BOX 3.3 Patterns of total factor productivity: A firm perspective

There is substantial variation in firm-level total factor productivity (TFP) across industries and across regions. Weak firm productivity in emerging market and developing economies (EMDEs) partly reflects the divergence between a few highly productive firms and a large number of firms that operate far from the productivity frontier. The difference between frontier and laggard firms is, on average, larger in EMDEs than in advanced economies. Among EMDE firms, large firms tend to be more productive than small firms. Firms in technology-intensive industries, mainly located in East Asia and Pacific (EAP), Europe and Central Asia (ECA), and South Asia (SAR), tend to be more productive than firms in more traditional sectors. Measures to promote exports and improve business climates can help close the observed TFP gap.

Introduction

Firm-level productivity in emerging markets and developing economies (EMDEs) has been low relative to advanced economies, and growth has lost momentum over the past decade. This has diminished prospects among many EMDEs to catch up with the advanced economies (Andrews, Criscuolo, and Gal 2016; Cusolito and Maloney 2018).

Numerous factors have been identified as underlying the low firm-level productivity observed in EMDEs: weak institutions and pervasive informality, slow technology innovation and adoption, subdued investment and poor quality infrastructure, low human capital and poor firm management practices, protectionist trade policies and weak economic integration (Cusolito and Maloney 2018; World Bank 2019d, 2019e).[1] Moreover, outdated technologies, lagging innovation, misallocation of labor to inefficient sectors, and market rigidities weigh on productivity and contribute to dispersion in total factor productivity (TFP) across countries (Araujo, Vostroknutova, and Wacker 2017; Bahar 2018; Syverson 2011). In some EMDEs, low participation in global value chains, or lack of openness to foreign direct investment and migration, has resulted in missed opportunities for a productivity boost through the transfer of innovative processes and managerial capabilities (Goldberg et al. 2010; World Bank 2019d).

This box undertakes a cross-sectional study to analyze firm-level TFP patterns, and maps these to firm characteristics in EMDEs to address the following questions:

- How does firm-level TFP vary across EMDE sectors and regions?
- What firm characteristics account for the dispersion in TFP?

TFP variation across sectors and regions

Productivity varies across firms, within sectors, and across regions (Goñi and Maloney 2017). By focusing on TFP, differences due to capital deepening or other factor inputs can be abstracted from. This allows to identify where TFP dispersion and gaps are the largest, and where steps are needed to improve productivity. Firm-level TFP data are obtained from surveys conducted by the World Bank from 2007 to 2017 (Cusolito et al. 2018). The database of survey results contains TFP for 15,181 manufacturing firms in 108 EMDEs, including 20 low-income countries (LICs). A cross-sectional analysis of the firm-level TFP database is undertaken, which complements longitudinal studies that use micro-level panel data, but with a smaller country coverage.[2] Two measures of TFP are constructed: output and value-added revenue TFP measures. The latter is obtained by subtracting the value of intermediate inputs (materials, electricity, etc.) from output before computing TFP. TFP measurement challenges are discussed in Annex 3.5.

TFP across sectors. Differences in firm-level TFP across sectors have been frequently emphasized in the literature.[3] On average, firms in technology-intensive industries have higher TFP than those in other sectors (Figure 3.3.1.A). Technology-intensive industries, denoted by TINT, include computing and electrical machinery, precision equipment, electronics, information, and communication sectors (as in Fernald 2015). One explanation for this observation is that firms operating in a technology-intensive industry rely more on research and development (R&D) and network linkages than physical assets, and as

Note: This box was prepared by Cedric Okou.

[1] Many studies focus on labor productivity, which depends on both TFP and capital per worker–also known as capital deepening.

[2] This analysis does not explore the time series dimension because World Bank's firm output and input data used to construct TFP estimates were collected at different time in different countries. For example, these firm surveys were conducted in 2007 in South Africa and in 2017 in Ecuador. Moreover, the number of surveyed firms in many countries is small, which does not allow to conduct robust within and cross-country comparisons.

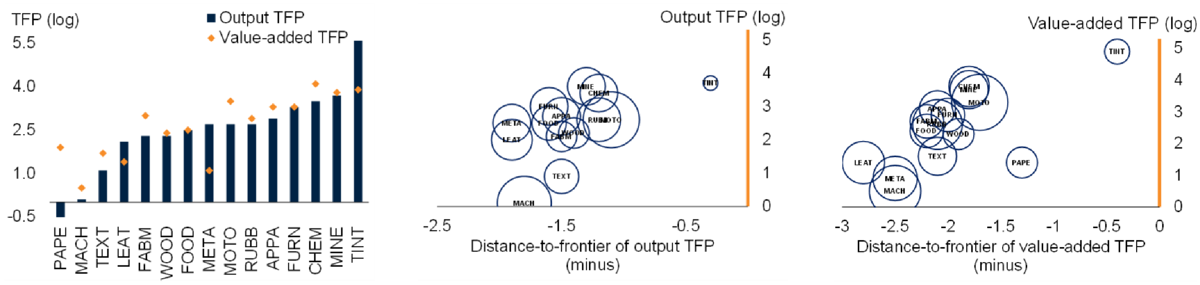
[3] See for example, Bartelsman and Doms (2000) and Levchenko and Zhang (2016).

BOX 3.3 Patterns of total factor productivity: A firm perspective (*continued*)

FIGURE 3.3.1 Firm TFP and distance-to-frontier in EMDEs by industry

Firms in technology-intensive industry (TINT) have higher average TFP. These technology-intensive firms are also more tightly clustered around their industry-specific frontier than firms in other sectors.

A. TFP estimates, by industry **B. Distance-to-frontier and average output TFP, by industry** **C. Distance-to-frontier and average value-added TFP, by industry**



Source: World Bank Enterprise Surveys, World Bank.

Note: Firm-level TFP is computed using a Cobb-Douglas production function for each industry, assuming that elasticities of output with respect to inputs are the same across countries in a given income group. The distance-to-frontier of TFP is computed within each industry, excluding the top 2.5 percent of firms. For each sector, the location shows the average and the size of the marker (circle) is proportional to one standard deviation of distance to frontier of TFP. Averages and standard deviations are computed using survey weights. Sample includes 15,181 firms in 108 EMDEs, including 20 LICs, for the period 2007-17. Firms operate in 15 industries: APPA = apparel, CHEM = chemicals, FABM = fabricated metals, FOOD = food, FURN = furniture, LEAT = leather, MACH = non-electrical machinery, META = metals, MINE = non-metallic minerals, MOTO = motor vehicles, PAPE = paper, RUBB = rubber, TEXT = textiles, TINT=technology-intensive, WOOD = wood. The technology-intensive industry (TINT) includes firms in computing and electrical machinery, precision equipment, electronics, information, and communication sectors.

A. In the manufacture of paper (PAPE) industry, the value-added TFP is positive and much higher than the corresponding (negative) output TFP due to a relatively high elasticity of output with respect to intermediate inputs.

B. C. Distance-to-frontier of firm-level TFP (minus) and TFP (log), by industry. The right-hand-side y-axis represent the frontier.

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such can reap the benefits of technology to boost productivity (Chevalier, Lecat, and Oulton 2012).

Distance to TFP frontier across sectors. TFP dispersion may signal rigidities in the generation, transfer and acquisition of technology across firms in a sector. To assess within-sector productivity dispersion, a firm's distance to an industry-specific TFP frontier is computed.[4] Firms in basic manufacturing industries, such as non-electrical machinery (MACH), textiles (TEXT), leather (LEAT), and basic metals (META), are not only on average less productive than firms in other sectors, but also relatively far from their industry-specific frontiers (Figure 3.3.1.B and 3.3.1.C). By contrast, firms in technology-intensive industries (TINT) are more tightly clustered around their industry-specific frontiers and are more productive.[5]

TFP across regions. Across regions, firms in East Asia and Pacific (EAP) are, on average, more productive than those in other regions (Figure 3.3.2.A). EAP also has the highest proportion of large size firms and firms exporting more than half of their sales (Figure 3.3.2.C and Figure 3.3.2.D). Most firms in technology-intensive industries are located in EAP, Europe and Central Asia (ECA), and South Asia (SAR) (Figure 3.3.2.B; regional boxes in Chapter 2). Perceptions of corruption and licensing as obstacles for firm operation seem to correlate negatively with total factor productivity (Figure 3.3.2.E-F).

Robustness of TFP dispersion. Substantial TFP dispersion may signal misallocation of factor inputs or rigidities in the generation, transfer, and acquisition of technology across firms (Hsieh and Klenow 2009). However, commonly used dispersion metrics can also reflect mismeasurements, quality differences, adjustment costs, markups, and investment risks, among other factors. Recent evidence shows that half of the dispersion is unrelated to misallocation, and driven rather by markups and technology wedges (Cusolito and Maloney 2018). Thus, dispersion results should be interpreted with caution. Nonetheless, the variation in distance to frontier in technology-intensive industries is less than one-fifth of that in basic manufacturing industries (leather, metals, machinery), suggesting that firms in technology-intensive industries are much closer to their sector-specific frontier.

[4] For a given firm *i*, the distance to an industry-specific TFP frontier (97.5th quantile) is computed as $DTF_i = TFP_{0.975} - TFP_{i \leq 0.975}$. The top 2.5 percent firm-level TFP values are dropped to minimize the impact of extreme values. Results are robust to alternative 1 and 5 percent cutoffs of top firm TFP values.

[5] This finding is broadly in line with the evidence in Hallward-Driemeier and Nayyar (2017).

BOX 3.3 Patterns of total factor productivity: A firm perspective (*continued*)

FIGURE 3.3.2 Firm TFP by regions

Firms in EAP are more productive than those located in other EMDE regions. EAP also has the highest share of large-size firms and those exporting more than half of their sales. Most firms in technology-intensive industry (TINT) are located in EAP, ECA, and SAR. Perceptions of corruption and licensing as obstacles for firm operation correlate negatively with total factor productivity (TFP).

Source: World Bank Enterprise Surveys, World Bank.

Note: Firm-level TFP is computed using a Cobb-Douglas production function for each industry, assuming elasticities of output with respect to inputs are the same across countries in a given income group. Unweighted regional averages are computed. Sample includes 15,181 firms in 108 EMDEs, including 20 LICs, for the period 2007-17. EAP = East Asia and Pacific, ECA = Europe and Central Asia, LAC = Latin America and the Caribbean, MNA = Middle East and North Africa, SAR = South Asia, and SSA = Sub-Saharan Africa.

A. Solid lines are averages of output TFP (log) for EMDEs (orange) and LICs (red). EMDEs = emerging markets and developing economies, LICs = low-income countries.

B. Bars show in each industry the percentage of firms in each region, by industry. Firms operate in 15 industries: APPA = apparel, CHEM = chemicals, FABM = fabricated metals, FOOD = food, FURN = furniture, LEAT = leather, MACH = non-electrical machinery, META = metals, MINE = non-metallic minerals, MOTO = motor vehicles, PAPE = paper, RUBB = rubber, TEXT = textiles, TINT = technology-intensive, WOOD = wood. The technology-intensive industry (TINT) includes firms in computing and electrical machinery, precision equipment, electronics, information, and communication sectors.

C. Firm size in terms of number of employees.

D. Share of exporting firms. High, medium, and low exports firms export more than 75 percent, between 50 and 75, and up to 25 percent of their sales, respectively.

E. Share of firms that perceive corruption as an obstacle for their operations.

F. Share of firms that perceive licensing and permits as an obstacle for their operations.

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Firm characteristics associated with higher TFP growth

Heterogeneous characteristics related to entering, incumbent, and exiting firms can explain the observed patterns of TFP dispersion (Bartelsman and Doms 2000). A large and expanding literature points to three broad categories of correlates of sectoral TFP dispersion in EMDEs: within-firm upgrading and spillovers, regulatory environment, and managerial ability.

Within-firm upgrading and technology spillovers. Controlling for both size and exports, firms in the technology-intensive industry are on average much closer to the TFP frontier than firms in traditional industries such as non-electric machinery, food, and non-metallic

BOX 3.3 Patterns of total factor productivity: A firm perspective (*continued*)

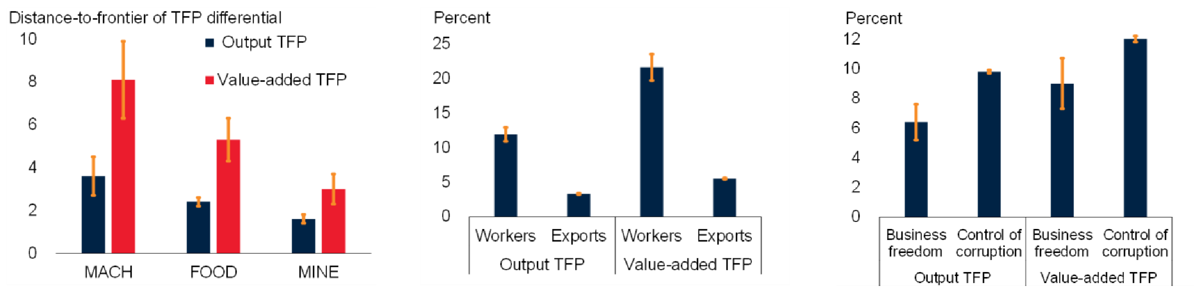
FIGURE 3.3.3 Distance-to-frontier of TFP, firm characteristics, and regulations

The average firm in the technology-intensive industry (TINT) is significantly closer to the frontier than the average firm in non-electric machinery (MACH), food (FOOD), and non-metallic minerals (MINE) industries, after controlling for firms' size and exports. As firms grow by number of employees and increase their ratios of exports to total sales, they move closer to the TFP frontier. A conducive business environment can enhance firm-level TFP. Improvements in business freedom and control of corruption are correlated with a reduction in the distance-to-frontier of TFP.

A. Distance to TFP frontier differential between traditional industries and the technology-intensive industry

B. Distance to TFP frontier differential between firms in lowest and highest quartile of firm size and exports

C. Distance to TFP frontier differential between firms in lowest and highest quartile of business environment



Source: World Bank Enterprise Surveys, World Bank.

Note: Firm-level TFP is computed using a Cobb-Douglas production function for each industry, assuming that elasticities of output with respect to inputs are the same across countries in a given income group. The distance-to-frontier (DTF) of TFP is computed within each sector, excluding the top 2.5 percent of firms. Sample includes 15,181 firms in 108 EMDEs, including 20 LICs, for the period 2007-17.

A. Distance-to-frontier of TFP differential between traditional industries, such as manufacturing of non-electric machinery (MACH), food (FOOD), and non-metallic minerals (MINE), and the technology-intensive (TINT) industry, controlling for firm characteristics (firm size and exports). Based on OLS regressions of the DTF of TFP (dependent variable) on industry dummies, controlling for firm characteristics and using the technology-intensive industry (TINT) as the base category as per Annex 3.5.

B. Distance to TFP frontier differential between the median firm in the lowest quartile and highest quartile of firms in terms of firm size (number of workers) and exports (share of exports in total sales). Based on OLS regressions of the DTF of TFP (dependent variable) on industry dummies, controlling for firm characteristics and using the technology-intensive industry (TINT) as the base category (Annex 3.5). A positive DTF differential implies that firms in the lowest quartile in terms of size and exports are far from the frontier relative to firms in the highest quartile. The lowest quartile of exports is zero, as more than half of firms have no exports.

C. Distance to TFP frontier differential between the median firm in the lowest quartile and highest quartile of firms in terms of business freedom and control of corruption index, controlling for firm characteristics. Based on OLS regressions of the DTF of TFP (dependent variable) on industry dummies and business environment quality, controlling for firm characteristics and using a technology-intensive industry (TINT) as the base category as per equation 3. A positive DTF differential implies that firms in the lowest quartile in terms of business freedom and control of corruption are far from the frontier relative to firms in the highest quartile.

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minerals industries (Figure 3.3.3.A). Knowledge, experience, R&D, and information technology can raise TFP through improvements in product quality and production process upgrading within firms.[6] Firms with a large number of employees are significantly closer to the TFP frontier, as larger firms can invest more in R&D and bring together a richer set of ideas. On average, the productivity of a firm in the highest quartile of size is about 12 and 22 percent closer to output and value-added TFP frontiers relative to a firm in the lowest quartile of size (Figure 3.3.3.B). Moreover, technology in frontier firms can have positive spillovers for productivity in other firms through agglomeration linkages and cross-border flows of goods, capital and people. Firms can reap agglomeration benefits by emulating the best production practices and organization structures of "nearby" highly productive firms (Dercon et al. 2004; Syverson 2011). Knowledge is also transferred through contacts with other firms, courtesy of trade, foreign direct investment and migration (De Loecker 2007). Firms with a high share of exports are significantly closer to the TFP frontier. A firm in the top quartile of exports, measured as a share of exports in total sales, is about 4 and 6 percent closer to output and value-added TFP frontiers relative to a firm in the lowest quartile of exports (Figure 3.3.3.B). Enabling effective innovation policies appears critical to boosting innovation gains (Cirera and Maloney 2017).

Regulatory environment. Institutions reflect political and legal forces that shape social and economic environments. Regulations and policies affect firms' productivity through incentives to acquire human capital, physical capital, and technology (Bartelsman and Doms 2000). Firm productivity tends to drop in poorly-regulated markets,

[6] See Brynjolfsson and Hitt (1995) and Goldberg et al. (2010).

BOX 3.3 Patterns of total factor productivity: A firm perspective (*continued*)

due to adverse incentives and the lack of creative destruction (Goldberg et al. 2010). In contrast, improvements in the business environment are associated with lower distance to TFP frontier, even after controlling for firm characteristics. Conducive regulatory practices—reflected in highest quartile values of business freedom index—may entail up to 9 percent reduction in the distance-to-frontier of TFP relative firms in the lowest quartile. Similarly, high quality governance—proxied by the top quartile estimates of control of corruption index—is associated with up to 12 percent drop in the distance to TFP frontier relative to firms in the bottom quartile (Figure 3.3.3.C).

Managerial ability. TFP also reflects how efficiently productive factors—labor, capital, and intermediate inputs—are assembled. Through their talents or the quality of their practices, managers coordinate the integration of factor inputs in the production process. Management and organizational styles may vary across firms due to competition, location, ownership, and trade ties. Intervention-led improvements in management practices can raise productivity by more than 10 percent (Van Reenen 2011). A policy shift that is more focused on enhancing firm managerial capabilities can, therefore, strengthen production synergies and bolster TFP gains (Cusolito and Maloney 2018).

Conclusion

The dispersion of firm-level TFP within and across industries in emerging markets and developing economies (EMDEs) is associated with various firm characteristics. TFP dispersion correlates negatively with firm size, partly because large firms can invest more in R&D to innovate. Exports also facilitate the transfer and adoption of new technologies, and therefore, can help close the gap between laggards and frontier firms. Moreover, a conducive business climate characterized by a greater freedom in entrepreneurship and less corruption can support TFP improvements. Undertaking policies to support R&D and innovation, promote exports, combat corruption, increase the ease of doing business, and enhance firm managerial capabilities, appears critical to boosting productivity.

innovation (proxied by higher per capita patents), stronger investment (as a share of GDP), higher levels of urbanization (proxied by population density), price stability, and a diverse and sophisticated economic structure (proxied by the economic complexity index of Hidalgo and Hausmann 2009), are all significantly associated with higher productivity growth (Figure 3.7).[17]

Differences between EMDEs and advanced economies. The estimated impact of improved levels of each driver of productivity growth depends on the stage of development and therefore differs between EMDEs and advanced economies. The extent of urbanization has a larger impact on productivity growth in EMDEs than in advanced economies, reflecting higher returns to the reallocation of workers away from rural agricultural production to higher productivity manufacturing and service sectors (Box 3.2). The level of education and investment also produces larger impacts on productivity in EMDEs in the long-run estimation, highlighting their importance at lower levels of productivity. Since 1995, the relationship between labor productivity and the economic complexity of tradable goods has strengthened in EMDEs.

Evolution of the drivers of productivity

Pre-crisis improvements. There were substantial gains in many of the underlying drivers of productivity growth in the pre-crisis period, growing faster in EMDEs than advanced economies (Figure 3.8). The selected drivers can be aggregated to an index based on the size of their estimated impacts on productivity—demographics, economic complexity, the number of patents filed, and price stability are all considered to be key determinants of productivity growth over this period by the econometric model. Cumulatively over 1995-2008, productivity in the one-quarter of EMDEs with the most

[17] These are largely consistent with existing studies which tend to have shorter time spans and smaller cross-sections (Durlauf, Kourtellos, and Tan 2008; Kim and Loayza 2019).