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# TFP determinants in the manufacturing sector: the case of Ecuadorian firms

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## Abstract

**Purpose** – Using a large firm-level data set, this paper examines total factor productivity (TFP) and its determinants in the Ecuadorian manufacturing sector in the period 2007–2018.

**Design/methodology/approach** – I analyze the role played by traditional TPF determinants, including internal firm characteristics, international trade activities, financial constraints and competition intensity. I contribute to the literature by presenting quantile regression results. Moreover, I analyze industry patterns, distinguishing between industries according to their technological intensity (following the organisation for economic co-operation and development classification).

**Findings** – My results confirm that firm age is positively related to TFP level but negatively related to TFP growth. I also find that being an exporter and an importer at the same time is associated with higher TFP levels and that this effect is higher than when being only an exporter or an importer. Additionally, I find that credit is positively related to TFP levels. Finally, I find that more competition is positively related to productivity in lower quantiles of output.

**Practical implications** – The results are the source of tools to propose policy recommendations, which are stated in the present document.

**Originality/value** – This paper aims to reopen the debate of firm productivity determinants in a developing country such as Ecuador. The authors use a set of covariates less analyzed in this issue.

**Keywords** Productivity, Financial constraints, Competition, Family firms, International trade, Ecuador

**Paper type** Research paper



**JEL classification** – D22, D24, F14, L60, L10

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## 1. Introduction

Traditionally, the manufacturing industry has been characterized as a driver of economic growth (particularly in developing countries) (see, for example, Haraguchi *et al.*, 2017). This industry produces goods with added value that helps the internationalization of firms and these goods not only could increase productivity but also boost the creation and dissemination of innovation through linkage effects (Marconi *et al.*, 2016). Because of this and among other reasons, productivity tends to be higher in manufactures than in other sectors and this helps a process of structural change (Szirmai and Verspagen, 2015; Rodrik, 2016).

However, less is known about the relative determinants of productivity (Harris and Moffat, 2015) and whether these determinants differ across intra-industry groups that cover the manufacturing industry (for example, between different manufacturing industries according to their technological intensity). In addition, literature on productivity determinants in developing countries and, more specifically, in Latin American countries (LAC), is still scarce.

In this paper, I explore the total factor productivity (TFP) determinants of Ecuadorian manufacturing firms using a comprehensive firm-level data set that covers the period 2007–2018. I also divide this sector according to the technological intensity of industries to capture the inter-industry heterogeneity of TFP determinants. The novelty of this paper lies in at least the following four aspects.

First, I return to the traditional analysis of TFP determinants by way of a two-step approach. In the first step, using the Wooldridge (2009) methodology, I estimate a production function to obtain a measure of firm TFP. In the second step, I relate TFP and its growth to internal firm characteristics, international trade activities, financial constraints and competition intensity. Second, I use an unconditional quantile regression approach (UQR) to analyze TFP and its growth determinants. This methodology allows for controlling for heterogeneity among firms. I use this technique because, in Ecuador, micro, small and medium firms represent 95% of all firms (Superintendencia de Compañías, Valores y Seguros [SCVS], 2018). Having a higher percentage of smaller firms in the economy could increase disparities in TFP. Third, I analyze differences in TFP determinants between industries according to their technological intensity [following the organisation for economic co-operation and development (OECD) classification]. This makes it possible to relax the assumption that all firms operate using standard technology across all manufacturing industries and in a similar competitive environment. Finally, to the best of my knowledge, this study is the most comprehensive and up-to-date study for developing countries. I have not been able to identify comparable papers for LAC in the literature that model TFP at the micro-level using such a wide range of determinants. Nevertheless, the papers most similar to this kind of analysis are for Great Britain (Harris and Moffat, 2015; Harris *et al.*, 2005), China (Ding *et al.*, 2016) and Portugal (Goncalves and Martins, 2016).

The paper is structured as follows. Section 2 discusses TFP determinants. Section 3 explains the econometric strategy. Section 4 describes the data. Section 5 presents the main results of TFP determinants. Finally, Section 6 summarizes our final remarks.

## 2. The determinants of productivity

The list of possible determinants of productivity is vast. Nevertheless, Syverson (2011) and Bloom *et al.* (2010a) summarize it in several aspects. In this paper, I group TFP determinants into four aspects as follows:

(1) Internal firm characteristics;

(2) International trade activities;

(3) Financial constraints; and

(4) Competition intensity.

Because of a lack of data, my analysis does not address other TFP determinants that appear to be important. In particular, a large body of empirical literature has focused on the relationship between research and development (R&D), innovation and productivity (Barge-Gil *et al.*, 2018; for a recent review).

*2.1 Internal firm characteristics*

The most traditional hypothesis that relates internal firm characteristics to TFP is learning-by-doing *(LBD)*. In this sense, productivity could increase with firm age, and thus so could the likelihood of survival (Jovanovic and Nyarko, 1996; Pakes and Ericson, 1998). This is because as firms age, managers accumulate experience, gain from *LBD*, undertake new investments or achieve economies of scale, all of which can improve productivity (Jensen *et al.*, 2001). Nevertheless, recent empirical evidence suggests that younger firms produce with higher efficiency and with better technology than older plants (a vintage capital effect). This could occur through "wear and tear" and because new capital embodies the latest technology (Harris and Moffat, 2015).

In addition, Bloom *et al.* (2010a) argues that "without delegating decision-making, firms in developing countries find that growth becomes unprofitable or even impossible because decisions are constrained by their owners' time." This issue is especially critical in family firms (FF) because the family will exert some strategic control over the firm's resources and processes. Bloom *et al.* (2010b) suggest that a key factor behind this are low levels of competition and high levels of family ownership in developing countries, which leads to the survival of many badly-run firms and this could have a negative effect on productivity. Barbera and Moores (2013) find that productivity is negatively affected by being a FF. Nevertheless, differences in TFP between family and non-FF disappear when they allow for heterogeneous output contributions of family production inputs. However, there is no consensus about the direction of the relationship between family involvement and a firm's productivity.

*2.2 International trade activities*

There is a large list of empirical papers that relate international trade activities and, in particular, export and import activities to firm productivity (Cassiman and Golovko, 2018; Wagner, 2012; present reviews of this literature). In fact, two alternative hypotheses may explain this relationship as follows: the self-selection hypothesis and the LBD hypothesis. The self-selection hypothesis argues that only the most productive firms decide to enter international markets (Melitz, 2003; Wagner, 2007). For its part, the LBD hypothesis argues that firms in international markets can take advantage of economies of scale and acquire knowledge from greater exposure to better practices, which fosters productivity (Fariñas and Martín-Marcos, 2007; De Loecker, 2013).

Additionally, empirical evidence has shown that two-way traders (firms engaged in both export and import activities) have higher productivity than firms that do only one of the two activities (see, for example, Aristei *et al.*, 2013; Wagner, 2013). Empirical literature offers at least two explanations for this result. First, there is evidence that suggests that import and export activities are complements to increase productivity (Camino-Mogro and López, 2021). Second, two-way traders could incur common sunk costs when they export and import and this would enhance the productivity level (Kasahara and Lapham, 2013).

Furthermore, international trade activities also concern foreign direct investment (FDI). The general consensus is that FDI improves productivity. In this line, Driffield and Love (2007) argue that firms may undertake FDI to source technology from the host economy rather than exploit superior technology from the home country. However, evidence for developing countries shows a weak direct effect of FDI on TFP growth. One exception is the study by Li and Tanna (2019). These authors find a robust effect of FDI on productivity after accounting for the roles of human capital and institutions as contingencies in the FDI on the TFP growth relationship.

*2.3 Financial constraints*

It is well known that credit access affects growth through the impact on productivity. In this sense, facilitating long-run, productivity-enhancing investment increases growth and reduces volatility (Aghion *et al.*, 2010). At the same time, one of the biggest hurdles to a firm's survival and expansion is access to credit, especially in developing countries. Moreover, this issue is of greater importance in small firms than in large firms and this could affect productivity growth at the bottom of the distribution of firm size (Kochar, 1997; Van Biesebroeck, 2005).

The effect of debt on TFP growth is not conclusive. For example, Goncalves and Martins (2016) find a negative relationship between debt and TFP growth in Portuguese manufacturing firms while Coricelli *et al.* (2012) qualify this result by considering a threshold effect. These authors find that there is a positive impact of debt on TFP below a certain level of debt (a threshold level of debt) while this effect turns out to be negative once this threshold is reached.

In contrast, VA Biesebroeck (2005) finds in African manufacturing firms that firms that receive any kind of credit have higher productivity levels than firms that do not receive credit (Gatti and Love (2008) for Bulgaria and Villalpando (2014) for Mexico find similar results). The basic idea about this positive relationship is that credit allows many productive firms to expand or make technological improvements and investments needed to increase their productivity beyond what their internal funds can support. In this sense, credit allows firms to export, import inputs and capital goods and invest in R&D, technology systems and advertising, among other instruments. However, the caveat is that if credit focused only on large firms, this might increase TFP disparities and the survival rates of smaller firms might decrease.

*2.4 Competition intensity*

Competition drives productivity through two key mechanisms. The first is the Darwinian selection among producers with heterogeneous productivity levels. In this mechanism, the competition moves the market share toward more efficient (i.e. lower-cost and generally, therefore, lower-price) producers, shrinking relatively high-cost firms/plants, sometimes forcing their exit and opening up room for more efficient producers. The second mechanism refers to an increase in inefficiency within plants or firms. In this mechanism, competition can induce firms to take costly productivity-raising actions that they might not otherwise (Syverson, 2011). In this vein, greater competition will pressure firms into adopting new technologies and operating more efficiently via increasing innovation (Aghion *et al.*, 1998) and R&D (Aghion *et al.*, 2001). However, under certain conditions, heightened competition (at least for a market of fixed size) can actually diminish a firm's incentives to make productivity-enhancing investments (Vives, 2008) [1].

## 3. Econometric strategy

The aim of this paper is to analyze the determinants of TFP (in both levels and growth rates) in the manufacturing sector. As there may be a lot of heterogeneity across firms, even within the same industry [2], I also perform the same analysis along with the whole distribution of TFP. To this end, I apply a two-step approach. First, I estimate a traditional Cobb-Douglas production (revenue) function to capture the TFP and then I regress the estimated TFP and its growth on a set of covariates to capture the determinants. Many authors argue that estimating the determinants of TFP in a second step would be biased because of an omitted variable(s) problem (see, for example, Camino-Mogro and Bermudez-Barrezueta, 2021; Ding *et al.*, 2016; Harris and Moffat, 2015; Harris *et al.*, 2005; Wang and Schmidt, 2002). However, De Loecker (2013) shows that including a dummy (export and R&D dummies in his case) as an input in the production function is problematic for at least two reasons. First, the impact of the dummy variable on productivity is only deterministic and implies that all (actions) entrants' productivity will increase by the estimated coefficient of the dummy. Second, the Cobb-Douglas production function implies that a firm can substitute any input with the base category of the dummy variable at a constant unit elasticity if the dummy variable is not included in the law of motion of productivity.

### *3.1 Specification of the production function*

I adopt the traditional production function (in this case, it is a revenue function) to be estimated at firm level $i$ in industry $j$ for year $t$, which is given by [3] as follows:

$$Y_{ijt} = e^{(\omega_{ijt}+\varepsilon_{ijt})} K_{ijt}^{\beta} L_{ijt}^{\alpha} M_{ijt}^{\gamma} \tag{1}$$

where $\omega_{ijt}$ is a serially correlated productivity shock (not observed by the econometrician but observable or predictable by firms), $K_{ijt}$ is capital input, $L_{ijt}$ is labor input, $M_{ijt}$ are the intermediate inputs and $\varepsilon_{ijt}$ is a standard i.i.d. error term that is neither observable nor predictable by the firm. The TFP is defined as:

$$e^{(\omega_{ijt}+\varepsilon_{ijt})} = \frac{Y_{ijt}}{K_{ijt}^{\beta} L_{ijt}^{\alpha} M_{ijt}^{\gamma}}$$

Then, from equation (1), I get:

$$\ln\left(e^{(\omega_{ijt}+\varepsilon_{ijt})}\right) = \ln A(\omega) = \omega_{ijt} + \varepsilon_{ijt} \tag{2}$$

The production function analysis allows for controlling the effects of observed plant-specific characteristics. In this sense, I control for a vector of dummy variables that represent cities (Guayaquil, Quito, Cuenca and others), years (2007–2018) and industry economic sectors at the two-digit level of the international standard industrial classification (ISIC) Rev. 4 ($z_{kijt}$) [4]. Taking logarithms of equation (1), the equation to be estimated is as follows:

$$y_{ijt} = \omega_{ijt} + \beta k_{ijt} + \alpha l_{ijt} + \gamma m_{ijt} + \sum_k \psi_k z_{kijt} + \varepsilon_{ijt} \tag{3}$$

To estimate equation (3), different estimators in the literature are used, such as ordinary least squares (OLS), fixed effects (FE), random effects (RE), the Olley and Pakes (1996) estimator, the Levinsohn and Petrin (2003) estimator, the Ackerberg *et al.* (2015) correction to the Olley & Pakes and LP estimators and the Wooldridge (2009) modification of the Levinsohn and Petrin (2003) estimator with FE. In this paper, I use the Wooldridge-Levinsohn-Petrin-fixed-effects (WDRG) estimator, which is an augmented version of the one implemented in Petrin and Levinsohn (2012). Caselli (2018) argues that the main reason for using this estimator is that it corrects for the simultaneous determination of inputs and unobserved productivity by proxying the latter with firm-level material inputs and FE. Once I estimate equation (3) with the WDRG estimator, I can recover the TFP ($\omega_{ijt}$) and I can construct the TFP growth by log-differences. Thus, the estimated TFP is given by as follows:

$$\hat{\omega}_{ijt} = y_{ijt} - \hat{\beta} k_{ijt} - \hat{\alpha} l_{ijt} - \hat{\gamma} m_{ijt} \tag{4}$$

Similar to Petrin and Levinsohn (2012), this estimate of TFP includes the error term $\varepsilon_{ijt}$. Nevertheless, as long as this error term is pure noise and uncorrelated with the variables in the revenue function, this does not bias the results, but it may lead to larger standard errors in the second stage of this analysis when productivity is used as the dependent variable (Caselli, 2018).

### *3.2 Determinants of total factor productivity*

Once the TFP is captured as in equation (4), I analyze the determinants of TFP (in both levels and growth rates) in a second-stage regression as follows:

$$\hat{\omega}_{ijt} = \alpha + \varphi_x X_{ijt} + \varepsilon_{ijt} \tag{5}$$

$$\Delta\hat{\omega}_{ijt} = \alpha + \varphi_x X_{ijt} + \varepsilon_{ijt} \tag{6}$$

where $\hat{\omega}_{ijt}$ is the estimated TFP, $X_{ijt}$ is a set of (potential) TFP determinants and $\varepsilon_{ijt}$ is the error term. I consider four categories of TFP determinants as follows:

(1) Internal firm characteristics. In this category, I consider two variables as follows: firm age (*age*) and being a *FF*. First of all, many authors argue that TFP decreases with firm age because of not accounting properly for capital obsolescence or not properly adopting new technologies and higher sunk-costs (Harris and Moffat, 2015). Nevertheless, authors like Jovanovic and Nyarko (1996) argue that older firms achieve higher levels of productivity according to the *LBD* process. Second, Barbera and Moores (2013) found that being a FF has a negative effect on productivity, but this negative effect disappears when they allow for heterogeneous output contributions of family production inputs.

(2) International trade activities. It is well known that international trade activities increase productivity. Therefore, in this category, I consider three dummy variables that represent firms engaged only in exporting activities (*ExpOnly*), firms engaged only in importing activities (*ImpOnly*) and firms engaged in both exporting and importing activities or two-way traders (*TWTraders*). Additionally, in this category, I also consider the role of FDI. In this sense, there are positive productivity spillovers from FDI (see, for example, Keller and Yeaple, 2009; Haskel *et al.*, 2007). In particular, I include a dummy variable that represents whether the firm receives *FDI*.

(3) Financial constraints. In this category, I consider two variables as follows: the debt-to-equity ratio (*dte*) and credit access (*credit*). *dte* ratio represents the firm's financial health. In this sense, an increase in this ratio could decrease TFP, as debt accumulation is a cumulative result of hierarchical financing decisions over time (see, for example, Nucci *et al.*, 2005). With regard to credit access, which represents access to financial loans, authors like Gatti and Love (2008) and Van Biesebroeck

(2005) found that firms that receive any credit have significantly higher productivity levels. Nevertheless, larger firms are much more likely to report having access to formal credit.

(4) Competition intensity. Following the idea that greater competition will pressure firms into adopting new technologies and operating more efficiently (see, for example, Meyer and Vickers, 1997; Nickell, 1996), I include the Herfindahl-Hirschman Index (*HHI*).

If traditional least squares (OLS) regression is used to estimate equations (5) and (6) and there is unobserved heterogeneity, then the estimated coefficients are not representative of the entire conditional TFP distribution (Mata and Machado, 1996; Dimelis and Louri, 2002). This unobserved heterogeneity may render the dependent variable (TFP) and the error term to be independent but not identically distributed across firms. This caveat could make OLS estimates inefficient and if there are long tails, extreme observations will have a significant influence on estimated coefficients. To solve this issue, I apply the UQR approach [5]. The main advantage of this approach is that the quantiles are defined pre-regression; therefore, the result is not influenced by any right-hand side variable (Killewald and Bearak, 2014). In UQR, one can, for instance, include high-dimensional FE to adjust for selection bias without redefining the quantiles, cluster-robust standard errors and bootstrapped standard errors. This methodology proceeds in two steps. The first step is to obtain the recentered influence function (RIF). The second step is to include this RIF as an outcome variable in a regression along with the right-hand side variables [6].

## 4. Data

I use underexplored, novel and administrative unbalanced panel data from 2007 to 2018 constructed from balance sheets and financial statements of the whole population of formal Ecuadorian manufacturing firms [7]. This information is reported directly by firms annually to the SCVS, which is the regulatory agency in Ecuador. Over this period, the data provides information on firm-level characteristics and financial accounts that allow us to estimate the revenue function (all measured in real values, using the respective annual price deflator) and revise TFP and its growth determinants. Furthermore, our analysis is based on all the firms in operation for all the years in the sample period and without restrictions on the number of employees or business age; this allows us to use a large quantity of firms that were active in each year, city and industry.

To estimate the production function, I use filtering criteria similar to Camino-Mogro *et al.* (2018), who used a similar database [8]. Table A2, in the Appendix, shows the definitions and mean values of all the variables used for the estimation of the production function and the TFP determinants.

Our data consist of an unbalanced panel data set with 36,061 observations and 5,745 formal manufacturing firms. Following the OECD classification, I analyze differences in TFP determinants between industries according to their technological intensity (Table A1 in the Appendix) [9]. In particular, it is well known that TFP is higher in firms that are engaged in international trade activities, firms that produce a differentiated output and firms in high-tech industries.

In addition, Table A2 in the Appendix presents a summary of statistics for the whole manufacturing sector during the period 2007–2018. Many interesting patterns are shown: the majority of firms are FF (87.9%); participation in international trade activities is very scarce; 6% of firms only export; 14.9% only import intermediates; and only 8.5% of firms are two-way traders. Moreover, I show that only 2.8% of Ecuadorian manufacturing firms receive FDI. Finally, 36.6% of firms receive financial credit [10]. Van Biesebroeck (2005) mentions that the difficulty of obtaining credit does not affect all firms equally. In this line, smaller firms are often thought to have difficulty accessing credit markets and larger firms are much more likely to report having access to formal credit. However, credit seems to be strongly and positively associated with productivity across firms (Gatti and Love, 2008).

## 5. Results

I begin the discussion of the results with the estimation of the traditional revenue function with the Wooldridge (2009) methodology with fixed effects [11]. In this first stage, I estimate equation (3) to obtain the TFP as in equation (4). In all estimates, I control for city, industry and year FE. As a comparison exercise, I also estimate equation (3) by using the Levinsohn and Petrin (2003) estimator.

Table 1 shows the results of the revenue function estimations for the entire manufacturing sector and by the OECD technological intensity classification. I show that input elasticities are different across industries with different technological intensity, which suggests significant heterogeneity among industries.

In the second stage, I analyze TFP determinants. To do this, I estimate equations (5) and (6) for the whole manufacturing sector and by the OECD technological intensity classification using the OLS-FE and the UQR approach to capture the effect of the different determinants along with the TFP distribution. In all the regressions, I include firm FE, time and city dummies to control for heterogeneity with 300 bootstrapped replications.

### *5.1 Manufacturing level results*

Table 2 shows the results of the determinants of TFP, in both levels and growth rates (see Panel A and Panel B, respectively) for the manufacturing sector as a whole. According to the internal firm characteristics, I find that age is positively related to TFP level, but negatively associated with TFP growth in all the quantiles. This is consistent with the hypothesis that younger firms produce with greater efficiency and better technology than older firms (Ding *et al.*, 2016), allowing them to have a higher growth rate of TFP. In this sense, the LBD hypothesis is not supported because as a firm gets older, the effect is positive only in year $t$, suggesting that the marginal effect on the TFP level is decreasing. Similar results are found for firms in different countries as follows: African countries (Van Biesebroeck, 2005), Bulgaria (Gatti and Love, 2008), Bangladesh (Fernandes, 2008), Great Britain (Harris and Moffat, 2015) and Portugal (Goncalves and Martins, 2016). Furthermore, being a *FF* is negatively related to TFP levels, but a non-statistically significant relationship is found in TFP growth.

In terms of international trade activities, I find that being a two-way trader (*Trader*) has a greater effect on firm productivity than only import or only export or no trade at all (see, for example, Muuls and Pisu, 2009). These results are consistent with the idea that import and export activities are complements to increase productivity (Camino-Mogro and López, 2021). However, I do not find evidence that supports a learning effect from exporting and importing activities for higher quantiles.

In line with financial constraints, Table 2 shows that *dte* is positively related to TFP levels and TFP growth for quantiles lower than 0.10 and only for quantiles higher than 0.95 for TFP growth. This suggests that for the whole manufacturing sector, firms with lower levels of TFP increase productivity with more debt. Nevertheless, firms with higher TFP growth benefit more from debt than firms with lower TFP growth rates. This result is in concordance with Coricelli *et al.* (2012), who argue that debt has positive impacts on TFP growth under a threshold, and therefore, after a certain level of debt is reached, the firm

**Table 1.**
Semi-parametric production function estimates

| Estimators | Manufacturing<br>All firms LP | Manufacturing<br>All firms WDRG | Industries according to their technological intensity<br>Low-tech industry LP | Low-tech industry WDRG | Medium-low tech industry LP | Medium-low tech industry WDRG | Medium-high and high-tech industry LP | Medium-high and high-tech industry WDRG |
|---|---|---|---|---|---|---|---|---|
| kit | 0.117*** | 0.061*** | 0.136*** | 0.093*** | 0.069*** | 0.046*** | 0.125*** | 0.046*** |
| | (0.017) | (0.008) | (0.019) | (0.0.018) | (0.024) | (0.010) | (0.043) | (0.013) |
| lit | 0.330*** | 0.344*** | 0.288*** | 0.302*** | 0.335*** | 0.343*** | 0.424*** | 0.460*** |
| | (0.010) | (0.007) | (0.013) | (0.009) | (0.019) | (0.012) | (0.028) | (0.018) |
| mit | 0.244*** | 0.197*** | 0.260*** | 0.1945*** | 0.250*** | 0.202*** | 0.196*** | 0.183*** |
| | (0.008) | (0.013) | (0.012) | (0.021) | (0.025) | (0.021) | (0.050) | (0.0.028) |
| Wald test CRS ($p$-value) | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Observations | 36,061 | 28,602 | 17,908 | 14,225 | 10,570 | 8,376 | 7,583 | 5,996 |

**Notes:** Robust standard errors clustered at the firm level in parentheses with 300 bootstrapped for the LP estimation. For the WDRG estimation, the GMM option is used. CRS is the constant returns to scale test. All estimations include city, industry and year FE; $^{***}p < 0.01$

| | OLS-FE | Q10 | Q25 | Q50 | Q75 | Q90 |
|---|---|---|---|---|---|---|
| *Panel A: TFP level* | | | | | | |
| Internal firm characteristics | | | | | | |
| *age* | 0.040*** | 0.055*** | 0.041*** | 0.035*** | 0.023*** | 0.017*** |
| | (0.002) | (0.004) | (0.002) | (0.002) | (0.002) | (0.002) |
| *FF* | −0.010** | −0.014** | −0.009*** | −0.002 | −0.001 | −0.006 |
| | (0.004) | (0.005) | (0.005) | (0.003) | (0.004) | (0.005) |
| International trade activities | | | | | | |
| *ExpOnly* | 0.017*** | 0.019*** | 0.010*** | 0.005 | 0.012*** | 0.014** |
| | (0.005) | (0.006) | (0.003) | (0.004) | (0.004) | (0.006) |
| *ImpOnly* | 0.008*** | 0.027*** | 0.012*** | 0.005* | −0.007** | −0.004 |
| | (0.002) | (0.004) | (0.003) | (0.003) | (0.003) | (0.003) |
| *TWTraders* | 0.018*** | 0.031*** | 0.015*** | 0.006* | −0.002 | −0.005 |
| | (0.002) | (0.004) | (0.003) | (0.003) | (0.004) | (0.006) |
| *FDI* | −0.000 | −0.006 | −0.003 | 0.002 | 0.004 | −0.012 |
| | (0.002) | (0.004) | (0.002) | (0.003) | (0.005) | (0.008) |
| Financial constraints | | | | | | |
| *dte* | −0.002 | −0.001 | −0.003** | −0.002* | −0.0004 | 0.0003 |
| | (0.001) | (0.004) | (0.002) | (0.001) | (0.001) | (0.001) |
| *credit* | 0.007*** | 0.014*** | 0.006*** | 0.006*** | 0.003** | 0.001 |
| | (0.001) | (0.002) | (0.001) | (0.001) | (0.001) | (0.002) |
| Competition intensity | | | | | | |
| *HHI* | −0.012*** | 0.008 | −0.002 | −0.021*** | −0.022*** | −0.009* |
| | (0.001) | (0.007) | (0.004) | (0.004) | (0.005) | (0.005) |
| Observations | | | 33,102 | | | |
| *Panel B: TFP growth* | | | | | | |
| Internal firm characteristics | | | | | | |
| *age* | −0.348*** | −0.190*** | −0.125*** | −0.119*** | −0.321*** | −0.887*** |
| | (0.016) | (0.028) | (0.013) | (0.007) | (0.016) | (0.056) |
| *FF* | −0.020 | −0.035 | −0.016 | −0.019 | −0.040* | 0.001 |
| | (0.038) | (0.051) | (0.021) | (0.012) | (0.024) | (0.069) |
| International trade activities | | | | | | |
| *ExpOnly* | 0.023 | 0.122** | 0.0272 | 0.0161 | −0.024 | −0.018 |
| | (0.029) | (0.057) | (0.023) | (0.014) | (0.028) | (0.065) |
| *ImpOnly* | −0.042** | 0.026 | −0.003 | −0.015 | −0.103*** | −0.211*** |
| | (0.017) | (0.039) | (0.016) | (0.010) | (0.018) | (0.048) |
| *TWTraders* | −0.037 | 0.077 | 0.020 | −0.024* | −0.107*** | −0.221*** |
| | (0.025) | (0.050) | (0.023) | (0.014) | (0.023) | (0.066) |
| *FDI* | −0.0213 | −0.0646 | −0.0157 | 0.007 | −0.018 | −0.044 |
| | (0.024) | (0.049) | (0.021) | (0.014) | (0.021) | (0.062) |
| Financial constraints | | | | | | |
| *dte* | 0.011 | 0.014 | −0.009 | 0.002 | 0.008 | 0.028 |
| | (0.009) | (0.017) | (0.007) | (0.004) | (0.007) | (0.0217) |
| *credit* | −0.015* | −0.028 | −0.009 | −0.005 | −0.016* | −0.054** |
| | (0.009) | (0.018) | (0.008) | (0.005) | (0.009) | (0.024) |
| Competition intensity | | | | | | |
| *HHI* | −0.0429 | −0.041 | 0.062** | 0.041** | −0.028 | −0.183** |
| | (0.030) | (0.070) | (0.029) | (0.016) | (0.030) | (0.081) |
| Observations | | | 26,809 | | | |

**Notes:** Standard errors in parentheses are clustered at the firm level; $^{*}p < 0.10$; $^{**}p < 0.05$; $^{***}p < 0.01$

**Table 2.** Determinants of TFP in the manufacturing sector

would see its TFP growth decrease. Additionally, credit is positively related to TFP levels for quantiles lower than 0.75, but negatively related to TFP growth for quantiles higher than 0.75, suggesting that access to credit prompts TFP in non-high productivity firms (TFP growth rates higher than 0.90). This result is interesting, as credit is related mainly to firms in the lower quantiles of productivity, although it is negatively related to highly productive firms (firms in higher quantiles of productivity). This result may be explained because firms with higher levels of productivity and TFP growth rates do not need credit to boost their productivity.

Finally, on average, a positive competition intensity on TFP levels for the whole manufacturing sector is found; nevertheless, this effect is significant only for the quantiles higher than the median. This result implies that greater competition will pressure firms into adopting new technologies and operating more efficiently (Harris and Moffat, 2015) and that greater market competition provides firms with an incentive to reduce internal inefficiencies, and therefore, increase their productivity (Nickell, 1996).

### *5.2 Results by technological intensity*

Tables 3–5 present the result**s** of TFP determinants for each industry according to technological intensity. Table 3 presents the result**s** for low-tech industries. For the internal firm characteristics, I find similar results to those obtained for the whole manufacturing industry. Firm age is positively related to TFP levels, but negatively to TFP growth in all the quantiles, suggesting that the LBD hypothesis is not supported. In terms of being a FF, the results in this industry show that there is a negative effect on TFP levels and TFP growth (on average). Also, in the TFP level distribution, FF is negatively related to TFP levels only in quantile 0.90 and with TFP growth in quantiles 0.50 and 0.75.

Regarding international trade activities in low-tech industries, the results show that being a two-way trader has a greater effect on productivity. Also, I do not find evidence that supports a learning effect from exporting and importing activities for quantiles higher than 0.50.

With respect to financial constraints, Table 3 shows that credit is positively related to TFP levels for quantiles lower than 0.75, but negatively related to TFP growth for higher quantiles. According to *dte*, it is positively related to TFP and its growth only in the lowest quantile. As for competition intensity, I show that *HHI* is negatively related to TFP levels for quantiles higher than 0.25, but positively related to TFP growth for quantiles 0.25 to 0.75.

Table 4 presents the result**s** for medium-low tech industries. According to internal firm characteristics, again I find that firm age is positively related to TFP levels, but negatively related to TFP growth in all the quantiles, suggesting that the LBD hypothesis is not supported. In terms of being a FF, the results show that there is a negative relationship for quantiles lower than 0.25. This evidence is different from the results of low-tech industries and is in concordance with the evidence of Barbera and Moores (2013). With regard to international trade activities, the results denote that being an exporter has no significant effect on productivity for firms in medium-low tech industries.

With respect to financial constraints, the results in the medium-low tech industries suggest that *dte* is negatively related to TFP levels in quantile 0.25 while the effect on TFP growth is not statistically significant in any quantile. In addition, I find that credit is positively related to TFP levels for quantiles lower than 0.75. This evidence shows that access to debt is associated with higher TFP. According to competition intensity, I show that less competition increases TFP growth, in particular for quantiles lower than the median. This result is somewhat unexpected; however, the sectors involved in medium-low

| | OLS-FE | Q10 | Q25 | Q50 | Q75 | Q90 |
|---|---|---|---|---|---|---|
| *Panel A: TFP level* | | | | | | |
| Internal firm characteristics | | | | | | |
| *age* | 0.037*** | 0.055*** | 0.039*** | 0.031*** | 0.020*** | 0.014*** |
| | (0.004) | (0.006) | (0.004) | (0.002) | (0.002) | (0.003) |
| *FF* | −0.007 | −0.004 | −0.005 | −0.002 | −0.006 | −0.016** |
| | (0.006) | (0.008) | (0.005) | (0.004) | (0.006) | (0.008) |
| International trade activities | | | | | | |
| *ExpOnly* | 0.016*** | 0.027*** | 0.005 | 0.004 | 0.010* | 0.012 |
| | (0.007) | (0.009) | (0.005) | (0.005) | (0.006) | (0.009) |
| *ImpOnly* | 0.009*** | 0.030*** | 0.012*** | 0.007 | −0.006 | 0.001 |
| | (0.003) | (0.006) | (0.004) | (0.004) | (0.004) | (0.006) |
| *TWTraders* | 0.017*** | 0.033*** | 0.015*** | 0.006 | −0.003 | −0.002 |
| | (0.005) | (0.006) | (0.004) | (0.005) | (0.006) | (0.009) |
| *FDI* | −0.001 | −0.007 | −0.000 | −0.002 | −0.004 | −0.013 |
| | (0.003) | (0.007) | (0.003) | (0.003) | (0.006) | (0.011) |
| Financial constraints | | | | | | |
| *dte* | 0.003** | 0.002 | −0.002 | −0.002 | −0.001 | −0.001 |
| | (0.002) | (0.003) | (0.002) | (0.001) | (0.001) | (0.001) |
| *credit* | 0.010*** | 0.018*** | 0.009*** | 0.008*** | 0.004** | 0.001 |
| | (0.002) | (0.003) | (0.002) | (0.002) | (0.002) | (0.003) |
| Competition intensity | | | | | | |
| *HHI* | −0.032*** | 0.017 | −0.043*** | −0.051*** | −0.036*** | −0.036*** |
| | (0.007) | (0.017) | (0.011) | (0.009) | (0.009) | (0.010) |
| Observations | | | 16,291 | | | |
| *Panel B: TFP growth* | | | | | | |
| Internal firm characteristics | | | | | | |
| *age* | −0.345*** | −0.208*** | −0.109*** | −0.118*** | −0.295*** | −0.949*** |
| | (0.021) | (0.038) | (0.015) | (0.009) | (0.018) | (0.086) |
| *FF* | −0.047 | −0.108 | −0.037 | −0.030* | −0.070** | 0.024 |
| | (0.060) | (0.069) | (0.025) | (0.016) | (0.029) | (0.095) |
| International trade activities | | | | | | |
| *ExpOnly* | 0.016 | 0.079 | 0.022 | 0.032* | −0.024 | −0.077 |
| | (0.040) | (0.077) | (0.027) | (0.018) | (0.032) | (0.099) |
| *ImpOnly* | −0.030 | 0.046 | 0.003 | −0.011 | −0.082*** | −0.281*** |
| | (0.022) | (0.053) | (0.021) | (0.013) | (0.024) | (0.071) |
| *TWTraders* | −0.008 | 0.068 | 0.021 | −0.004 | −0.082*** | −0.287*** |
| | (0.035) | (0.070) | (0.028) | (0.019) | (0.030) | (0.091) |
| *FDI* | 0.001 | −0.062 | −0.019 | −0.004 | 0.027 | 0.060 |
| | (0.032) | (0.069) | (0.029) | (0.021) | (0.030) | (0.085) |
| Financial constraints | | | | | | |
| *dte* | 0.013 | 0.025 | −0.007 | 0.002 | 0.002 | 0.044 |
| | (0.013) | (0.020) | (0.008) | (0.005) | (0.009) | (0.031) |
| *credit* | −0.018 | −0.035 | −0.008 | −0.008 | −0.010 | −0.074** |
| | (0.012) | (0.026) | (0.011) | (0.007) | (0.011) | (0.035) |
| Competition intensity | | | | | | |
| *HHI* | 0.009 | −0.064 | 0.101* | 0.087*** | 0.102* | −0.110 |
| | (0.059) | (0.127) | (0.056) | (0.034) | (0.06) | (0.188) |
| Observations | | | 13,221 | | | |

**Notes:** Standard errors in parentheses are clustered at the firm level; $^{*}p < 0.10$; $^{**}p < 0.05$; $^{***}p < 0.01$

**Table 3.** Determinants of TFP in low-tech intensity industries

| | OLS-FE | Q10 | Q25 | Q50 | Q75 | Q90 |
|---|---|---|---|---|---|---|
| *Panel A: TFP level* | | | | | | |
| Internal firm characteristics | | | | | | |
| *age* | 0.042*** | 0.057*** | 0.043*** | 0.038*** | 0.024*** | 0.022*** |
| | (0.004) | (0.008) | (0.004) | (0.003) | (0.003) | (0.003) |
| *FF* | −0.015** | −0.025** | −0.016** | −0.000 | −0.001 | 0.003 |
| | (0.007) | (0.011) | (0.006) | (0.006) | (0.008) | (0.010) |
| International trade activities | | | | | | |
| *ExpOnly* | 0.008 | 0.009 | 0.014** | 0.003 | 0.009 | 0.021 |
| | (0.006) | (0.009) | (0.006) | (0.007) | (0.010) | (0.015) |
| *ImpOnly* | 0.013*** | 0.032*** | 0.013** | 0.013** | −0.001 | 0.007 |
| | (0.005) | (0.010) | (0.006) | (0.005) | (0.005) | (0.006) |
| *TWTraders* | 0.021*** | 0.038*** | 0.016*** | 0.019*** | −0.002 | 0.003 |
| | (0.008) | (0.010) | (0.005) | (0.006) | (0.009) | (0.014) |
| *FDI* | 0.0002 | −0.009 | −0.002 | 0.006 | 0.015* | −0.020 |
| | (0.004) | (0.009) | (0.004) | (0.004) | (0.008) | (0.015) |
| Financial constraints | | | | | | |
| *dte* | 0.0001 | −0.003 | −0.005** | −0.002 | −0.000 | 0.001 |
| | (0.002) | (0.004) | (0.002) | (0.002) | (0.002) | (0.002) |
| *credit* | 0.007*** | 0.015*** | 0.008*** | 0.006** | 0.006** | 0.004 |
| | (0.002) | (0.004) | (0.003) | (0.002) | (0.002) | (0.003) |
| Competition intensity | | | | | | |
| *HHI* | −0.003 | 0.037** | 0.010 | −0.020** | −0.018** | −0.015 |
| | (0.007) | (0.018) | (0.011) | (0.008) | (0.009) | (0.011) |
| Observations | | | 9,846 | | | |
| *Panel B: TFP growth* | | | | | | |
| Internal firm characteristics | | | | | | |
| *age* | −0.360*** | −0.206*** | −0.141*** | −0.130*** | −0.355*** | −0.690*** |
| | (0.031) | (0.055) | (0.025) | (0.013) | (0.031) | (0.076) |
| *FF* | 0.017 | 0.010 | 0.035 | 0.009 | −0.035 | −0.038 |
| | (0.057) | (0.100) | (0.050) | (0.030) | (0.050) | (0.105) |
| International trade activities | | | | | | |
| *ExpOnly* | −0.014 | 0.148 | −0.053 | −0.068* | −0.086 | 0.078 |
| | (0.057) | (0.035) | (0.066) | (0.135) | (0.035) | (0.066) |
| *ImpOnly* | −0.016 | 0.094 | 0.024 | −0.010 | −0.119*** | −0.094 |
| | (0.031) | (0.085) | (0.035) | (0.023) | (0.042) | (0.084) |
| *TWTraders* | −0.065 | 0.110 | 0.034 | −0.044 | −0.135** | −0.193* |
| | (0.045) | (0.122) | (0.049) | (0.036) | (0.053) | (0.114) |
| *FDI* | −0.023 | 0.077 | 0.001 | 0.016 | −0.041 | −0.057 |
| | (0.037) | (0.070) | (0.038) | (0.038) | (0.052) | (0.110) |
| Financial constraints | | | | | | |
| *dte* | 0.001 | −0.042 | −0.019 | −0.000 | 0.000 | 0.046 |
| | (0.019) | (0.038) | (0.013) | (0.008) | (0.015) | (0.038) |
| *credit* | 0.002 | 0.021 | 0.012 | 0.012 | −0.010 | −0.016 |
| | (0.017) | (0.037) | (0.019) | (0.011) | (0.018) | (0.041) |
| Competition intensity | | | | | | |
| *HHI* | 0.083 | 0.376** | 0.218*** | 0.174*** | −0.025 | −0.184 |
| | (0.067) | (0.155) | (0.065) | (0.041) | (0.078) | (0.148) |
| Observations | | | 7,942 | | | |

**Notes:** Standard errors in parentheses are clustered at the firm level; *$p < 0.10$; **$p < 0.05$; ***$p < 0.01$

**Table 4.**
Determinants of TFP in medium-low tech intensity industries

| | OLS-FE | Q10 | Q25 | Q50 | Q75 | Q90 |
|---|---|---|---|---|---|---|
| *Panel A: TFP level* | | | | | | |
| Internal firm characteristics | | | | | | |
| *age* | 0.038*** | 0.059*** | 0.041*** | 0.037*** | 0.022*** | 0.016*** |
| | (0.004) | (0.009) | (0.004) | (0.004) | (0.004) | (0.005) |
| *FF* | −0.009 | −0.017 | −0.003 | 0.002 | 0.003 | −0.001 |
| | (0.009) | (0.011) | (0.006) | (0.009) | (0.010) | (0.013) |
| International trade activities | | | | | | |
| *ExpOnly* | 0.024* | 0.024** | 0.014* | 0.006 | 0.002 | 0.018 |
| | (0.007) | (0.009) | (0.009) | (0.013) | (0.009) | (0.009) |
| *ImpOnly* | 0.001 | 0.019** | 0.008 | −0.008 | −0.015** | −0.016** |
| | (0.006) | (0.008) | (0.005) | (0.006) | (0.006) | (0.007) |
| *TWTraders* | 0.009 | 0.023** | 0.013** | −0.012* | −0.010 | −0.004 |
| | (0.007) | (0.009) | (0.006) | (0.007) | (0.009) | (0.012) |
| *FDI* | 0.0001 | −0.016* | −0.004 | 0.005 | 0.009 | −0.003 |
| | (0.006) | (0.009) | (0.004) | (0.006) | (0.009) | (0.018) |
| Financial constraints | | | | | | |
| *dte* | 0.001 | −0.002 | −0.002 | −0.002 | −0.002 | 0.001 |
| | (0.002) | (0.005) | (0.002) | (0.002) | (0.002) | (0.002) |
| *credit* | 0.001 | 0.010** | 0.002 | 0.003 | −0.003 | −0.001 |
| | (0.002) | (0.004) | (0.003) | (0.003) | (0.003) | (0.004) |
| Competition intensity | | | | | | |
| *HHI* | −0.008 | 0.010 | 0.004 | −0.011** | −0.016** | −0.006 |
| | (0.005) | (0.010) | (0.006) | (0.006) | (0.007) | (0.007) |
| Observations | | | | 6,965 | | |
| *Panel B: TFP growth* | | | | | | |
| Internal firm characteristics | | | | | | |
| *age* | −0.324*** | −0.144* | −0.123*** | −0.113*** | −0.303*** | −0.858*** |
| | (0.035) | (0.075) | (0.0231) | (0.01) | (0.035) | (0.145) |
| *FF* | 0.002 | 0.067 | −0.034 | −0.028 | 0.011 | 0.063 |
| | (0.067) | (0.127) | (0.048) | (0.034) | (0.058) | (0.177) |
| International trade activities | | | | | | |
| *ExpOnly* | 0.105* | 0.281** | 0.108** | 0.085** | 0.068 | −0.014 |
| | (0.052) | (0.036) | (0.063) | (0.190) | (0.036) | (0.063) |
| *ImpOnly* | −0.117*** | −0.154 | −0.042 | −0.053** | −0.098*** | −0.243** |
| | (0.044) | (0.095) | (0.036) | (0.026) | (0.038) | (0.108) |
| *TWTraders* | −0.070 | −0.043 | −0.027 | −0.040 | −0.102** | −0.135 |
| | (0.058) | (0.128) | (0.048) | (0.036) | (0.048) | (0.146) |
| *FDI* | −0.111 | −0.129 | −0.048 | −0.005 | −0.080* | −0.167 |
| | (0.060) | (0.112) | (0.048) | (0.039) | (0.048) | (0.155) |
| Financial constraints | | | | | | |
| *dte* | 0.020 | 0.065* | 0.006 | 0.013 | 0.010 | −0.020 |
| | (0.020) | (0.039) | (0.015) | (0.009) | (0.016) | (0.051) |
| *credit* | −0.039** | −0.084* | −0.047*** | −0.028** | −0.028 | −0.083 |
| | (0.019) | (0.046) | (0.018) | (0.011) | (0.020) | (0.057) |
| Competition intensity | | | | | | |
| *HHI* | −0.098** | −0.159 | −0.025 | −0.000 | −0.081* | −0.155 |
| | (0.044) | (0.114) | (0.040) | (0.023) | (0.044) | (0.125) |
| Observations | | | | 5,646 | | |

**Notes:** Standard errors in parentheses are clustered at the firm level; $^{*}p < 0.10$; $^{**}p < 0.05$; $^{***}p < 0.01$

**Table 5.** Determinants of TFP in medium-high and high-tech intensity industries

tech industries are highly concentrated. Schumpeter (1943) argues that the level of competition may be inversely related to productivity if monopoly rents are required for management to invest in R&D, which, in turn, leads to innovation and improvements in TFP.

Finally, Table 5 presents the results of TFP determinants for the medium-high and high-tech industries. According to the internal firm characteristics, the results show that firm age is positively related to TFP levels across the distribution but negatively related in all the TFP growth quantiles, suggesting no LBD effects. Regarding international trade activities, the results suggest that *ImpOnly* and *Trader* are positively associated with TFP levels for quantiles lower than the median. Something interesting is that *ExpOnly* is positively related to productivity growth for quantiles lower than the median, suggesting learning-by-exporting effects on less productive firms in more innovative industries.

With regard to financial constraints, the results in the medium-high and high-tech intensity industries suggest that credit is positively related to TFP levels at quantile 0.10 but negatively associated with TFP growth at quantiles lower than the median. This evidence suggests that access to credit in high-tech industries is not the main source of TFP growth and it needs other sources to be affected. In terms of competition intensity, I show that more competition not only increases TFP levels, in quantiles 0.50 and 0.75 but also increases productivity growth in firms in quantile 0.75.

Overall, the analysis of industry differences in terms of technological intensity shows that there is a consensus on the relationship between age and TFP levels and TFP growth. In addition, I find evidence that supports that being a two-way trader is positively associated with TFP levels but not with TFP growth. Moreover, for all industries analyzed, engaging in both exporting and importing activities has a greater effect than engaging in only one of these activities. In addition, firm**s** in low-tech industries benefit more from international trade activities than firms in more technologically intense industries. Furthermore, financial constraints differently affect firms in the three industries analyzed. More specifically, less productive firms are positively affected by debt in low-tech industries, but more productive firms are more positively affected in medium-low tech industries. Nevertheless, in medium-high and high-tech industries, the evidence is not clear. Finally, competition seems to be less important in all three industries; however, the evidence suggests that more competition increases productivity in lower quantiles.

## 6. Final remarks

I find a consensus that firm age is positively related to TFP levels but negatively related to TFP growth. This suggests that the TFP impact of the obsolescence of older vintages of technology embodied in the capital of older plants outweighs any LBD effect (Harris and Moffat, 2015) in Ecuadorian manufacturing firms. Moreover, this result holds even when distinguishing between industries according to their technological intensity. Another consensus in two of the industries analyzed and the whole manufacturing sector is that being an exporter and an importer at the same time (*TWTraders*) is associated with higher TFP levels but not with TFP growth. This effect is higher than when being only an exporter or importer. However, firms in low-tech industries benefit more from international trade activities than firms in more technologically intense industries.

In addition, there is no consensus on the relationship between financial constraints and TFP. Credit is positively related to TFP levels in lower quantiles in most industries. This suggests that TFP association with credit is larger in less productive firms, as expected. In terms of competition intensity, I find that HHI is negatively associated with TFP levels.

However, the evidence suggests that more competition increases productivity in lower quantiles.

Therefore, according to my results, several public incentives to promote Ecuadorian firms' productivity should be implemented as follows:

- Internal firm characteristics: The government should focus on stimulating the creation of new manufacturing firms. To this end, the red tape procedure should be diminished and the time required to start a business needs to be as short as possible. Also, and in concordance with Goncalves and Martins (2016), bankruptcy legislation and judicial efficiency can encourage experimentation with innovation and new technologies. In this sense, bankruptcy should not be penalized too severely.
- International trade activities: Our results suggest that public trade policies should focus on boosting entry into international markets, especially for high-productivity manufacturing firms. This could be done by reducing customs fees, implementing a tax devolution reform and giving subsidies. However, these actions need to be accompanied by the coordination and integration of internationalization and innovation policies under a single authority to boost R&D incentives (Altomonte *et al.*, 2013).
- Financial constraints: Given that productivity increases with the *dte* ratio and financial credit, in particular in lower quantiles, policies that generate credit access are necessary, especially for micro and small firms, which are firms with lower productivity levels and growth rates. Also, this could be in line with the idea of generating better access to the stock market as an alternative source of financing firms.
- Competition intensity: A more competitive environment increases TFP. In this line, policies to avoid possible collusion practices are needed, but they are also needed to increase the number of firms in each market. This should be in line with the idea of reducing the time required to start a business and tax cuts for new firms to improve their survival rates.

Although TFP determinants have been studied in depth, there is still room for future research. Specifically, in LAC, the study of productivity and the analysis of its determinants is relatively scarce, among other things, because of a lack of data. For example, having access to better data, especially information on quantities produced and not only on sales but also would allow us to analyze sunk costs, production processes and value added, etc. Moreover, having more detailed information on the international trade of firms, such as which countries the firm exports to or imports from and the types of products involved, could help raise questions about how the quality of products or inputs are related to TFP. Finally, the information available in the data set used limits the TFP determinants that can be included in my analysis. For example, the analysis of the role played by R&D and innovation would also be of great interest.

## Notes

1. For an extensive review of the literature on competition and productivity, see Holmes and Schmitz Jr (2010).
2. Many studies have shown that idiosyncratic shocks and uncertainty in technology affect plants differently, even within the same industry (see, for example, Hopenhayn, 1992; Ericson and Pakes, 1995; Olley and Pakes, 1996).

3. Our data set provides information only on sales and not quantities, so I estimate a revenue function. This implies that the estimated productivity is a revenue TFP and differences in prices and productivity effects cannot be detected (see, for example, De Loecker *et al.*, 2016; Caselli, 2018).
4. Year dummies are included in the model to capture macroeconomic shocks and changes in the institutional environment over time. City dummies are included to correct for the exogenous disparities in the productivity differences across cities. Industry dummies are included to account for production differences across the 23 industries in the data.
5. Koenker and Bassett (1978) introduce the conditional quantile regressions; nevertheless, I apply the UQR approach of Firpo *et al.* (2009) because I am interested in the quantiles ($q_\tau$) of the marginal distribution of the outcome variable *TFP*.
6. For details about estimating the first and second step, see Firpo *et al.* (2009) and Borgen (2016). I omitted this part in the document to save space.
7. By "formal firm" I mean a firm that is legally constituted in the SCVS and has a unique taxpayer record as a company.
8. Camino-Mogro and Bermudez-Barrezueta (2021) used a similar data set and empirical strategy for another Ecuadorian industry and with different contextual variables.
9. I group the medium-high tech industry and high-tech industry into one because there are few observations in this latter industry group. Also, the high-tech industry in the OECD is different from that in Ecuador, as some sectors that are considered high-tech in Ecuador are medium-high tech for the OECD. Because of the reviewer for this point.
10. By "financial credit" I am referring to loans given by any financial institution in the Ecuadorian economy. I also refer to short-run or long-run credit.
11. In all the estimations of the production function, I use the command *prodest* proposed by Rovigatti and Mollisi (2018).

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## Further reading

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## Appendix

| Industry | Subsectors | ISIC codes |
|---|---|---|
| Low-tech industry | Food, beverages and tobacco | 10 + 11 + 12 |
| | Textile and clothing | 13 + 14 + 15 |
| | Wood products | 16 |
| | Paper manufacturing | 17 |
| | Editing and printing | 18 |
| | Furniture and other manufacturing industries | 31 + 32 |
| Medium-low tech industry | Coke manufacturing and oil refining | 19 |
| | Manufacture of rubber and plastic products | 22 |
| | Manufacture of other non-metallic mineral products | 23 |
| | Mineral-based products | 24 |
| | Metal products | 25 |
| | Repair and installation of machinery and equipment | 33 |
| Medium-high and high-tech industry | Chemical industry | 20 |
| | Machinery and electrical equipment | 27 |
| | Agricultural and industrial machines | 28 |
| | Motor vehicles | 29 |
| | Other transport material | 30 |
| | Pharmaceutical products | 21 |
| | Manufacture of computer, electronic and optical products | 26 |

**Sources:** Eurostat indicators on high-tech industry and Knowledge; SCVS

**Table A1.** Correspondence between ISIC codes and industries according to technological intensity

| Variables | Definition | Obs. | Mean | SD |
|---|---|---|---|---|
| $Y$ | Gross revenues from sales | 36,061 | 6,831,927 | 3.33e + 07 |
| $L$ | Number of legally registered employees | 36,061 | 64 | 397 |
| $K$ | Net tangible assets | 36,061 | 2,052,403 | 1.26e + 07 |
| $M$ | Total intermediate inputs | 36,061 | 3,358,302 | 1.93e + 07 |
| $y$ | ln (total revenues from sales). This variable is deflated using the industry-specific price index obtained from the Ecuadorian National Institute of Statistics | 36,061 | 13.454 | 2.111 |
| $l$ | ln (number of legally registered employees) | 36,061 | 2.695 | 1.542 |
| $k$ | ln (net tangible assets). It is the sum of the real dollar value of buildings, machinery and vehicles, assuming a depreciation of 5%, 10% and 20%. I measure the capital stock with the gross investment in equipment in year $t$ ($I_{it}$), net fixed assets in real value (physical capital in year $t-1$) ($k_{it-1}$), a depreciation rate ($d_{it}$) and the price index for equipment at the industry level ($P_t$) obtained from the Ecuadorian National Institute of Statistics | 36,061 | 11.474 | 2.815 |
| $m$ | ln (intermediate inputs). This variable is deflated using the industry-specific price index obtained from the Ecuadorian National Institute of Statistics | 36,061 | 11.591 | 2.978 |
| *age* | ln (firm age). Measured as the difference between the current year and the year the firm registered to start a business in the Ecuadorian mercantile register | 36,061 | 2.295 | 1.076 |
| *FF* | Dummy variable equal to one if the firm is a FF at time $t$, zero otherwise | 35,308 | 0.879 | 0.325 |
| *ExpOnly* | Dummy variable equal to one if the firm exports but does not import at time $t$, zero otherwise | 36,061 | 0.060 | 0.237 |
| *ImpOnly* | Dummy variable equal to one if the firm imports but does not export at time $t$, zero otherwise | 36,061 | 0.149 | 0.356 |
| *Trader* | Dummy variable equal to one if the firm exports and imports at time $t$, zero otherwise | 36,061 | 0.085 | 0.279 |
| *FDI* | Dummy variable equal to one if the firm receives FDI at time $t$, zero otherwise | 36,061 | 0.028 | 0.166 |
| *dte* | ln ([Total liabilities/Equity] + 1) | 33,757 | 1.306 | 1.034 |
| *credit* | Dummy variable equal to one if the firm receives a credit from any financial institution at time $t$, zero otherwise | 36,061 | 0.361 | 0.480 |
| *HHI* | ln (HHI of industrial concentration [by two-digit ISIC]) | 36,061 | −2.702 | 0.736 |

**Source:** Authors, based on data provided by SCVS

**Table A2.** Definition and descriptive statistics for variables used in TFP estimation and its determinants

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