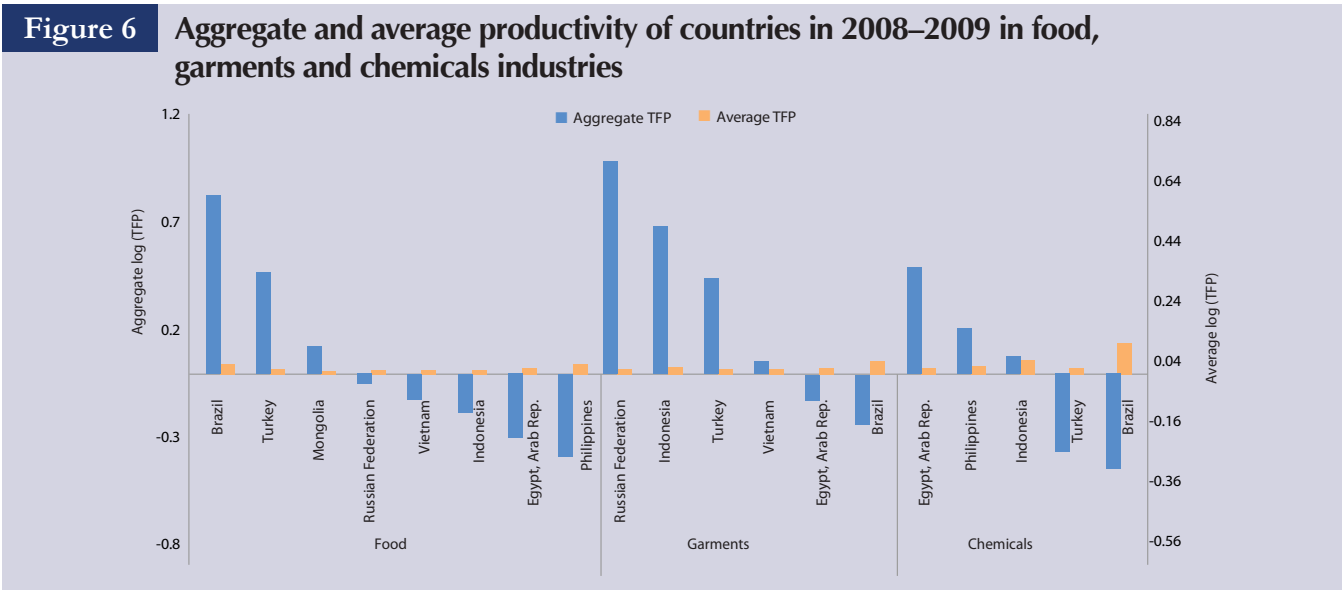
The manufacturing industries listed in Table 2 are likely to have different production technologies. Therefore, separate estimations at the industry level are not only desirable but they could be useful in understanding differences in firm performance as well as revealing comparative advantages within countries.

Industry-level estimates of TFP values are presented only for those countries that had at least 45 observations in each selected industry—food, garments and chemicals.¹⁵ The countries for which industry-level TFP values could be computed in the 2008–2009 period are presented in Figure 6. The cross-country comparison of aggregate productivities shows that Brazil, which has the second

highest average productivity in the food industry, has the highest aggregate productivity. In addition, in the garments and chemicals industries, Brazil shows the lowest aggregate productivity but the highest average productivity. The Arab Republic of Egypt has the highest aggregate productivity in the chemicals industry and it ranks second to last in food and garments. Comparison of average productivities shows that Turkish manufacturers have the second lowest productivity in all three industries.

As mentioned earlier, the discrepancies between average and aggregate productivities could be caused by differences in firm-size distributions within the samples and average productivity levels at different size groups. For example, the Philippines has the highest average productivity in the food industry, but exhibits the lowest aggregate productivity level. In the Philippines sample, the share of firms with more than 100 employees in the food industry is relatively small (9 firms) and they have relatively low productivity.

Table 4 presents a comparison of aggregate and average TFP for the group of countries surveyed in 2006–2007.¹⁶ Chile has the highest aggregate productivity in the food industry. Bolivia shows the highest aggregate productivity in garments while Peru is the country with the highest average productivity (Figure 7). Morocco has highest aggregate productivity in chemicals although the average productivity is second to last. Mexico exhibits relatively good performance in garments and chemicals industries. Firms in Mexico have the third highest aggregate productivity and the fourth highest average productivity in garments, and the second highest aggregate productivity and the third highest average productivity in chemicals.



Source: Enterprise Surveys.

Table 4 High and low productivity levels of countries in 2006-2007 in the food, garments and chemical industries											
Food		Garments		Chemicals		Food		Garments		Chemicals	
High Values of Aggregate TFP						High Values of Average TFP					
Chile	0.44	Bolivia	0.32	Peru	0.31	Nicaragua	0.08	Peru	0.05	Morocco	0.04
Malaysia	0.24	Guatemala	0.26	South Africa	0.21	El Salvador	0.05	El Salvador	0.04	Mexico	0.03
Kenya	0.23	Mexico	0.09	Ecuador	-0.12	Pakistan	0.05	Zambia	0.04	Chile	0.03
Low Values of Aggregate TFP						Low Values of Average TFP					
Tanzania	-0.35	Tanzania	-0.37	Mexico	-0.16	Mali	0.01	Nigeria	0.01	Malaysia	0.02
Uruguay	-0.37	El Salvador	-0.38	Morocco	-0.26	Ghana	0.01	Mali	0.01	South Africa	0.02
Honduras	-0.51	Peru	-0.42	Chile	-0.22	Malaysia	0.01	Ghana	0.01	Peru	0.01

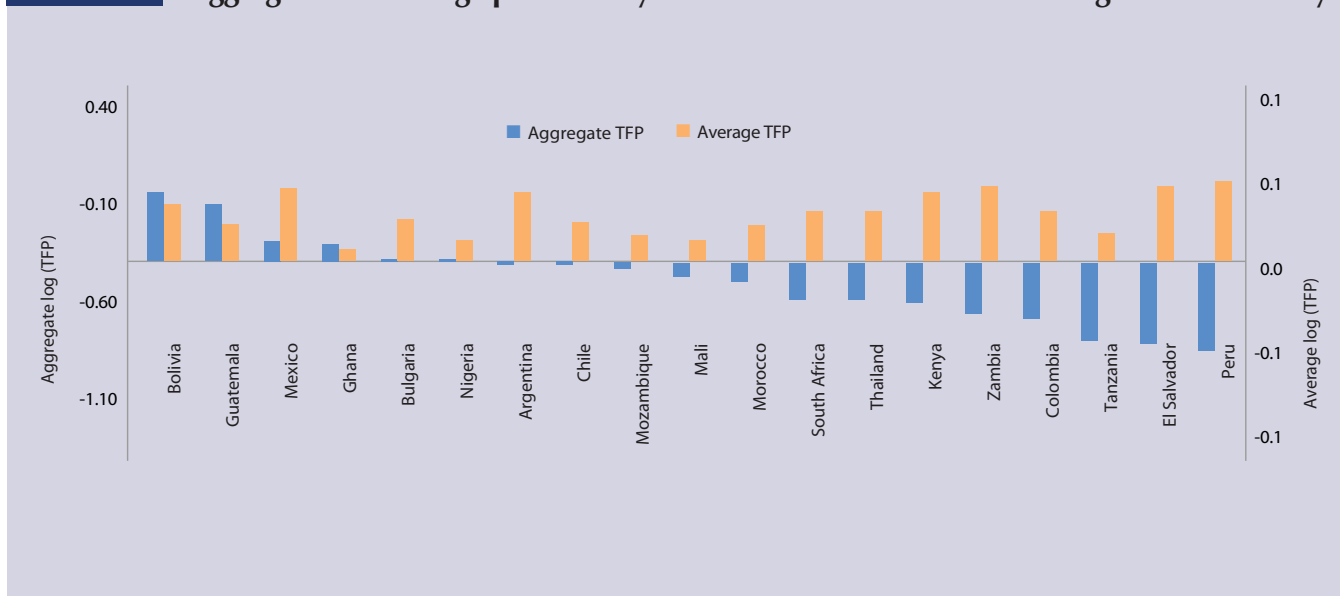
Source: Enterprise Surveys.

Conclusion

This note provides an analysis of the total factor productivity for firms in developing countries from different regions of the world using the World Bank's Enterprise Surveys. It presents cross-industry, cross country and regional productivity comparisons. Indonesia has the highest aggregate productivity among the countries that were surveyed in 2008–2009, followed by Turkey, while Brazil has the highest average productivity. Among the countries that were surveyed in 2006–2007, Peru has the highest aggregate productivity among these countries. However, average productivity is among the

lowest in this country. The regional analysis shows some variation across ECA, LAC and AFR regions in terms of average productivity distributions. The dispersion of total factor productivity in AFR is the smallest among the three regions. The analysis across industries shows how countries vary in the productivity performances of their industries. In 2008–2009 Brazil stands out for having the highest average productivity in the garments and chemicals industries and the second highest average productivity in the food industry. Among the countries that were surveyed in 2006–2007, Mexico exhibits relatively good performance in garments and chemicals.

Figure 7 Aggregate and average productivity of countries in 2006–2007 in the garments industry



Source: Enterprise Surveys.

Notes

1. 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. The countries included in the analysis, by region, are: Eastern Europe and Central Asia (**ECA**): Armenia; Azerbaijan; Belarus; Bosnia and Herzegovina; Bulgaria; Croatia; Czech Rep.; Estonia; Macedonia, FYR; Georgia; Hungary; Kazakhstan; Kyrgyz Rep.; Latvia; Lithuania; Moldova; Poland; Romania; Russian Federation; Serbia; Slovak Rep.; Tajikistan; Turkey; Ukraine; Uzbekistan; Middle East and North Africa (**MENA**): Algeria; Egypt, Arab Rep.; Jordan; Morocco; Syrian Arab Rep.; Yemen, Rep.; Latin America and the Caribbean (**LAC**): Argentina; Bolivia; Brazil; Chile; Colombia; Ecuador; El Salvador; Guatemala; Honduras; Mexico; Nicaragua; Panama; Paraguay; Peru; Uruguay; South and East Asia and Pacific (**Asia**): India; Indonesia; Malaysia; Mongolia; Nepal; Pakistan; Philippines; Thailand; Vietnam; Sub-Saharan Africa (**AFR**): Angola; Botswana; Burundi; Cameroon; Côte d'Ivoire; Congo, Dem. Rep.; Ethiopia; Ghana; Guinea; Guinea-Bissau; Kenya; Madagascar; Mali; Mauritania; Mauritius; Mozambique; Namibia; Nigeria; Rwanda; Senegal; South Africa; Swaziland; Tanzania; Uganda; Zambia. Indicator Surveys (IS) were excluded because of the small size of the sample.
3. The Cobb-Douglas production function specification used in the estimation is $Y=AK^{\alpha}L^{\beta}M^{\gamma}$, where K is capital, L is labor and M is material input. The exponents represent factor elasticities.
4. In the non-parametric Solow residual method, output elasticity of each input factor is calculated as the cost share of that input in total cost. TFP is estimated as the residual of the production function, making use of the calculated elasticities.
5. The paper is available from the authors upon request.
6. Exchange rates and GDP deflators are obtained from World Development Indicators, World Bank.
7. In total, 3,381 observations (out of 24,793) were identified as outliers.
8. Please refer to the Methodology page of the Enterprise Surveys website for more information: <http://www.enterprisesurveys.org/Methodology>
9. Elasticity values of the 80 countries are available upon request.
10. In this study the value of capital stock is measured by the replacement cost of machinery, vehicles and equipment.
11. More countries were surveyed in 2006–2007 than in 2008–2009 and many of the countries in the 2006–2007 survey had sample sizes above 100 observations. Hence 200 observations is used as a cutoff only to make the graph easier to read.

12. A box plot graphically displays the distribution/spread for a set of data. The three vertical lines of the box itself correspond to the 25th, 50th, and 75th percentiles. The formulas used to construct the box's "whiskers" correspond to J. W. Tukey's *Exploratory Data Analysis* (1977). The dots that appear outside the whiskers correspond to actual data values and visually indicate how many data points are in the lower/upper extremes of the distribution.
13. $\frac{TFP(95\text{ pct})}{TFP(5\text{ pct})} = e^{1.2} = 3.3$
14. The upper and lower tails of the cumulative density graphs are trimmed in order to have a better illustration of the central part of the TFP distribution across regions.
15. These industries were chosen due to their relatively higher coverage across countries. The analysis was also performed for textile, non metallic and metal and machinery industries. Additional results are available upon request.
16. Among the countries surveyed in 2006–2007, 30 countries meet the 45 observations criterion in the food industry, 19 countries in garments and 8 countries in chemicals.

References

- Bailey, M. N., C. Hulten, and D. Campbell. 1992. "The Distribution of Productivity in Manufacturing Plants." *Brookings Papers on Economic Activity: Microeconomics* 4:187-267.
- Bartelsman, E. J. and P. J. Dhrymes. 1998. "Productivity dynamics: U.S. manufacturing plants, 1972–1986." *Journal of Productivity Analysis* 9(1):5–34.
- Eslava, M., J. Haltiwanger, A. Kugler, and M. Kugler. 2004. "The Effects of Structural Reforms on Productivity and Profitability Enhancing Reallocation: Evidence from Colombia." *Journal of Development Economics* 75(2):333-371.
- Hallward-Driemeier, M., G. Iarossi, and K. L. Sokoloff. 2002. "Exports and Manufacturing Productivity in East Asia: A Comparative Analysis with Firm-Level Data," NBER Working Paper No: 8894.
- Roberts, M. and J. Tybout. 1996. *Industrial Evolution in Developing Countries: Micro Patterns of Turnover, Productivity and Market Structure*. New York: Oxford University Press.
- Saliola, F. and M. Seker. 2010. "Productivity analysis using micro level data from Enterprise Surveys," Working Paper, Enterprise Analysis Unit, World Bank.
- Solow, R. 1957. "Technical change and the aggregate production function." *Review of Economics and Statistics* 39(3): 312-320.

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