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Disentangling trade reform impacts on firm market and production decisions ☆

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ABSTRACT

This paper disentangles the impacts of trade liberalization on firm market and production decisions. Using firm-product data for Ecuador, we exploit exogenous tariff changes at entry to the World Trade Organization and find positive effects of trade liberalization on revenue total factor productivity (TFP-R). Input-trade liberalization improves firm efficiency, measured by quantity total factor productivity (TFP-Q) and leads firms to raise their markups and to introduce new products following an increase in imported input quality. Output-trade liberalization also improves firm efficiency and raises marginal costs as firms increase input quality and improve the quality of their core products. Firms' markups and product scope decrease. Chinese imports also contributed positively to productivity while the exchange rate's volatility prior to dollarization had reverse effects. We find positive welfare effects as consumers were offered better and cheaper products. Trade liberalization also benefited the more productive firms introduce new or better products while less productive firms were more likely to exit.

1. Introduction

A substantive literature on the impacts of trade liberalization has documented positive effects on firm productivity (e.g., Pavcnik, 2002, Schor, 2004; Fernandes, 2007; Amiti and Konings, 2007; Topalova and Khandelwal, 2011). The majority of these studies did so by measuring revenue total factor productivity (TFP-R). This measure, however, says little about how

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trade liberalization changed firms' market and production decisions. While higher firm TFP-R after trade liberalization may result from production efficiency improvements, variations in markups can also be the source of higher TFP-R since markups are also affected by trade liberalization (Lu and Yu, 2015; De Loecker et al., 2016; Brandt et al., 2017; Fan et al., 2018). If firms invest in their products to fight foreign competitors and sell products of higher quality at higher cost and prices, then TFP-R would also increase (Fernandes and Paunov, 2013; Amiti and Khandelwal, 2013; Iacovone, 2012). Knowing the precise impacts of trade liberalization on firms' production processes is critical to understand better the reform's welfare implications. Lack of detailed data on firms' market and production decisions, however, has been an obstacle to this type of assessment. Another challenge in assessing trade liberalization's effects is distinguishing from other contemporaneous reforms. Not only are trade liberalization reforms often part of a wider liberalization program of the economy, but they also are often implemented in response to difficult economic conditions or crises.

In this paper, we investigate how output- and input-trade liberalization with Ecuador's entry to the World Trade Organization (WTO) impacted Ecuadorian firms' market and production decisions. We do so by studying the impacts of trade liberalization on a comprehensive set of variables that describe firms' market decisions and production characteristics. This includes revenue and quantity total factor productivity (TFP-R and TFP-Q), markups, marginal cost (MC) and prices as well as product scope and quality. We exploit the exogenous change in effectively applied tariffs across products and over time in highly demanding within-firm or within-firm-product estimations that also include firm-size trends, industry trends and, in firm-product level estimations, firm-product size trends. Estimations control for the major structural changes that took place in the country during the period of analysis 1997–2007 – including Ecuador's crisis of 1999, the shock of China's entry to global trade, labor and financial market reforms and changes in firms' market conditions.[1]

Trade liberalization affects firms' performance in two ways: increased foreign competition in the domestic market – the pro-competitive effect – and access to imported inputs – the sourcing effect. Firms may respond to those changes to their market environment in different ways. To face foreign competition from output tariff cuts, firms may adjust their prices by reducing their MC and markups to increase their price competitiveness (Levinsohn, 1993; Harrison, 1994; De Loecker et al., 2016; Brandt et al., 2017). Firms may, however, also react to increased competition from foreign firms by investing in the quality of their production to improve non-price competitiveness, thereby increasing their MC and selling better products at higher prices (Fernandes and Paunov, 2013; Amiti and Khandelwal, 2013; Iacovone, 2012). Input tariff cuts in turn may allow firms to access cheaper intermediate goods from abroad and reduce MC and output prices (De Loecker et al., 2016). The magnitude of output price changes depends on the degree of pass-through of cost reductions to consumers (De Loecker et al., 2016; Brandt et al., 2017). Alternatively, if trade liberalization offers firms access to more technologically advanced or high-quality imported inputs, they may take the opportunity of tariffs cut to produce higher quality products, which may in turn be reflected in higher output prices (Bas and Strauss-Kahn, 2015; Fan et al., 2015; Bas and Paunov, 2019). Bas and Paunov (forthcoming) identify causal effects of input-trade liberalization in Ecuador on firm access to foreign high-quality inputs and its impacts on firms' skill intensity to upgrade output quality.

Our work offers the following main contributions to the literature on the impacts of trade liberalization on firm performance. We are first to look at the effects of both output and input tariff cuts on TFP-Q relative to TFP-R and analyze within our empirical framework the effects on the core firm production measures i.e. firm-product-level output prices, markups, MC, output product and input quality and firm product scope in addition to the productivity measures. We build on the seminal work of Brandt et al. (2017) and De Loecker et al. (2016) on the impacts of trade liberalization beyond TFP-R. Brandt et al. (2017) focus on markup and productivity effects (measured using TFP-R but with 4-digit price deflators) for China, while De Loecker et al. (2016) focus on firm-product level prices, costs and markups for India. Our findings present new evidence on positive effects of output-and input-trade liberalization on firm efficiency gains (TFP-Q) that were unexplored. We confirm previous findings that show firms reduce their markups to face foreign competition. However, we also find that after output tariff cuts firms invest in high-quality (cost) inputs and outputs, and consequently increase MC and charge higher prices. Differently from the literature, we find that input-tariff cuts not only have positive effects on the efficiency of the firms we analyze, but also allow them to increase their markups since firms improve input quality and product scope. Our findings consequently show differences in firms' market and production decisions in response to trade reforms, pointing to the role played by country conditions. Our empirical analysis explicitly disentangles the impacts of trade liberalization from other reforms and shocks firms were exposed to. As is the case for other countries, trade liberalization reforms were undertaken in a context of other liberalization reforms and coincide with important shocks – in Ecuador's case a major crisis in 1999 – as well as external developments (the entry of China to the global market). We find that trade liberalization plays an important role.

Our analysis builds on a unique dataset that is collected by the Ecuadorian Institute of Statistics (INEC) for the period 1997–2007 that it is complemented by two other datasets, which have information on plants' intermediate inputs and on plants' output products, respectively. These data allow assessing in depth changes in firms' market and production decisions. This includes assessing impacts on quantity total factor productivity (TFP-Q), markups and MC as well as output and input quality. We obtain those measures following the latest procedures suitable to this type of data as proposed in De Loecker et al. (2016), Garcia-Marin and Voigtländer (2019) and Khandelwal et al. (2013).

[1] The authors would like to thank an anonymous referee for suggesting adding the wider economic context Ecuadorian firms faced to their empirical specification.

We first explore trade liberalization's impacts on productivity. We find that input- and output-tariff cuts positively affect firms' TFP-R, as is consistent with the existing literature. The 8-percentage point reduction of output tariffs in Ecuador from 1997 to 2007 is associated with an increase in TFP-R by almost 17%. The 7-percentage-point reduction of input tariffs in Ecuador from 1997 to 2007 is associated with an increase in firm TFP-R of 9.7%. We also find positive but lower effects of output- and input-trade liberalization related to production efficiency. The 8-percentage point reduction of output tariffs is associated with an increase in firm TFP-Q of 10.5%. Input-trade liberalization also has positive effects on TFP-Q: the 7-percentage point reduction of input tariffs boost production efficiency by 6.1%.

Regarding the possible impacts of Ecuador's economic context and reforms, we find the real exchange rate volatility that skyrocketed during Ecuador's crisis had a negative and significant effect on firms' productivity (as measured by TFP-R and TFP-Q) prior to the country's adoption of the dollar as national currency. We also find that increased imports from China had positive significant effects on both productivity measures, with higher effects on TFP-Q than TFP-R. As was the case across the world, Chinese imports also provided access to lower-cost products on output markets. Coherently with this hypothesis, we find that Chinese import penetration negatively affected prices. This explains the lower effects of foreign competition from China on TFP-R relative to TFP-Q. Ecuador's financial liberalization reform is associated with a positive effect only on TFP-R and higher markups, possibly reflecting privileged access of firms with higher TFP-R and markups to financial resources that become available with liberalization.

We then explore whether the higher effects of trade liberalization on TFP-R relative to TFP-Q are driven by changes in markups. We find that the 8-percentage point reduction in output tariffs reduces firms' product markups by almost 13.6%. The magnitude of this impact is similar to the effects of the large output tariff cuts India experienced from 1987 to 1997 and which, based on the estimates by De Loecker et al. (2016), were of 9 to 18%. We find that input-trade liberalization increases firms' markups. The positive impact on markups indicates that firms are in a position to increase their profit margins. This evidence is in line with the findings of Brandt et al. (2017) on China's and De Loecker et al. (2016) on India's input tariff reductions.

Next, we investigate the reforms' impact on the evolution of MC and output prices. We find that the 8-percentage-point reduction of output-tariff cuts increases MC by 18% and output prices by 4.8%. Output price increased in spite of the reduction in markups as a result of MC increases. This explains why TFP-R increases more than TFP-Q as a result of the trade reforms. This differs from De Loecker et al. (2016), who identify price decreases from output tariff cuts of 18% but no effects on MC in India. The different response may relate to the different development level of Ecuadorian firms compared to the leading Indian firms tracked by De Loecker et al. (2016). Our findings suggest that Ecuadorian firms react to foreign competition by improving non-price competitiveness and investing in costly production process improvements and high-quality inputs that raise MC.

We then explore how firms react to foreign competition with regards to their product scope, product additions and drops as well as product quality, investigating also the role of their input changes. Our findings show that firms react to foreign competition by re-organizing their production process: Firms reduce their product scope but increasing the firm-product output quality of surviving products and upgrade imported and domestic input quality. By contrast, input-trade liberalization allowed firms to expand product scope, introducing new products in the market, increasing imported input quality. These findings suggest that Ecuadorian firms react to reforms by upgrading their production, manufacturing new or better products.

An important question in evaluating the welfare implications from trade liberalization regards the distributional impacts across firms and between firms and consumers. Our results show that consumers benefitted from trade liberalization since they are offered better products at lower quality-adjusted prices while firm' product level markups decreased since the pro-competitive effect of output tariff cuts on markups is greater than the increased in markups due to input tariff reductions. Output-trade liberalization led only the initially most productive firms to concentrate their production on core products and improve their product's quality. Less productive firms were more likely to exit over the period.

The remainder of the paper is organized as follows: Section 2 describes the theoretical motivation for our empirical analysis. Section 3 provides a review of the literature and Section 4 describes Ecuador's economic conditions from 1996 to 2006. Sections and 6 describe the empirical framework we adopt, the data we use and how we obtain the variables for our analysis. Section 7 describes our results. The last section concludes.

2. Theoretical motivation

Unilateral trade liberalization affects firm productivity through two main channels highlighted in the literature. Output tariff cuts increase foreign competition in the domestic market. In order to sell in a more competitive market, firms have incentives to improve productivity (Helpman and Krugman, 1985; Aghion et al., 2005; Bernard et al., 2011 and Mayer et al., 2014). Input tariff reductions allow firms to access inputs at more affordable prices. Firms can benefit from input tariff cuts to access more imported input varieties at lower prices (Kasahara and Lapham, 2013). Firms may also access higher-quality inputs that facilitate firms' upgrading of their production processes. Consequently, firms may become more efficient in the production process as they increase units of output produced with the same units of inputs that are now of higher quality/technology (Ethier, 1982; Markusen, 1989). Firms may also be in position to introduce new higher-quality products as they have more suitable inputs (Grossman and Helpman, 1991).

Most of the works in the micro-econometric literature on trade liberalization and firm performance rely on TFP-R, a measure that is obtained as the residual of a production function estimation using firm revenues deflated with industry price indexes as proxy of total output (see Section 3 for references). TFP-R is the difference between the logarithm of firms' revenues and the estimated contribution of the logarithm of firms' labor demand, materials and capital. Following the same notation as De Loecker et al. (2016) and Garcia-Marin and Voigtländer (2019), where the lower-case letters represent the logarithms of variables, TFP-R is the residual of a log-linear production function:

$$r_{it} = \boldsymbol{x'}_{it}\alpha + (\omega_{it} + p_{it}) \tag{1}$$

where r_{it} is the revenues of firm i in year t, x'_{it} is the vector of inputs used by the firm, α is the vector of estimated output elasticities, ω_{it} is physical efficiency and p_{it} is the logarithm of firm output prices. The last term in brackets in Eq. (1) is the TFP-R composed by the sum of both the logarithm of physical efficiency (TFP-Q) and output prices. The first term, physical efficiency, is the ability of firms to produce more units of output with the same amount of inputs. Under imperfect competition, output prices can be decomposed in two sub-components, the logarithm of MC (mc_{it}) and markups (μ_{it}) as:

$$p_{it} = mc_{it} + \mu_{it} \tag{2}$$

It is straightforward to notice that TFP-R reflects both changes in physical efficiency and in output prices, and the latter reflects changes in MC and market power. Therefore, changes in TFP-R might result from changes in MC and/or markups, unrelated to changes in firms' production efficiency.

Conversely, TFP-Q reflects actual physical efficiency, ω_{it}, since it is computed as a residual of a production function using firm sales deflated with firm prices (or physical quantities, q_{it}) :[2]

$$q_{it} = x'_{it}\alpha + \omega_{it} \tag{3}$$

Both firm efficiency and output prices vary with tariff on final products p, τ_p , (output tariffs) and tariff in inputs k,τ_k,(input tariffs): $\omega_{it}(\tau_p, \tau_k)$ and $p_{it}(\tau_p, \tau_k) = mc_{it}(\tau_p, \tau_k) + \mu_{it}(\tau_p, \tau_k)$. Output tariff cuts, through foreign competition, create incentives for firms to become more efficient. Improvements of physical efficiency, changes in ω_{it} , represent changes in technical progress and know-how at the firm level. These can be achieved by upgrading production processes and output through investments in high-quality inputs and on product innovation. The latter is defined for the purposes of collecting statistics on firm innovation as the introduction of new products and products of higher output quality (OECD, 2018). The theoretical Schumpeterian growth model developed in Aghion et al. (2005) shows that firms respond to competition by investing in new technologies and production processes. The multiproduct firm models of trade of Bernard et al. (2011) and Mayer et al. (2014) show that competition from abroad increases firm efficiency by forcing firms to concentrate on their "best" products.[3] Input tariff reductions allow firms to improve firm efficiency in the production process by increasing units of output produced with the same units of inputs, some of which are now of higher imported quality. This feature is present in the early trade models of Ethier (1982), Markusen (1989), and Grossman and Helpman (1991).

The net effect of output and input tariff cuts on firms' price decisions depends on how those channels – foreign competition and access to imported inputs – affect the components of output-prices in Eq. (2). Under imperfect competition, firms' MC are composed of the unit cost of production factors (costs of materials, labor and capital) over the efficiency of the firm (ω_{it}). A log-linear MC function is given by: $mc_{it}(\tau_p, \tau_k) = uc(\tau_p, \tau_k) - \omega_{it}(\tau_p, \tau_k)$. Output tariff reductions induce firms to adjust and reduce their markups to stay in the market as in the models of endogenous markups and heterogeneous firms (Melitz and Ottaviano, 2008). Micro-level evidence on this mechanism is showed by De Loecker et al. (2016) for India, Brandt et al. (2017) and Lu and Yu (2015) for China. At the same time, output tariff cuts may increase firms' production costs. Firms invest in high-cost technology, high-quality inputs and upgrade output quality to escape foreign competition (as in the model of Aghion et al., 2005, discussed previously). Higher input quality and upgrading technology process increases unit costs (as in the models of Verhoogen, 2008 and Kugler and Verhoogen, 2012). These costly investments can afterwards lead to increases in firm efficiency that in turn reduces MC. The net effect of output tariff on prices depend on which of those effects if stronger.

Input tariffs have also an ambiguous effect on output prices. On the one hand, firms can benefit from input tariff cuts to access cheaper inputs from abroad reducing unit cost and MC (De Loecker et al. 2016). The magnitude of output prices' changes depends on the degree of pass-through of cost reductions to consumers. De Loecker et al. (2016) and Fan et al. (2018) show that firms increase markups with input tariff cuts and do not pass-through all the gains from reducing MC to consumers. On the other hand, firms might instead invest in high-quality inputs or high-cost foreign technology at a more affordable price relative to prior the input tariff cut, as in the model presented by Fan et al. (2015). Then, firms benefit from imported input-quality upgrading to upgrade their final goods (Bas and Strauss-Kahn, 2015, and Fan et al., 2015).

The main contribution of our work to the literature is to disentangle within the same empirical framework the effects of output and input tariff reductions on TFP-R and its components TFP-Q, prices, MC and markups. We also provide empirical insights on the different mechanisms described in this section by looking at firms' production upgrading (product scope,

[2] Using firm sales deflated by a firm-level price index allows aggregating across products for multiproduct firms, which in our case represent more than half of the sample.

[3] The trade model of Helpman and Krugman (1985) predicts that foreign competition leads firms to increase their efficiency by reducing their average cost curves.

adding new products, output and input quality). As described in Section 5, we compute TFP-R and TFP-Q as a residual of a production function relying on Eqs. (1) and (3), respectively. Also, we proxy firm-product prices with unit values using the information on values and quantities provided in our data (described in Section 5), estimate the firm-product level markups and then rely on Eq. (2) to compute firm-product level MC.

3. Literature review

Our paper adds new findings to the literature on trade liberalization's impacts on productivity. Differently from ours, most studies investigating the effects of trade liberalization on firm productivity measure TFP-R (e.g. Pavcnik, 2002; Amiti and Konings, 2007; Topalova and Khandelwal, 2011). These studies unanimously conclude that output and input trade liberalization positively affect firm productivity (TFP-R), which they attribute to efficiency gains while acknowledging that some of the effects may be related to changes in firm markups that cannot be isolated in TFP-R measures. This includes notably several studies that have investigated the effects of trade liberalization on firm productivity in Latin American countries (Fernandes, 2007, for Colombia; Luong, 2011, for Mexico; Schor, 2004, and Costa et al., 2018 for Brazil; Pavcnik, 2002, for Chile). Only De Loecker (2011) investigates the impacts of trade liberalization on TFP-Q. The study uses information on prices for Belgian firms and shows that the removal of import quotas in the Belgian textile market leads to lower efficiency gains as measured by TFP-Q as compared to those estimated by TFP-R.[4] Verhoogen (2020) offers an extensive literature review of the evidence of trade liberalization effects on firm productivity.

Our work also contributes to the literature on the effects of input-trade liberalization on firms' production mechanisms, notably production costs, (exported) product output scope, prices and quality. Bas and Strauss-Kahn (2015) and Fan et al. (2015) show that input tariff cuts allowed Chinese firms to access high-price imported inputs and to sell high-price exported products. This evidence is in line with the findings of Kugler and Verhoogen (2009, 2012), Hallak and Sivadasan (2013), Bastos and Silva (2010) and Bastos et al. (2018) that have also shown that Colombian, Indian and Portuguese firms relying on high-price inputs also sell final goods at higher prices. The empirical works of Fernandes and Paunov (2013), Amiti and Khandelwal (2013), Iacovone (2012) provide micro-econometric evidence of the effect of foreign competition on firms' technology/quality upgrading. Goldberg et al. (2010) demonstrate that input-tariff cuts in India facilitated access to new varieties of important inputs which led firms to increase their product scope.

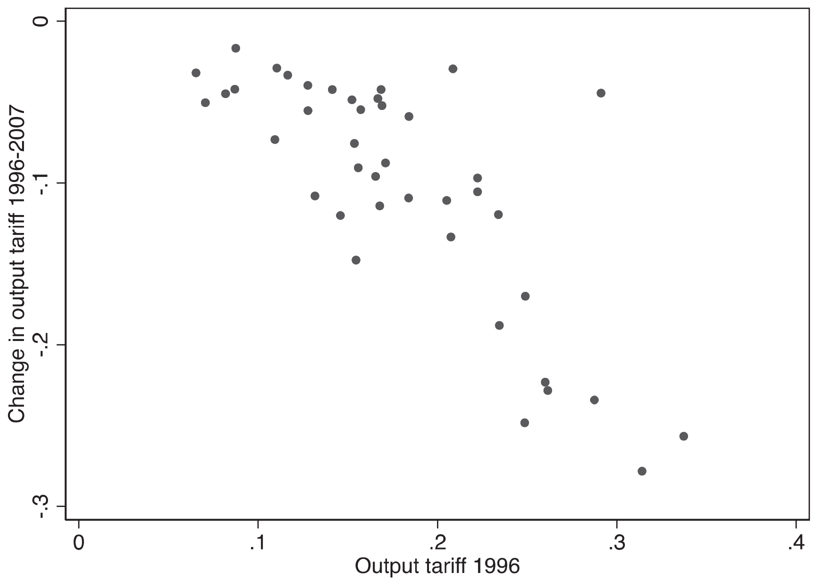
Our work also relates to other works on trade liberalization on firms, including their pricing strategy/markups. Regarding firms' markups, our work adds to Levinsohn (1993), Harrison (1994), De Loecker et al. (2016), Brandt et al. (2017), Fan et al. (2018) and Lu and Yu (2015). De Loecker et al. (2016) show that input-trade liberalization in India explains the incomplete pass-through of input tariff cuts cost adjustments to consumers due to the increase in firm-product level markups. Brandt et al. (2017) investigate the impacts of trade liberalization in China on the evolution of firm-level markups (and TFP-R using detailed 4-digit industry price deflators). Their findings suggest that output tariff cuts reduce markups while input tariff cuts raise them. Fan et al. (2018) confirm these results and study the effect of input-trade liberalization in China on firm-product level markups depending on their trade status. Lu and Yu (2015) focus on the effects of trade liberalization, mainly through foreign competition, on markup dispersion at the industry level. They show that trade liberalization in China reduces markup dispersion within industries.

Most of the papers that study how trade liberalization affects firm performance cited above do not take into account directly the effects of other contemporaneous reforms. The previous studies focused on countries where trade liberalization was part of a package of structural reforms such as Latin American countries (Colombia, Mexico, Brazil) or India, Indonesia and China. Two exceptions are the works of Topalova and Khandelwal (2011) and Goldberg et al. (2010) for India that control for industrial liberalization, FDI and labor market reforms when looking at the effects of trade liberalization on firm productivity and product scope, respectively.

Other works have focused on the impact of foreign competition from China, after the country joined the WTO in 2001, on firm performance (innovation, export margins, exit-entry dynamics and aggregate industry productivity) in several countries. Bloom et al., 2016, for European countries, Iacovone et al. (2013), for Mexico, Goya (2019) for Chile, Chakravorty et al. (2017), Chakraborty and Henry (2018) for India and Gampfer and Geishecker (2019) for Denmark show that overall import competition from China improves firm performance.

The main contribution of our work to this vast literature is to investigate the effects of both output and input tariff cuts on TFP-Q relative to TFP-R and analyze within our empirical framework the effects on all core firm production measures i.e. firm-product level output prices, markups, MC, output product and input quality, firm product scope in addition to the productivity measures. Our rigorous empirical analysis explicitly disentangles the impacts of trade liberalization from other reforms and shocks firms were exposed to.

[4] Two other studies have investigated the impacts of trade on TFP-Q: Smeets and Warzynski (2013) use firm-product data for Danish firms to investigate the relationship between exports, imports and firm productivity and show that exporter-importer productivity premia differ for measures using TFP-Q compared to TFP-R. Garcia-Marin and Voigtländer (2019) investigate learning-by-exporting and find that the Chilean, Colombian and Mexican firms increase TFP-Q after they started exiting.



Source: Authors' calculation based on Ecuador's effectively applied import tariffs with respect to the rest of the world at HS 6-digit product level from WITS (World Bank).

Note: Each dot represents the change in input tariffs at 3-digit ISIC Rev.3 industry level.

Fig. 1. Changes in output tariffs from 1996 to 2007.

4. Ecuador's economic conditions from 1996 to 2006

In this section, we describe the economic conditions that Ecuadorian firms faced between 1996 and 2006.

4.1. Ecuador's accession to the WTO

Ecuador's trade policy during the 1970s and 1980s was characterized by protectionism and import substitution, as in other Latin American and Caribbean countries during this period. Trade was tightly restricted in order to shield industries from foreign competition, with high nominal tariffs and import licenses in most sectors. In the 1990s, Ecuador pursued trade liberalization, along with most other countries in Latin America, along the principles of the Washington Consensus.

In 1996, when Ecuador's acceded to the WTO, the country adopted substantial unilateral tariff reductions. During the period 1997–2000, multilateral negotiations within the WTO on the specific accession commitments of Ecuador led to further tariff reductions and the elimination of import licenses in specific sectors.[5] Fig. 1 shows the variation in industry level tariffs between 1996 and 2007. The highest initial tariffs experienced the greatest reduction over the period. Average output tariffs declined by 8-percentage points, from 17% in 1996 to 9% in 2007. Average input tariffs declined by 7-percentage points during the period from 12.8% to 5.8%. The largest reduction of output tariffs was of 27.8-percentage points for the 3-digit industry 173 (Manufacture of knitted and crocheted fabrics and articles), from 31.4% in 1996 to 3.6% in 2007. The lowest tariffs reduction was zero change and corresponded to the 3-digit industry 221 (Publishing).

Moreover, in an effort to facilitate access to intermediate inputs from abroad, Ecuador reduced import restrictions and signed the "Customs Law". The latter reduced customs procedures from 18 steps to only 3 and simplified them. The Ecuadorian government also signed the "Foreign Trade Law" (1997). This law resulted in the creation of the Ministry of Foreign Trade. A core mission of this new Ministry was to promote foreign technology transfer through the import of inputs and capital goods.

4.2. The economic crisis of 1999

Ecuador's economic situation deteriorated in 1997 and 1998, with a decline in the price of oil, the country's largest export commodity, and the El Niño weather shock that reduced agricultural output. Ecuador experienced a major currency and banking crisis. The balance of payments problems that had emerged in 1998 put pressure on the currency and depleted

[5] More information on these negotiations is provided here: https://www.wto.org/english/thewto_e/acc_e/a1_ecuador_e.htm

international reserves, leading to inflation reaching 60% by 1999 with a steep devaluation putting further pressure on banks (Vos and de Jong, 2003). Bank failures and credit shortages driven by devaluation accelerated the crisis. GDP fell by 7.3%, the investment rate almost halved, and the country defaulted on external debt obligations (Brady Bonds), leading to further uncertainty in exchange markets. The country's economy recovered gradually in the following years, with the adoption of the dollar as its currency in 2020.

4.3. Labor market and financial market liberalization and other reforms efforts

In the 1990s and 2000s, several structural reform plans were developed but only partly realized. These included liberalizing financial markets, removing very stringent formal labor market regulations, reducing barriers to foreign direct investment (FDI) and privatizing public enterprise.

With regards to the financial sector, the 1994 Law of the Financial System Institutions (LFSI) created the legal basis for financial sector reforms aimed at improving the sector's performance, including better access to credit for firms. Reforms focused on facilitating free entry and exit to the financial market and levelling the playing field between domestic and foreign banks. The number of financial institutions increased from 31 in 1993 to 44 in 1996 (Jácome, 2004). In the same year, restrictions on banks' lending operations were also lifted. Two additional reforms implemented in the 1996–2007 period of our study were the liberalization of international capital in- and outflows as of 1999 and the wider privatization of the financial sector as of 2003 (Abiad et al., 2008). This brought a moderate increase in Ecuador's performance in the IMF's financial liberalization index from the beginning of the 1990′s to the early 2000′s (ibid.).

As to labor markets, an assessment of Ecuador's labor market regulations over the 1997–2007 period concluded that the economic recovery following the 1999 crisis could have had a stronger impact on employment if companies had faced a better investment climate and less restrictive labor regulations (Rinne and Sanchez-Páramo, 2008). The World Economic Forum's Global Competitiveness Report for 2006–2007 identified Ecuador's very high restrictions for hiring and dismissing employees (it placed 106th out of 125 countries), low flexibility in setting salaries (98th), lack of relation between employees' salaries and productivity (96th), and difficult relationship between employees and employers (97th) (Lopez-Claros, 2006). Moreover, the national minimum wage imposed hiring constraints for low-skilled workers in the formal economy.

While labor markets were still very rigid at the end of the period, the crisis of 1999 led to some changes in the level of labor market rigidities, including notably temporary reductions in the minimum wage. The Economic Freedom Index, which assesses the degree of liberalization across several policy domains, including labor markets, identifies moderate improvements in hiring and firing costs in the years following the 1999 crisis (Gwartney et al., 2001). New dialog forums under the leadership of the Ministry of Labor and the Ministry of the Economy – under the auspices of the World Bank, the Inter-American Development Bank and the International Labour Organization – on labor reforms, including of hiring and firing processes, were held in 2004 but only resulted in limited changes to labor market rigidities (Rinne and Sanchez-Páramo, 2008). More substantial improvements were realized with regards to minimum wage regulations. These are due to involuntary changes in the country's minimum wage, the real value of which plummeted with hyperinflation in 1999 and the adoption of the dollar as national currency in 2000 (Ponce and Vos, 2014). While the real value of the minimum wage increased again in the post-crisis years of 2000–2006, its increase was below that of the average wage (Rinne and Sanchez-Páramo, 2008).

Other reform plans that were only marginally implemented included reducing barriers to foreign direct investment (FDI) and privatizing large public enterprises. With regards to FDI, barriers to entry continued to be substantial over the 1990′s and early 2000′s, and consequently FDI inflows were modest (UNCTAD, 2001). Of those inflows, the oil sector, which is not part of our estimating firm sample, received 80%. The specific nature of the industry and its remote geographic location facilitated few benefits to the remainder of the economy, including the manufacturing sector that our study focuses on. Other reform efforts aimed to privatize some of the country's public enterprises mainly concentrated in the oil, electricity and communications sectors, none of which are included in our estimating firm sample. The Modernization Law of 1993 that established the Consejo Nacional de Modernización (CONAM) that was tasked with executing the privatization of state enterprises. Nonetheless, privatizations did not materialize in the 1990′s. In consequence, Ecuador became the only country in Latin America with growing public investment during this period as operational losses forced public enterprises to rely more on fiscal resources to finance their investments, in turn increasing public debt (UNCTAD, 2001). The country did not implement privatization programs in the early 2000′s due to a myriad of concerns over privatizations, including losing the government's grip on sectors of the strategic relevance.

4.4. China's accession to the WTO

Ecuador's period of trade liberalization is contemporaneous to a major global change to global trade: the rise of China as a major player in the global trading system. Following a series of successful internal reforms and the country's entry to the WTO in 2001, China's share of global exports increased from 3.2% in 2000 to 7.3% in 2007 (World Bank, 2021). Data from the WITS database on Ecuador's imports show that the share from China went up from less than 1% in 1997 to more than 8% in 2007. However, it remained small relative to import penetration from other countries – particularly in Latin America – that increased their share by 10-percentage points from 34% to 44% in the same period. Imports increased across different industries, involving basic products such as wood, textile and non-metallic mineral products but also products with a higher technological content such as machinery and equipment, electrical machinery and communications and motor vehicles.

5. Overview of the data and variable definitions

5.1. Panel data on manufacturing plants, their inputs and output products

We use a Census panel dataset that is collected by the Ecuadorian Institute of Statistics (INEC) of formal manufacturing plants (corresponding to ISIC Rev. 3 category D) with 10 or more employees for the period 1997–2007. The distinctive feature of our data is that it is complemented by two other datasets, which have information on plants' intermediate inputs and on plants' output products, respectively. The first dataset gives annual plant-level information on primary materials, auxiliary materials, replacements and accessories, and packing materials used in production. For each intermediate input, plants provide information on quantities and values separately for national and foreign inputs. The second dataset has the following information on each plant's final products: quantities and values sold in the market and their quantities as well as the cost of production for each product. Both input and output products are provided by INEC at detailed 11-digit product code level that is built on the ISIC-Rev. 3 industry classification.[6]

We implement several data cleaning procedures and check the quality of our dataset following Bernard et al. (2010), Kugler and Verhoogen (2012) and Goldberg et al. (2010). This includes testing for firms with irregular output product drops (i.e. products that disappear from production and then reappear again) and firms with product jumps (i.e. products that are produced only once in the intermediate years of firm presence in the sample). These tests are satisfactory in that product drops and jumps are relatively infrequent. Moreover, the consistency of importer characteristics to those Kugler and Verhoogen (2012) obtain for Colombia gives additional confidence in the quality of the new data (see Bas and Paunov, 2019, for these statistics). Details on data cleaning procedures and quality checks are provided in Bas and Paunov (2019).

This detailed information on each firm's product output and input quantities and values allows us to retrieve measures of prices (unit values), markups, MC costs and TFP-R and TFP-Q. Our final main estimating dataset with non-missing information for firm TFP contains 10,725 firm-year observations spread across 14 2-digit ISIC Rev.3sectors with, as is characteristic of a developing country, a large number (a quarter) operating in the food and beverage industry. For the firm-product level estimations on prices, MC and markups the final estimating sample contains 52,167 firm-product level observations.

The next subsections describe the empirical methodology applied to compute TFP-R, TFP-Q, prices (unit values), markups, MC and output and input product quality. The Appendix presents a detailed description of the variables used in our estimations.

5.2. Obtaining TFP-R and TFP-Q for multiproduct firms

We compute TFP-R and TFP-Q following De Loecker et al. (2016) and estimate Cobb-Douglas production functions. Our production function estimations rely on the methodology introduced by Ackerberg et al. (2015) that controls for the simultaneity bias in the estimation of production functions using firm-level data. This bias arises since input demand for materials and labor is positively correlated with the unobserved productivity. Regarding inputs, we rely on total materials expenditures, total workers (labor) and capital. For TFP-R, we rely on firm' total revenues and input expenditures deflated with industry price indexes. We obtain TFP-Q using total revenues and input expenditures deflated with price-level obtained as Tornquist price indices based on a weighted average of the growth in price of firm i's manufactured products p (input k) between year t-1 and year t.

We do not know how multi-product firms allocate their inputs across products. Therefore, we rely on single product firms to estimate the production function, since for those firms we know the inputs used in the production of the single product have been allocated to that good. Results of production function estimates for TFP-R are shown in columns 2–4 of Appendix Table A3. Results also do not differ dramatically from estimates for TFP-Q as reported in columns 6–8 of Appendix Table A3.[7] The output-elasticities to variable inputs are similar to those obtained by De Loecker et al. (2016) for India. An interesting difference is that elasticities for labor are generally somewhat higher for our estimates, possibly reflecting less automation of Ecuadorian firms' production processes compared to the large formal Indian firms that De Loecker et al. (2016) study. For multiproduct firms, we then compute TFP-R and TFP-Q using the elasticity of output with respect to inputs of their main products at the 2-digit industry level estimated from single product firms and the amounts of inputs of multiproduct firms.

[6] The dataset provides information on plants and does not have information on which plants are part of one single firm and which plants are single-product firms as several other micro datasets used in the literature such as the data for Colombia in the works of Kugler and Verhoogen, (2009, 2012) and for Chile in the works of Pavcnik (2002) and Garcia-Marin and Voigtlaender (2019).

[7] As is the case for De Loecker et al. (2016), some of the elasticities for capital are negative although insignificant and of low value. This is likely related to the challenge firm-level productivity analyses face in estimating capital adequately.

5.3. Prices, markups, marginal costs and quality measures

5.3.1. Firm-product level prices, markups and marginal costs

Firm-product output prices are computed as total value of a product over the quantity (unit values). We estimate firm-product level markups relying on the methodology developed by Hall (1986), revisited by De Loecker and Warzynski (2012) and applied at the firm-product level by De Loecker et al. (2016) as described below. Then marginal costs are computed by dividing unit values (prices) by the estimated markups.

The advantage of this methodology is that it allows measuring markups in the absence of information on demand or market structure. The key assumption is that firms minimize costs. In this setting, firm-product markups (μ_{ipt}) are firm-product prices (P_{ipt}) over marginal costs (MC_{ipt}) and correspond to the deviation between output elasticity relative to variable input $\frac{\partial Q_{ipt}}{\partial V_{ipt}} \frac{V_{ipt}}{Q_{ipt}}$ and that input's share of total revenue. $\frac{P^V{}_{ipt}}{P_{ipt}} \frac{V_{ipt}}{Q_{ipt}}$:

$$\mu_{ipt} = \frac{P_{ipt}}{MC_{ipt}} = \left[\frac{\partial Q_{ipt}}{\partial V_{ipt}} \frac{V_{ipt}}{Q_{ipt}}\right] / \left[\frac{P^V{}_{ipt}}{P_{ipt}} \frac{V_{ipt}}{Q_{ipt}}\right]$$

We use the output elasticity relative to variable input estimated in the production function estimation. For single product firms, we use the share of expenditures in materials over total sales as input share to compute the firm-product level markups. For multiproduct firms, we followed the method of Garcia-Marin and Voigtländer (2019) to compute product-specific material inputs for multiproduct firms by using the information provided in our firm-product dataset on cost of production for each product and firm by year.

5.3.2. Firm-product-level output and input quality and other output measures

We measure firm-product-level output and input quality by relying on the methodology proposed by Khandelwal et al. (2013) (KSW hereafter). This measure of product quality developed by KSW is widely used (Fan et al., 2015, 2018, Manova and Yu, 2017, Bas and Strauss-Kahn, 2015; among others). KSW estimate quality as a demand shifter that corresponds to the residual of an OLS estimation of the quantity and price (unit value) on country-time fixed effects (to control for price index and income at destination) and product fixed effects (to control for variation across products since prices and quantities are not comparable across products). The estimated quality is a function of the residual of such estimation and the elasticity of substitution between products.[8] Quality is then represented as any product attribute that shifts the demand curve as first proposed by Sutton (1991). Inferring product quality from demand functions means that conditional on prices a product with higher demand (quantity) is assigned higher quality.

For our purposes we adapt KSW's estimation to estimate the quality of output and input products of firms in Ecuador. The firm-product quality corresponds to the residual of an OLS estimation of the following regression: $\mathrm{q}_{ipt} + \sigma\,\mathrm{p}_{ipt} = \alpha_p + \alpha_t + \eta_{ipt}$, where $\mathrm{q}_{\mathrm{ipt}}$ and $\mathrm{p}_{\mathrm{ipt}}$ denote the natural logs of the quantity and price of product *p* at 11-digit code produced (or used) by firm *i* in year *t*. The product-fixed effect α_{p} controls for unobservable characteristics across products since prices and quantities are not comparable across products. The estimated log quality, λ_{ipt}, depends on the residual of that estimation η_{ipt} and the elasticity of substitution σ: $\lambda_{\mathrm{ipt}} = \eta_{\mathrm{ipt}}/(\sigma - 1)$.[9]

We obtain other measures of firms' output composition, including product scope measured as the total number of products produced by a firm in a year, an indicator variable if the firm adds a new 11-digit code product that was not produced before and an indicator if the firm drops more products than new products produced.

5.4. Output and input tariffs

We use Ecuador's effectively applied import tariffs at the HS 6-digit product level as provided by the WITS database of the World Bank. The effectively applied tariffs correspond to the most-favored nation (MFN) tariff or the tariff applied by the country as decided under a preferential trade agreement, if applicable.

We link this tariff data to our data on Ecuadorian firms by establishing a product correspondence between an 11-digit product code level that is built on the ISIC-Rev. 3 industry classification and the HS 6-digit product level categories. Next, we aggregate output and input tariffs at the 3-digit ISIC-Rev.3 industry level. Output (input) tariffs at the 3-digit industry level are computed as a weighted average of the output (input) tariffs at the product level faced by each firm using constant weights averaged over the period. The output products are indexed by *p*, while the input products are indexed by *k*. The 3-digit industry output tariffs ($Output\ \tau_{jt}$) is given by:

$$Output\ \tau_{jt} = \sum_p \theta_p \tau_{pt}$$

[8] In their case, the objective is to estimate product quality of exported products at the firm level for Chinese firm-product disaggregated at the HS 6-digit level and country of destination level from customs data for the textile sector.

[9] For input quality, we are able to estimate firm-input quality at 2-digit sector relying on sectoral sigma at HS3 from Broda et al. (2006). For output quality, due to limited data at HS3, we rely on the average elasticities of substitution estimated by Broda and Weinstein (2006) for the US that equals 5.

Where τ_{pt} is the tariff of HS6-output product p in year t and product p is the final output produced by our Ecuadorian firms, with θ_p being computed as a constant weight average over the period of a specific product p over total value of firm i's sales in a 3-digit industry j. For single-product firms, θ_p is equal to 1 for the industry in which it sells its products. For multi-product firms that produce goods in different 3-digit ISIC Rev.3 industry we rely on the industry of the main product.[10]

The 3-digit industry input tariffs ($Input\ \tau_{jt}$) are computed similarly by matching the import tariffs at HS 6-digit with our dataset of firms' input products in Ecuador:

$$Input\ \tau_{jt} = \sum_k \theta_k \tau_{kt}$$

Where τ_{kt} is the tariff of HS6-input product k in year t and product k is the input used by our Ecuadorian firms, with θ_k being computed as a constant weight average over the period of the share of input k over total value of inputs from 3-digit industry j.

There are two main advantages of using constant weights to compute industry level output and input tariffs. First, these measures reduce potential reverse causality concerns between changes in firm performance and variations in the product mix over time. Second, using fixed weights avoids potentially biased estimates stemming from changes in the composition of the output and input mix over time due to changes in tariff. Third, we rely on a constant average weights instead of initial year of the sample weights to avoid losing information on products (inputs) that are not produced (used) in the initial year.

5.5. Control variables: market dynamics, other reforms and shocks

This section describes the variables we use to deal with the major economic developments Ecuadorian firms faced during the period we analyzed outlined in Section 3 above.

With regards to market dynamic measures, we include an indicator of firm exit that is equal to one if firm exits in t+1 ($Exit_{i,t}$). Two additional controls for market dynamics at the 3-digit ISIC Rev.3 industry level are i) the share of firms that exited the market in t+1 ($indExit_{jt}$) and ii) the Herfindahl index of market concentration ($Herf_{jt}$), which we compute as the sum of the squared market shares in each industry.

As to controls for the crisis and currency volatility. First, we include in estimations interaction terms of our tariff measures with an indicator variable equal to one for the years of Ecuador's crisis (1999–2000). Second, we compute the 3-digit industry real exchange rate (RER) volatility as the yearly standard deviation of monthly logarithm of the real exchange rate. The monthly real exchange rate of Ecuador vis-à-vis its trading partners is the ratio of the nominal exchange rate of the Ecuadorian peso before 2000, or the US dollar after the dollarization, with respect to the partner's currency multiplied by the consumer price index (CPI) of Ecuador over the partner's CPI. We use data from the IMF International Financial Statistics database to compute monthly real exchange rates between Ecuador and its trading partners. We rely on data of imports of Ecuador to its trading partners at the HS6 product level from COMTRADE and match it by trading country with the RER volatility to compute HS6 product level RER volatility (ϕ_{kt}) using as weights the 1997 share of each country in Ecuador's imports at the HS6 product level. Next, we match this data with the information on the inputs purchased by Ecuadorian firms at the 11-digit product code level. Finally, we compute the 3-digit industry RER volatility, ϕ_{jt}, in a similar way as input tariffs relying on constant averaged weights over the period: $\phi_{jt} = \sum_k \theta_k \phi_{kt}$, where θ_k is computed as a constant-weight average over the period of a specific input k over total value of sales in a 3-digit industry j as in Paunov (2011). We also add an interaction with the dollarization period, an indicator equal to one after 2000.

We account for financial liberalization by relying on the IMF's financial reform index for Ecuador from the "Financial Reform Dataset Dec 2008″ developed by Abiad et al. (2008). This index is composed of eight sub-indices covering the following policy areas: credit controls, reserve requirements, aggregate credit ceilings, interest rate liberalization, entry barriers in the banking sector, capital account transactions, banking privatization, securities markets and banking sector supervision. The higher the index, the higher the financial liberalization. The IMF financial reform index that varies yearly is weighted by 2-digit industry dependence on external finance in the US. These weights are constructed using the external dependence measure developed by Rajan and Zingales (1998) and subsequently updated by Braun (2002) based on 18 US manufacturing industries. The rationale of this approach is that financial sector reforms should have a more important impact in those industries that depend more on external funding than in others.

As to labor market reforms, we use the minimum wage and labor costs provided by the Economic Freedom index, an assessment on the liberalization across 57 economies (Gwartney et al., 2001). Those indicators vary at the yearly level and are then interacted with the labor share at the 3-digit industry level from Ecuador. The rationale of this approach is that labor market reforms, if of impact, should have a more important effects in those industries that depend more on labor.

Although assessing reforms is always tricky, these indicators of financial and labor market reforms provide a rough indication of the evolution of reforms. They certainly do not provide a perfect account of the financial and labor market conditions faced by Ecuador's manufacturing firms.

[10] Less than 20% of firms produce goods in more than one 3-digit industry. The sales of these firms represent on average 0.06% of sales.

Finally, we take into account directly the role of foreign competition from the import of final goods from China. As done in the literature on the impacts of China, we include the industry-level import penetration from China ($MChina_{j,t}$) computed as the share of imports of Ecuador from China over total imports of Ecuador in the 3-digit industry that comes from COMTRADE dataset.

6. Empirical framework

6.1. Exogeneity of tariff changes

Our analysis makes use of the changes in input and output tariffs across industries over the 1996–2007 period. We make use of the sectoral differences in tariff reductions shown in Fig. 1 above that describe Ecuador's institutional context. For this approach to be valid, potential reverse causality between tariff changes and firm performance needs to be excluded. In particular, it should not be the case that firms producing in industries with greater input- and output-tariff cuts lobbied for these lower tariffs.

We test whether tariff changes are exogenous to initial industry and firm characteristics. As done in previous studies such as Topalova and Khandelwal (2011) and Goldberg et al. (2010), we regress first changes in input and output tariffs on firm performance and a number of industry characteristics in the initial year. Tables A1 and A2 in the Appendix show that input and output tariff changes between 1996 and 2007 were uncorrelated with industry-level characteristics and with initial firm performance measures. If the government had targeted specific firms and industries during trade liberalization, then tariff changes would have been correlated with initial firm performance.

Unfortunately, firm-level data is only available from 1997. Thereby, it is not possible to provide an analysis of firm-product or firms' pre-trends prior to trade reform. To control for possible differences in trends, we will include in all firm level estimations an initial size trend that takes into account different trends across firms of different sizes. We will also include initial firm-product-size trends in firm-product estimations to control for differences in demand trends across firms' products. The empirical framework is introduced in the next section.

6.2. Baseline estimation strategy

We investigate the impacts of trade liberalization on total factor productivity by relying on the following specification using a within-firm estimator:

$$\begin{aligned} TFP_{ijt} = {} & \alpha + \gamma_{I\tau}\, Input\ \tau_{j,\ t-1} + \gamma_{O\tau} Output\ \tau_{j,\ t-1} + \kappa_{exit}\, exit_{it} + \kappa_{indExit}\, indExit_{jt} + \kappa_{herf} Herf_{j,\ t} \\ & + \mathrm{K}_r \boldsymbol{SR}_{j,t-1} + \kappa_{China} MChina_{j,t} + \Gamma_s Size_{\ i,t0} * \eta_t + \Gamma_j Ind_j * \eta_t + \mu_i + \eta_t + \varepsilon_{ijt} \end{aligned} \tag{4}$$

where TFP_{ijt} is either revenue total factor productivity (*TFP-R*) or quantity total factor productivity *(TFP-Q*) of firm *i* operating in industry *j* in year *t*. Our variables of interest are input tariffs ($Input\ \tau_{j,\ t-1}$) and output tariffs ($Output\ \tau_{j,\ t-1}$). These and all other variables we include in our estimation are described in Section 5 above.

We control for impacts of possibly changing firm dynamics during the period of change and crisis in Ecuador by including an indicator of firm exit ($exit_{it}$). Since firms' leaving the economy may itself have affected the opportunities for others, we also want to account for the share of firms that exited ($indExit_{jt}$). We also want to account for changes in market concentration in our specifications that may have resulted from those other reforms and affected the prospects of different firms ($Herf_{it}$). We may otherwise attribute impacts to tariff reductions that are related to changing firm dynamics and/or the crisis. $\boldsymbol{SR}_{j,t-1}$ are a set controls account for the 1999 crisis and national reforms as discussed in detail in Section 5.5. and $MChina_{j,t}$ is an indicator of China's role as importer to Ecuador.

We also control for different trends at firm-size level by including $Size_{i,t0} * \eta_t$, which accounts for possible differences in trends across differently sized firms. In addition, we introduce industry trends, $Ind_j * \eta_t$, to account for differences in developments across industries, including those driven by reforms that affected specific sectors. The estimation includes firm fixed effects, μ_i, and year fixed effects, η_t. ε_{ijt} is an error term. Since tariffs vary at the 3-digit ISIC Rev.3 industry level over time, the standard errors are clustered at the 3-digit industry level.

6.3. Controls for Ecuador's economic conditions

As outlined in Section 4.2 and 4.3, Ecuador experienced a period of major reforms and challenges aside from trade liberalization. The empirical framework includes a set of very stringent firm-size and industry trends and firm and year fixed effects that control for contemporaneous developments caused by those reforms. The controls on firm exit and industry characteristics (exit and competition) account for impacts of those developments that may have affected changes to firms' productivity and product processes that we may otherwise pick up in our productivity measures.

Nonetheless, we want to ensure that our tariff measures are not impacted by other reforms and crisis effects and explicitly account for those impacts. For this reason, a vector of controls, $\boldsymbol{SR}_{j,t-1}$, is included as follows:

- As to the crisis, we include an interaction of our tariff measures with an indicator of Ecuador's crisis period (1999–2000) to ensure we do not pick up an effect driven by the crisis rather than by tariff changes. We also account for the possible effects of the national currency's high volatility during the crisis period as it is very like to have impacted for firms due to the extreme volatility prior to the crisis and for the implications of the adoption of the dollar as national currency on volatility.

- As to reforms, we introduce measures capturing the two reforms Ecuador implemented over the period and that were directly relevant to manufacturing firms: financial liberalization and labor market reforms with regards to labor costs and the minimum wage.

6.4. Additional empirical estimation framework and outcome variables

We investigate how firm mechanisms are effective by looking into effects on markups, marginal costs and prices. These regressions are conducted at firm-output-product level and take the following form:

$$Y_{pijt} = \alpha + \gamma_{I\tau} Input\ \tau_{j,t-1} + \gamma_{O\tau} Output\ \tau_{j,t-1} + \kappa_{exit}\, exit_{it} + \kappa_{indExit} indExit_{jt} + \kappa_{herf} Herf_{j,t} + \mathrm{K}_r \boldsymbol{SR}_{j,t-1} + \kappa_{China} MChina_{j,t} + \Gamma_s Size_{\ i,t0} + \boldsymbol{\Pi}_{\boldsymbol{pi}} FProdSize_{pi,t0} * \eta_t + \Gamma_j Ind_j * \eta_t + \pi_{ip} + \eta_t + \varepsilon_{pijt} \quad (5)$$

where Y is respectively the markup, marginal cost and price of product p of industry j of firm i at time t. We also control for firm-product-size trends $FProdSize_{pit0} * \eta_t$ to control for unobservable diverging trends in demand for firm i's product p. Instead of firm fixed effects we include firm-product fixed effects. All other controls are as specified before. ε_{pijt} is an error term.

We investigate alternative outcomes product scope, product adding and churning following as baseline specification in Eq. (4) instead of productivity.

7. Results

7.1. Productivity

This section presents evidence on the effects of output and input tariff cuts in Ecuador on firm TFP-R and TFP-Q.

Table 1 presents the estimates of Eq. (4) for TFP-R. Consistent with the literature (Schor, 2004; Fernandes, 2007; Amiti and Konings, 2007 and Topalova and Khandelwal, 2011), we find positive effects of input- and output-tariff cuts on TFP-R (column 1). This effect is maintained as we progressively control for the potential impact of firm dynamics (column 2), the 1999 crisis, including exchange rate volatility and the impacts of dollarization on volatility (column 3), financial and labor market reforms (column 4) and the impact of China's import penetration as well as industry trends (column 5). We discuss what we find for those controls below.

Results from our preferred specification, shown in column 5, show that output tariffs declined in Ecuador from 1997 to 2007 by 8-percentage points, resulting in an increase of TFP-R by almost 17%. Input tariffs in Ecuador were reduced by 7-percentage points in the same period and this reduction is associated with an increase in firm TFP-R of 9.7%.

We next assess to what extent the impact of trade liberalization on TFP-R is a result of improvements in firms' efficiency. Table 2 presents the results using TFP-Q as dependent variable. Both output-and input-trade liberalization have a positive but lower effect on firm efficiency gains compared to the effects on TFP-R. The 8-percentage-point reduction of output tariff in Ecuador over the period we analyze is associated with an increase in firm TFP-Q of 10.5% and the 7- percentage-point reduction of input tariff leads to a 6.1% increase of TFP-Q.

We investigate in the next section if the differential effect of tariff cuts on TFP-R and TFP-Q is driven by changes in firm prices.

Our estimates also provide interesting evidence on changing market conditions for Ecuadorian firms. As in Pavcnik (2002), Amiti and Konings (2007) among many other studies, we find that firms that exit the market in the next year have lower TFP-R and TFP-Q than surviving firms. Our findings also show that higher industry exit rates have positive effects on TFP-Q. Our data allow investigating what drives those effects. Interestingly, we find a positive effect of higher rate of industry exit on prices (column 6 of Table 3 below). An explanation for this finding is that less tight market conditions allow firms to charge higher prices to invest in production process improvements that then raise TFP-Q.

Regarding Ecuador's crisis, we show that our results on the impacts of trade liberalization on TFP-Q and TFP-R were not driven by the crisis (columns 3 to 5 of Tables 1 and 2). However, as expected the volatility of RER had a negative and significant effect on both productivity measures (ibid.). Unsurprisingly, we find that the dollarization period did not produce such effects as RER volatility was much more predictable than in the pre-dollarization period.

As to other reform measures, financial liberalization had a positive effect on TFP-R. This finding echoes the large literature on the importance of financial reforms for firm productivity (see Gehringer, 2014, for an overview). We do not find that labor reforms benefited Ecuadorian firms' productivity.

As to the effects of increased import penetration from China, we find in line with the literature that these positively affect both productivity measures. As was the case elsewhere, Chinese imports also provided access to lower cost products on output markets. Coherently with this hypothesis, we find that Chinese import penetration negatively affected prices

Table 1
The effects of trade liberalization on TFP-R.

Dependent variable:	TFP-R of firm i in year t				
	(1)	(2)	(3)	(4)	(5)
Output tariff(j,t-1)	−1.903***	−1.937***	−2.142***	−1.977***	−2.054***
	(0.452)	(0.456)	(0.462)	(0.478)	(0.497)
Input tariff(j,t-1)	−1.567***	−1.632***	−1.380***	−1.353***	−1.389***
	(0.345)	(0.357)	(0.394)	(0.394)	(0.390)
Exit(i,t)		−0.083**	−0.085**	−0.086**	−0.084**
		(0.037)	(0.037)	(0.037)	(0.037)
Share of industry exit(j,t)		0.086	0.161	0.158	0.215
		(0.160)	(0.159)	(0.159)	(0.162)
Herfindhal(j,t)		0.017	0.018	0.020	0.020
		(0.013)	(0.013)	(0.013)	(0.013)
Input tariff(j,t-1) x crisis(t)			−0.263	−0.379	−0.358
			(0.480)	(0.480)	(0.484)
Output tariff(j,t-1) x crisis(t)			0.890	0.897	0.968
			(0.609)	(0.610)	(0.617)
RER volatility(j,t-1)			−1.507***	−1.568***	−1.639***
			(0.513)	(0.524)	(0.530)
RER volatility(j,t-1) x dollarization(t)			0.361	0.407	0.868
			(0.916)	(0.913)	(0.924)
Financial liberalization(j,t-1)				0.019***	0.015**
				(0.006)	(0.007)
Minimum wage index(j,t-1)				−0.044	−0.050
				(0.034)	(0.035)
Labor cost index(j,t-1)				0.014	0.025
				(0.091)	(0.091)
Share imports China(j,t)					0.287**
					(0.124)
Initial firm-size trend	yes	yes	yes	yes	yes
Firm fixed effects	yes	yes	yes	yes	yes
Year fixed effects	yes	yes	yes	yes	yes
Observations	10,725	10,725	10,725	10,725	10,725
R-squared	0.728	0.728	0.729	0.729	0.730

Note: Estimations reported in this table are at firm level. Variable definitions are provided in Section 5 and in Appendix Tables A1 and A2. Column (5) also includes an industry trend. ***, **, and * indicate significance at the 1, 5 and 10% levels respectively.

(column 6 of Table 3). That is also the reason why the effects of foreign competition from China are higher for TFP-Q than TFP-R since prices are reduced.

We confirm the robustness of our results. We show that our results are not reliant on the production function approach. Our findings are robust when we use alternative TFP measures obtained by the TFP index method developed by Caves et al. (1982) and applied by Aw et al. (2011) and Arnold and Javorcik (2009), as reported in columns 1–2 of Table A4.[11] Our results are also not driven by any biases we may have in estimating the productivity of single- and or multi-product firms (columns 3–4 and 5–6 of Table A4). We also confirm results are not driven by any particular industry as they are robust to their individual exclusion (Table A5).

7.2. Product markups, marginal costs and prices

This section disentangles the channels that drive changes in TFP-Q and TFP-R by looking at the effects of trade liberalization on firm-product level prices, markups and marginal costs.

We estimate Eq. (5) at the firm-product level. Since marginal costs are measured as prices over the estimated markups, (log) marginal costs and (log) markups sum to (log) prices, the tariffs' coefficients on prices equal the sum of the coefficients on marginal costs and markups.

[11] The total factor productivity index of plant i in year t is expressed as deviation from a single reference point and defined as follows for plant i in year t the index: $ln\ TFPQ_{it} = (ln\ Y_{it} - \overline{\ln Y_t}) + \sum_{\tau=2}^{t} (\overline{lnY} - \overline{lnY_{\tau-1}}) - \left[\sum_{j=1}^{m} \frac{1}{2}(s_{kit} + \overline{s_{kt}})(lnX_{kit} - \overline{lnX_{kt}}) + \sum_{\tau=2}^{t}\sum_{j=1}^{m} \frac{1}{2}(\overline{s_{k\tau}} + \overline{s_{k\tau-1}})(\overline{lnX_{k\tau}} - \overline{lnX_{k\tau-1}}\right]$ where i denotes firm, t year, k type of input, measured in real terms. Inputs (X) include labor (total employees), materials, energy and services (real value) and capital (real value). S denotes input shares, that is, the ratio of the wage bill (and materials, services and energy as well as capital) to output. The first expression of the index is the deviation from the mean output in that year while the second term sums the change in the main output across all years and captures the shift of the output distribution over time by chain-linking the movement in the output reference point. The remaining terms repeat the exercise for each input k. The inputs are summed using a combination of the input revenue share for the plant (S_{kit}) and the average revenue share in each year as weights.

Table 2
The effects of trade liberalization on efficiency gains.

Dependent variable:	TFP-Q of firm *i* in year *t*				
	(1)	(2)	(3)	(4)	(5)
Output tariff(j,t-1)	−1.433***	−1.453***	−1.360***	−1.188***	−1.322***
	(0.417)	(0.420)	(0.428)	(0.438)	(0.439)
Input tariff(j,t-1)	−0.898***	−0.995***	−0.844**	−0.958**	−0.877**
	(0.349)	(0.352)	(0.393)	(0.401)	(0.403)
Exit(i,t)		−0.090**	−0.092**	−0.091**	−0.092**
		(0.037)	(0.037)	(0.037)	(0.037)
Share of industry exit(j,t)		0.247	0.263	0.306*	0.325*
		(0.159)	(0.162)	(0.166)	(0.166)
Herfindhal(j,t)		0.004	0.004	0.008	0.005
		(0.014)	(0.014)	(0.015)	(0.015)
Input tariff(j,t-1) x crisis(t)			0.120	0.139	0.254
			(0.509)	(0.522)	(0.524)
Output tariff(j,t-1) x crisis(t)			−0.603	−0.603	−0.507
			(0.405)	(0.408)	(0.408)
RER volatility(j,t-1)			−1.406***	−1.620***	−1.557***
			(0.528)	(0.544)	(0.542)
RER volatility(j,t-1) x dollarization(t)			0.419	0.823	0.883
			(0.871)	(0.875)	(0.875)
Financial liberalization(j,t-1)				0.010	0.009
				(0.007)	(0.007)
Minimum wage index(j,t-1)				−0.020	−0.014
				(0.038)	(0.038)
Labor cost index(j,t-1)				−0.067	−0.074
				(0.094)	(0.094)
Share imports China(j,t)					0.421***
					(0.121)
Initial firm-size trend	yes	yes	yes	yes	yes
Firm fixed effects	yes	yes	yes	yes	yes
Year fixed effects	yes	yes	yes	yes	yes
Observations	10,725	10,725	10,725	10,725	10,725
R-squared	0.748	0.748	0.748	0.749	0.749

Note: Estimations reported in this table are at firm level. Variable definitions are provided in Section 5 and in Appendix Tables A1 and A2. Column (5) also includes an industry trend. ***, **, and * indicate significance at the 1, 5 and 10% levels respectively.

Table 3 columns 1 and 2 presents the results for markups, columns 3 and 4 for marginal costs and columns 5 and 6 for output prices. In each case, we show results with and without the variables that control for firm dynamics, reforms as well as Ecuador's crisis and the effect of China.

Our findings show that output tariff cuts reduce firms' markups while input tariff cuts increase markups. The 8-percentage point reduction in output tariffs in Ecuador during this period is associated with a reduction of markups by almost 13.6% (column 2 of Table 3). The 7-percentage point reductions of input tariff during the period is associated with a markup increase of almost 8%. This evidence is in line with the results of De Loecker et al. (2016) for India and Brandt et al. (2017) for China. The estimates of De Loecker et al. (2016) suggest that output-trade liberalization in India results in a reduction of 9 to 18% of markups due to foreign competition. As to input tariff cuts, we find larger effects of markup increases. An explanation for higher markups is that Ecuadorian firms are able to increase their profit margins by upgrading their production with easier access to high-quality inputs from abroad. We investigate this possible mechanism in the next section.

The next columns present the impact of output and input tariff reductions for marginal costs and prices. Our estimates suggest that the 8-percentage point reduction of output tariffs increases marginal costs by 18% (column 4) and to a lesser extent firms' product prices by 4.8% (column 6). These findings differ from De Loecker et al. (2016) on the effects of output trade liberalization on marginal costs and prices. They find no significant effect of foreign competition on marginal costs but a reduction in prices. The different effects of output trade liberalization on firm-product marginal costs and output prices can be explained by different responses of Ecuadorian firms due to a higher gap to the technology frontier compared to the leading Indian and Chinese firms tracked by Brandt et al. (2017) and De Loecker et al. (2016). Our findings suggest that Ecuadorian firms have reacted to foreign competition by upgrading their product processes by investing in costly inputs that raise marginal costs and then adjusted their markups to partially compensate the marginal cost increase. In the next section we explore this explanation further by looking at the effects of foreign competition on firms' output and input upgrading process.

Finally, we find no significant effect of input tariff cuts on marginal costs and prices. The reason could be that firms' access to high-(price)-quality imported inputs thanks to input tariff cuts and thereby input tariff cuts do not reduce marginal

Table 3
The effects of trade liberalization on markups, marginal costs and prices.

Dependent variable:	Markups		Marginal costs of firm *i*'s product *k* in year *t*		Prices	
	(1)	(2)	(3)	(4)	(5)	(6)
Output tariff (j,t-1)	1.764***	1.701***	−2.270***	−2.310***	−0.505*	−0.609*
	(0.301)	(0.343)	(0.644)	(0.670)	(0.272)	(0.313)
Intput tariff (j,t-1)	−1.093**	−1.101*	1.437	1.567	0.344	0.465
	(0.489)	(0.594)	(1.003)	(1.143)	(0.505)	(0.576)
Exit(i,t)		−0.023		0.042		0.019
		(0.046)		(0.058)		(0.034)
Share of industry exit(j,t)		0.605		−0.224		0.381**
		(0.380)		(0.541)		(0.194)
Herfindhal(j,t)		0.216*		−0.160		0.055
		(0.128)		(0.193)		(0.111)
Input tariff(j,t-1) x crisis(t)		0.536		−1.321		−0.785
		(0.686)		(1.292)		(0.714)
Output tariff(j,t-1) x crisis(t)		−0.160		0.441		0.281
		(0.612)		(1.055)		(0.762)
RER volatility(j,t-1)		0.002		0.207		0.209
		(0.700)		(1.565)		(0.834)
RER volatility(j,t-1) x dollarization(t)		−0.175		0.167		−0.008
		(1.357)		(1.865)		(1.216)
Financial liberalization(j,t-1)		0.019**		−0.010		0.010
		(0.008)		(0.014)		(0.008)
Minimum wage index(j,t-1)		−0.006		0.019		0.013
		(0.046)		(0.070)		(0.053)
Labor cost index(j,t-1)		−0.002		−0.041		−0.043
		(0.097)		(0.138)		(0.112)
Share imports China(j,t)		0.145		−0.343		−0.198
		(0.142)		(0.263)		(0.138)
Initial firm-size trend	yes	yes	yes	yes	yes	yes
Initial firm-product-size trend	yes	yes	yes	yes	yes	yes
Firm-product fixed effects	yes	yes	yes	yes	yes	yes
Year fixed effects	yes	yes	yes	yes	yes	yes
Industry trend		yes		yes		yes
Observations	52,810	52,167	52,810	52,167	52,810	52,167
R-squared	0.712	0.711	0.819	0.810	0.832	0.824

Note: Estimations are at firm-product level. Variable definitions are provided in Section 5 and in Appendix Tables A1 and A2. ∗∗∗, ∗∗, and ∗ indicate significance at the 1, 5 and 10% levels, respectively.

costs and prices. We explore in the next section one possible reason for this result by looking at the effects of trade liberalization on input upgrading processes.

Our findings are robust to alternative measures of markups computed at the firm level following the methodology of De Loecker and Warzynski (2012) relying on the output elasticity and the firm level share of inputs (see column 7 of Table A4).

7.3. Disentangling the channels of transmission

This section investigates a possible explanation for our findings by looking at the effects on firms' output production and the evolution of input products.

7.3.1. Output-product changes

We first use Eq. (4) to assess firms' change the number of products they produce in response to trade liberalization. We find that input trade liberalization facilitates an expansion of scope while output trade liberalization has the reverse effect (column 1 of Table 4). The shifts result from the addition of new products (column 2 of Table 4), while the negative effects of output tariffs arise from drops in products as firms focus on their core products (column 3 of Table 4). To understand whether these changes are related to product upgrading we test at the firm-product level whether product quality improved. We find that output tariff reductions result in improved output quality (column 4 of Table 4). The 8-percentage point reduction of output tariffs result in an increase of firm-product output quality by 5.3%. The 7-percentage points reduction of input tariffs result in an increase of the likelihood of adding new products of 5%. Finally, we look at the effect tariffs on output prices adjusted for quality measured as the logarithm difference between firm-product level output prices and output quality. Results in column (5) of Table 4 indicate that input tariff cuts seem to reduce the output price adjusted for quality investments. Moreover, those results also show that output tariff cuts have no significant effect on quality-adjusted output prices since actually the increase in output quality (column 4 of Table 4) to face foreign competition compensates the increase in output prices (column 6 of Table 3).

Table 4
Trade liberalization and output-product changes.

Dependent variable: Analysis level:	Product scope Firm level (1)	Adding products Firm-product level (2)	Net product churning (3)	Ouput quality (4)	Price adjusted for quality (5)
Output tariff(j,t-1)	0.479***	0.704***	−0.248**	−0.667*	0.058
	(0.094)	(0.166)	(0.104)	(0.389)	(0.166)
Input tariff(j,t-1)	−0.356**	−0.679**	0.009	−0.135	0.600**
	(0.170)	(0.304)	(0.209)	(0.712)	(0.276)
Control variables	yes	yes	yes	yes	yes
Initial firm-size trend	yes	yes	yes	yes	yes
Industry trend	yes	yes	yes	yes	yes
Firm fixed effects	yes	yes	yes		
Year fixed effects	yes	yes	yes	yes	yes
Initial firm-product-size trend				yes	yes
Firm-product fixed effects				yes	yes
Observations	11,129	11,129	11,129	52,167	52,167
R-squared	0.852	0.321	0.404	0.385	0.883

Note: Estimations of columns (1), (2) and (3) are at firm level, while estimations of column (4) and (5) are at firm-product level. ***, **, and * indicate significance at the 1, 5 and 10% levels, respectively.

Table 5
Trade liberalization and input-product upgrading.

Dependent variable:	Imported input prices (1)	Imported input quality (2)	Domestic input quality (3)	Imported (4)	Domestic (5)
Output tariff(j,t-1)	−0.316***	−2.412***	−1.464***	−2.516***	−1.502***
	(0.104)	(0.773)	(0.408)	(0.823)	(0.428)
Input tariff(j,t-1)	−1.001	−4.962**	1.209	−4.860**	1.361
	(0.618)	(2.410)	(1.140)	(2.402)	(1.173)
Output tariff(j,t-1) x capital importer(i)				0.911	0.510
				(0.960)	(0.422)
Input tariff(j,t-1) x capital importer(i)				−7.454	−5.767
				(8.964)	(4.137)
Control variables	yes	yes	yes	yes	yes
Initial firm-size trend	yes	yes	yes	yes	yes
Industry trend	yes	yes	yes	yes	yes
Initial firm-input-size trend	yes	yes	yes	yes	yes
Firm-input fixed effects	yes	yes	yes	yes	yes
Year fixed effects	yes	yes	yes	yes	yes
Observations	14,433	14,433	37,114	14,433	37,114
R-squared	0.749	0.176	0.298	0.176	0.298

Note: Estimations are at firm-input product level. Variable definitions are provided in Section 5 and in Appendix Tables A1 and A2. ***, **, and * indicate significance at the 1, 5 and 10% levels, respectively.

7.3.2. Input changes

We turn to investigate explicitly how inputs changed with tariff reductions to confirm input quality improves with liberalization so as to allow for production additions and higher quality products. We use the following adjusted estimation framework (6) at firm-input level to investigate effects of input prices and quality. We adjust estimation framework (6) by including instead of firm-product-size trend firm-input-size trends ($\boldsymbol{\Pi_{ki}} FProdSize_{ki,t=0} * \eta_t$). Rather than firm-product fixed effects we apply firm-input fixed effects (κ_{ik}).

Results are presented in Table 5. Our estimates show that firms pay higher imported input prices when output tariffs drop (column 1). They also show that both output and input tariff cuts lead to an upgrade of imported input quality (column 2). Our estimates suggest that the 8-percentage point decrease in output tariff is associated with an increase in imported intermediate goods input quality of 19% and 11% of domestic input quality. The 7-percentage point reduction of input tariffs leads to an increase of around 30% of imported input quality. Output trade liberalization is also associated to domestic input quality upgrading as domestic suppliers stepped up the quality of their products (column 3). We conclude this analysis by testing whether the quality of capital goods improved by including an interaction term between the tariff measures and an indicator variable for capital goods (identified by code 84 of the HS-2 classification). We do not find this to be the case and conclude that Ecuadorian firms have mainly upgraded variable inputs due to output and input tariff cuts. To provide just one example from our database, an Ecuadorian firm improved the quality of the jerseys, pullovers and related articles (HS-6 code 611090) it produced, importing as part of the quality upgrading process higher-quality fibers (HS-6 code 550700).

These results confirm the explanation we provide above as to the impacts of output and input tariff liberalization. Firms in Ecuador upgrade their input quality. Since input quality upgrading implies investing in high-cost inputs, firms increase their marginal costs and output prices after output-trade liberalization (shown in columns 4 and 6 of Table 3). The positive effect of input tariff cuts on imported input quality also explains why we do not find a significant effect of input tariff cuts on reductions of marginal costs (column 4 of Table 3). Firms offset their input tariff reductions by accessing high-quality (cost) inputs.

7.4. Insights on the distributional effects

An important question for assessing trade liberalization episodes regards the distributional effects of the gains induced by trade openness across different firms and between firms and consumers. It is beyond the scope of this study to provide a comprehensive analysis on this question to understand how welfare was affected. Nonetheless, our unique data provide for new insights on how the benefits from trade liberalization across firms and also between firms and consumers.

7.4.1. Heterogeneous effects across firms

First, we investigate the effect of trade liberalization on production upgrading across different firms. We classify firms into two groups depending on their initial efficiency level (TFP-Q) and look at the impacts of output and input tariff cuts for firms with above- and below-median TFP-Q.[12] Results presented in Table 6 suggest that only initially more efficient firms

[12] We compute the high-(above the median) and low-(below the median)-initial TFP-Q indicator taking the median TFP-Q in the initial year of the sample by 3-digit industries.

Table 6
Heterogeneous effects across firms.

Dependent variable: Analysis level:	Product scope Firm level (1)	Adding products Firm-product level (2)	Net product churning (3)	Ouput quality (4)	Prices (5)	Markups (6)	Marginal costs (7)
Output tariff (j,t-1)*High TFP-Q(t0)	0.456***	0.447**	−0.052	−0.955**	−0.826**	1.801***	−2.627***
	(0.113)	(0.207)	(0.140)	(0.480)	(0.388)	(0.382)	(0.557)
Output tariff (j,t-1)*Low TFP-Q(t0)	−0.106	0.370	−0.200	−0.318	−0.354	1.620***	−1.974***
	(0.517)	(0.911)	(0.542)	(0.522)	(0.422)	(0.498)	(0.624)
Input tariff (j,t-1)*High TFP-Q(t0)	−0.538***	−0.740***	0.071	0.141	0.620	−0.942	1.562*
	(0.152)	(0.281)	(0.185)	(0.756)	(0.607)	(0.645)	(0.892)
Input tariff (j,t-1)*Low TFP-Q(t0)	−0.385	−0.761	0.233	−0.456	0.300	−1.356*	1.657
	(0.730)	(1.195)	(0.755)	(0.932)	(0.763)	(0.776)	(1.064)
Control variables	yes	yes	yes	yes	yes	yes	yes
Firm initial size trend	yes	yes	yes	yes	yes	yes	yes
Industry trend	yes	yes	yes	yes	yes	yes	yes
Firm fixed effects	yes	yes	yes				
Firm-product-trend				yes	yes	yes	yes
Firm-product fixed effects				yes	yes	yes	yes
Year fixed effects	yes	yes	yes	yes	yes	yes	yes
Observations	11,129	11,129	11,129	52,167	52,167	52,167	52,167
R-squared	0.852	0.320	0.403	0.385	0.824	0.711	0.810

Note: Estimations in columns (1) to (3) are at firm level and in columns (4) to (7) are at firm-output product level. Variable definitions are provided in Section 5 and in Appendix Tables A1 and A2. ***, **, and * indicate significance at the 1, 5 and 10% levels, respectively.

benefitted from input cuts to increase their product scope to introduce new products to the market (columns 1 and 2). We also find that output tariff decreases caused only the most productive firms to reduce their product scope and add fewer new products as they invested in improving the quality of their surviving products (columns 1, 2 and 4). Columns (5) to (7) indicate that all firms reduce their markups due to foreign competition as they invest in product upgrading and increase their marginal costs. However, least productive firms compensate completely the increase in marginal costs by adjusting their markups and so there is no significant effect on output prices. While the most productive firms have the capacity to undertake higher cost investments, upgrading their output quality, they also increase their output prices since their markup adjustment is lower relative to the increase in marginal costs.

Moreover, as in Pavcnik (2002), Amiti and Konings (2007) among many other studies, we find that firms that exit the market in the next year have lower TFP-R and TFP-Q than surviving firms (column 5 of Tables 1 and 2). This evidence points to a reallocation towards more productive firms upgrading their production processes.

Another question regards the possibly detrimental impact of trade liberalization on domestic input suppliers. Our evidence on domestic inputs, reported in columns 3 of Table 5, shows that foreign competition resulted in an increase in the quality of domestic suppliers' products. Interestingly, these firms were not more likely to exit than their counterparts at any point during the period of analysis.

7.4.2. Distributional impacts on consumers and firms

Another important question regards how trade liberalization benefited consumers. Did consumers benefit from input-trade liberalization by improving their access to products at cheaper prices? We investigate this question by looking at the effects of input tariff reductions on quality adjusted prices, which we compute as the change in output prices (unit values) relative to quality. Results, shown in Column (5) of Table 4, indicate that input-tariff reductions benefited consumers, as for a 7-percentage point reduction of input tariffs, quality-adjusted product prices fall by 4.2%.

Did firms pass all gains from input-trade liberalization through to consumers? Our findings show that firms benefitted from input tariff cuts to increase their markups (column 2 of Table 3). Improved market power for firms from upgraded production processes resulted in the incomplete pass-through of input-trade liberalization gains. Concerning output trade liberalization, our findings show that firms' markups decreased as a result of foreign competition. Overall, the net effect from trade liberalization on markups is a net reduction of 11-percentage points since firms increase their markups thanks to input tariffs cuts by 7% but they reduce markups by 18% due to foreign competition.

To sum up, we find that consumers benefitted from trade liberalization since they are offered better products at lower prices while firms' markups decreased. Input-trade liberalization led only the initially most productive firms to add products. Less productive firms were more likely to exit over the period.

8. Conclusions

In this paper, we investigate how output- and input-trade liberalization with Ecuador's entry to the World Trade Organization (WTO) impacted Ecuadorian firms' market and production decisions. We present new evidence on firms' responses to trade liberalization. We find new evidence that trade liberalization increases firm efficiency (TFP-Q) besides increasing TFP-R. We confirm previous empirical findings that show that firms reduce their markups to face foreign competition. However, we also find that firms invest in high-quality (cost) inputs and outputs, and consequently increase MC and charge higher prices for their higher-quality outputs. The increase in output prices after output tariff cuts explains why the effect of trade liberalization on TFP-R is higher than on TFP-Q. Our findings suggest that input-tariff cuts have positive effects on Ecuadorian firms' efficiency at the same time as firms improve input quality and product scope as firms introduce new products allowing firms to raise markups. These differences point to the role played by country conditions in how firms react to trade liberalization. Moreover, our analysis on firms' market decisions illustrates that welfare analyses of trade liberalization also requires evaluating how consumers are affected as firms' markups and prices change as a result of these reforms. In our case, we find that consumers benefit from accessing lower-priced higher-quality products. However, firms do not pass through all benefits from trade liberalizations. Future empirical cross-country work could shed further light into what drives differential responses to show when trade liberalization allows for industry upgrading and its impacts on how gains from trade liberalization are shared.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.euroecorev.2021.103726.

Appendix

Description of dependent variables

Variable	*Description*
TFP-R / TFP-Q	The firm level TFP-R / TFP-Q is estimated following the methodology developed De Loecker et al. (2016). TFP-R and TFP-Q is the residual of a Cobb-Douglas production function estimation for each 2-digit industries using the subsample of single-product firms and firm' total revenues and input expenditures deflated with industry price indexes for TFP-R and with firm-input prices for TFP-Q. See Section 5.2.
Prices	Firm-product output prices are computed as total value of a product over the quantity (unit values). See Section 5.3.
Prices adjusted for quality	The logarithm of output prices adjusted for quality is the logarithm difference between firm-product level output prices and the estimated firm-product level output quality. See Section 5.3.
Markups	Firm-product level markups are estimated relying on the methodology developed by De Loecker et al. (2016). Markups are the deviation between output elasticity relative to variable input and input's share of total revenue. See Section 5.3.
Marginal costs (MC)	Firm-product level marginal costs are computed by dividing unit values (prices) by the estimated markups. See Section 5.3.
Product scope	The logarithm of the number of 11-digit products based on the ISIC Rev. 3 classification produced by firm *i* in year *t*. See Section 5.3.
Adding products	The variable is equal to 1 if firm *i* introduces an 11-digit product based on the ISIC Rev. 3 classification in year *t* it did not produce before. See Section 5.3.
Net product churning	The variable is equal to 1 if firm *i* drops an 11-digit product and those not add a new product based on the ISIC Rev. 3 classification in year *t* it produced in year *t-1*. See Section 5.3.
Output quality	Firm-product output quality is computed as a residual of a demand function estimation relying on quantities and unit values following the methodology of Khandelwal et al. (2013). See Section 5.3.
Input prices	Firm-product input prices are computed as total value of an input product over the quantity (unit values). See Section 5.1.
Input quality	Firm-input quality is computed as a residual of a demand function estimation relying on input quantities and unit values following the methodology of Khandelwal et al. (2013). See Section 5.3.
Output / Input tariffs	Output / Input tariffs are computed as a 3-digit industry weighted average of the output / input tariffs at the product level faced by each firm using constant weights averaged over the period. We link tariff data to our data on Ecuadorian firms by establishing a product correspondence between the 11-digit product categories of Ecuadorian firms' output and input products and the HS 6-digit product categories. Both output and input tariff measures are aggregated at the 3-digit ISIC-Rev.3 industry level using constant weights. See Section 5.4.

Control variable descriptions

Variable	***Description***
$Exit_{i,t}$	Firm level exit dummy is an indicator variable equal to one if the firm exits the market in *t + 1*. See Section 5.5.
$indExit_{jt}$	The industry level exit rate is the share of exiting firms in t+1 in the 3-digit industry over total firms in the industry. See Section 5.5.
$Herf_{jt}$	Herfindhal index of market concentration is defined as the sum of the squared market shares in each 3-digit industry. See Section 5.5.
Crisis period	The crisis period is an indicator variable equal to one for the years of Ecuador's crisis (1999–2000). See Section 5.5.
RER volatility	The 3-digit industry level RER volatility is the weighted average of the yearly standard deviation of monthly logarithm RER faced by each firm using constant weights averaged over the period. See Section 5.5.
Dollarization period	The dollarization period is an indicator variable equal to one after the year 2000 till the last year of the sample, 2007. See Section 5.5.
Financial liberalization	The industry level financial liberalization index is constructed using the IMF financial reform index for Ecuador weighted by 2-digit industry dependence on external finance in the US from Rajan and Zingales (1998) and subsequently updated by Braun (2002). See Section 5.5.
Minimum wage index	The industry level minimum wage indicator is constructed using the index of minimum wage for Ecuador from Economic Freedom of the World (Gwartney et al., 2001), weighted with the labor share at the industry level from Ecuador. See Section 5.5.
Labor cost index	The industry level labor cost indicator is constructed using the index of hiring and firing costs from Economic Freedom of the World Gwartney et al., 2001), weighted with the labor share at the industry level from Ecuador. See Section 5.5.
$MChina_{j,t}$	The industry level import penetration from China is computed as the share of imports of Ecuador from China over total imports of Ecuador in the industry. See Section 5.5.

Table A1
Tariff reductions between 1996 and 2007 and pre-reform industrial characteristics.

Panel A: Change in output tariffs from 1996 to 2007							
Dependent variable:	Change in output tariffs 1996–2007						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Sales(j,t)	0.001						
	(0.001)						
TFP-R(j,t)		0.002					
		(0.003)					
TFP-Q(j,t)			0.004				
			(0.004)				
Product scope(j,t)				0.001			
				(0.002)			
Workers(j,t)					0.001		
					(0.001)		
Number of importers(j,t)						0.001	
						(0.003)	
Herfindhal(j,t)							0.003
							(0.002)
Observations	203	203	203	203	203	156	203
R-squared	0.709	0.707	0.714	0.705	0.705	0.797	0.717
Panel B: Change in input tariffs from 1996 to 2007							
Dependent variable:	Change in input tariffs 1996–2007						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Sales(j,t)	0.000						
	(0.001)						
TFP-R(j,t)		0.000					
		(0.002)					
TFP-Q(j,t)			0.000				
			(0.002)				
Product scope(j,t)				−0.001			
				(0.001)			
Workers(j,t)					−0.000		
					(0.001)		
Number of importers(j,t)						−0.002	
						(0.002)	
Herfindhal(j,t)							0.001
							(0.002)
Observations	203	203	203	203	203	156	203
R-squared	0.814	0.814	0.814	0.815	0.813	0.826	0.814

Notes: The dependent variable is the changes in input or output tariffs between 1996 and 2007. The table shows regressions at the 3-digit industry level of changes in input tariffs on different industry-level characteristics and 2-digit industry fixed effects. Industry level sales, TFP-R, TFP-Q, number of products (product scope) and workers are the average of those firm level variables. The Herfindahl index is computed as described in Appendix Table A2. All industry-level variables are expressed in logarithms. Heteroskedasticity-robust standards errors are reported in parentheses.

Table A2
Initial firm characteristics in 1997 and tariff changes between 1996 and 2007.

Dependent variable:	Sales (1)	TFP-R (2)	TFP-Q (3)	Product scope (4)	Workers (5)	Importer status (6)
Change in output tariffs(j,07,96)	−0.154	−0.657	−4.255	0.063	−0.050	0.296
	(1.680)	(0.770)	(2.979)	(0.471)	(0.819)	(0.540)
Change in input tariffs(j,07,96)	−3.331	2.262	5.245	−0.588	−0.655	0.973
	(5.224)	(2.790)	(6.500)	(1.099)	(2.410)	(0.964)
Observations	679	679	679	679	679	678
R-squared	0.14	0.25	0.30	0.10	0.06	0.22

Notes: The dependent variables in each column are the initial firm-level outcomes in the initial year of the sample. The table shows the coefficients on changes in output and input tariffs between 1996 and 2007 from firm-level regressions of initial firm characteristics and 2-digit industry fixed effects. Firm-level variables are expressed in logarithms except for the importer of inputs dummy. Standards errors clustered at the 3-digit ISIC Rev.3 industry level are reported in parentheses.

Table A3
Observations and sectoral output elasticities, TFP-R and TFP-Q.

Sector	Obs. in prod. estimates (total)	TFP-R				TFP-Q				
		Labor (1)	Materials (2)	Capital (3)	Returns to scale (4)	Labor (5)	Materials (6)	Capital (7)	Returns to scale (8)	(9)
15	Food and beverages	1127	0.237***	0.749***	0.051***	1.04	0.321***	0.692***	0.023	1.04
		(2652)	(0.005)	(0.006)	(0.019)		(0.009)	(0.005)	(0.023)	
17	Textiles	407	0.282***	0.726***	0.080***	1.09	0.309**	0.743**	0.043	1.10
		(888)	(0.046)	(0.117)	(0.027)		(0.133)	(0.295)	(0.044)	
18	Wearing apparel	310	0.308***	0.702***	0.060**	1.07	0.322***	0.676***	0.024	1.02
		(806)	(0.009)	(0.010)	(0.024)		(0.013)	(0.012)	(0.029)	
19	Leather	278	0.282***	0.718***	0.075***	1.08	0.243***	0.597***	0.115***	0.96
		(462)	(0.017)	(0.015)	(0.026)		(0.021)	(0.016)	(0.039)	
20	Wood and wood products	302	0.390***	0.681***	0.090**	1.16	0.401***	0.621***	0.152**	1.17
		(434)	(0.021)	(0.015)	(0.042)		(0.043)	(0.091)	(0.067)	
21	Paper and paper products	194	0.314***	0.720***	0.031	1.07	0.347	0.775*	−0.028	1.09
		(436)	(0.048)	(0.105)	(0.037)		(0.266)	(0.430)	(0.124)	
24	Chemicals	275	0.323***	0.611***	0.104	1.04	0.486***	0.523***	0.163**	1.17
		(907)	(0.061)	(0.060)	(0.090)		(0.042)	(0.044)	(0.082)	
25	Rubber and plastic	515	0.211***	0.718***	0.064**	0.99	0.167***	0.769***	0.002	0.94
		(949)	(0.011)	(0.011)	(0.029)		(0.020)	(0.025)	(0.051)	
27	Basic metals	722	0.459***	0.622***	0.065***	1.15	0.436***	0.661***	0.037	1.13
		(990)	(0.009)	(0.008)	(0.023)		(0.010)	(0.005)	(0.026)	
28	Fabricated metal	191	0.271***	0.732***	0.088***	1.09	0.507***	0.561***	0.165***	1.23
		(269)	(0.056)	(0.031)	(0.030)		(0.053)	(0.044)	(0.060)	
29	Machinery and equipment	282	0.379***	0.662***	0.042	1.08	0.435***	0.629***	−0.001	1.06
		(655)	(0.010)	(0.014)	(0.036)		(0.031)	(0.026)	(0.054)	
31	Electrical machinery and communications	116	0.458***	0.721***	−0.064	1.12	0.650***	0.588***	0.079	1.32
		(149)	(0.046)	(0.130)	(0.100)		(0.134)	(0.140)	(0.075)	
34	Motor vehicles, trailers	190	0.211***	0.779***	0.023	1.01	0.203***	0.767***	0.037	1.01
		(302)	(0.008)	(0.009)	(0.027)		(0.019)	(0.025)	(0.049)	
36	Furniture	119	0.290***	0.731***	0.113***	1.13	0.334***	0.705***	0.146	1.19
		(588)	(0.021)	(0.036)	(0.038)		(0.118)	(0.154)	(0.143)	

Note: The table reports the average output elasticities of each factor of production from the Cobb-Douglas production function estimation for TFP-R (columns 2–5) and TFP-Q (columns 6–9). Standard errors are reported in brackets. Average returns to scale are the sum of the preceding three columns. The table also reports in column 1 the number of observations for each production function estimation and in parentheses the total number of observations in the sample (including multi-product plants). ***, **, and * indicate significance at the 1, 5 and 10% levels respectively.

Table A4
Robustness tests.

Dependent variable:	TFP-R Index (1)	TFP-Q Index (2)	TFP-R Single product firms (3)	TFP-Q Multi-product firms (4)	TFP-R (5)	TFP-Q (6)	Markups (7)
Output tariff(j,t-1)	−0.818***	−0.600**	−0.506***	−0.407**	−2.689***	−1.309***	0.242***
	(0.201)	(0.260)	(0.127)	(0.192)	(0.494)	(0.489)	(0.045)
Input tariff(j,t-1)	−0.747***	−0.726**	−0.523***	−0.364**	−1.855***	−1.926***	−0.326***
	(0.257)	(0.333)	(0.137)	(0.173)	(0.407)	(0.423)	(0.089)
Control variables	yes	yes	yes	yes	yes	yes	yes
Initial firm-size trend	yes	yes	yes	yes	yes	yes	yes
Industry trend	yes	yes	yes	yes	yes	yes	yes
Firm fixed effects	yes	yes	yes	yes	yes	yes	yes
Year fixed effects	yes	yes	yes	yes	yes	yes	yes
Observations	10,186	10,185	4117	4118	6441	6441	10,594
R-squared	0.679	0.659	0.752	0.746	0.877	0.784	0.943

Note: Columns (1) and (2) alternative measures of TFP-R and TFP-Q as described in Section 7.5. Columns (3) and (4) report estimations using the sample of single product firms and columns (5) and (6) the sample of multiproduct firms. Column (7) reports estimations on alternative markups. ***, **, and * indicate significance at the 1, 5 and 10% levels, respectively.

Table A5
Alternative samples.

Dependent variable	TFP-R				TFP-Q			
	Food and beverages (1)	Textil (2)	Paper (3)	Basic Metal (4)	Food and beverages (5)	Textil (6)	Paper (7)	Basic Metal (8)
Output tariff(j,t-1)	−2.035***	−1.968***	−2.016***	−1.927***	−1.253***	−1.107**	−1.271***	−1.462***
	(0.527)	(0.503)	(0.503)	(0.459)	(0.464)	(0.440)	(0.443)	(0.476)
Input tariff(j,t-1)	−2.034***	−1.771***	−1.396***	−1.046***	−1.404***	−1.372***	−0.866**	−0.994**
	(0.491)	(0.416)	(0.399)	(0.359)	(0.472)	(0.415)	(0.413)	(0.415)
Control variables	yes	yes	yes	yes	yes	yes	yes	yes
Firm initial size trend	yes	yes	yes	yes	yes	yes	yes	yes
Industry trend	yes	yes	yes	yes	yes	yes	yes	yes
Firm fixed effects	yes	yes	yes	yes	yes	yes	yes	yes
Year fixed effects	yes	yes	yes	yes	yes	yes	yes	yes
Observations	8087	9916	10,296	9736	8087	9917	10,297	9737
R-squared	0.735	0.731	0.730	0.738	0.754	0.751	0.752	0.732

Note: The table replicates estimations for TFP-R (columns 1 to 4) and TFP-Q (columns 5 to 8) dropping key industries one at a time. The industry indicated in each column is dropped from the estimation. ∗∗∗, ∗∗, and ∗ indicate significance at the 1, 5 and 10% levels, respectively.

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