

# Imports, Exports, and Earnings Inequality: Measures of Exposure and Estimates of Incidence\*

Rodrigo Adao  
Chicago Booth

Paul Carrillo  
GWU

Arnaud Costinot  
MIT

Dave Donaldson  
MIT

Dina Pomeranz  
U Zurich

## Abstract

The earnings of individuals depend on the demand for the factor services they supply. International trade may therefore affect earnings inequality because either: (i) foreign consumers and firms demand domestic factor services in different proportions than domestic consumers and firms do, an export channel; or (ii) domestic consumers and firms change their demand for domestic factor services in response to the availability of foreign goods, an import channel. Building on this idea, we develop new measures of export and import exposure at the individual-level and provide estimates of their incidence across the earnings distribution. The key input fed into our empirical analysis is a unique administrative dataset from Ecuador that merges firm-to-firm transaction data, employer-employee matched data, owner-firm matched data, and firm-level customs transaction records. We find that export exposure is pro-middle class, that import exposure is pro-rich, and that, in terms of overall incidence, the import channel is the dominant force. As a result, earnings inequality in Ecuador is higher than it would be in the absence of trade.

---

\*This version: November 2021. Author contacts: rodrigo.adao@chicagobooth.edu, pcarrill@gwu.edu, costinot@mit.edu, ddonald@mit.edu, and dina.pomeranz@econ.uzh.ch. We thank Thomas Bijl, Juan David Hernandez, Shanon Hsuan-Ming Hsu, Wouter Leenders, Antoine Levy, John Sturm, and Miguel Vazquez Vazquez for excellent research assistance, as well as Jonathan Vogel, Adrian Wood, our discussants, Oleg Itskhoki, Ahmad Lashkaripour, and Robert Staiger, the editor, Pol Antras, five anonymous referees, and numerous seminar participants for helpful comments. We are grateful to the Centro de Estudios Fiscales and the Departamento de Control of the Ecuadorian Tax Authority for outstanding collaboration. In addition, this paper has benefited from funding from the National Science Foundation (grant SES-1559015), the CEPR and the UK Department for International Development (DFID) (under the 'Private Enterprise Development in Low-Income Countries' program, reference MRG004 3834), and the European Research Council under the European Union's Horizon 2020 research and innovation programme (grant agreement No 758984). The views expressed are not necessarily those of CEPR, DFID, or ERC.

# 1 Introduction

Some individuals participate in the world economy. They own, work for, or sell to the supply chains of global firms that export and import. Others do not. What is the impact of such differences on earnings inequality? If a country's exports and imports were suddenly to drop to zero, because of some extreme policy or natural disaster, would its distribution of earnings become more or less equal?

In this paper, we propose to revisit these classical questions using an intuitive supply and demand framework. The basic idea upon which our analysis builds is that, for any country, international trade amounts to a shift in the demand for its domestic factor services. This occurs either because foreign consumers and firms demand domestic factor services in different proportions than domestic consumers and firms do, *an export channel*, or because domestic consumers and firms change their demand for domestic factor services in response to the availability of foreign goods, *an import channel*. This suggests (i) measuring differences in trade exposure across individuals by evaluating the extent to which the opportunity to export and import shifts the demand for the factor services they supply, and (ii) estimating the overall incidence of international trade on earnings inequality by estimating the elasticity of the demand for these factor services.

The key input fed into our empirical analysis is a unique administrative dataset from Ecuador that merges firm-to-firm domestic trade data, employer-employee matched data, owner-firm matched data, and firm-level customs transaction records over the period 2009-2015. On the export side, this allows us to measure the extent to which individuals across the earnings distribution, be they workers or capital owners, sell their factor services abroad, either directly through the exports of their firms or indirectly through the exports of the firms supplied by their firms, the exports of the firms supplied by the firms that their firms supply, etc. Likewise, on the import side, this dataset allows us to measure the extent to which firms purchase imports, either directly or indirectly, and, in turn, to infer how changes in import prices affect the demand for the factor services supplied by both their workers and capital owners.

Our main empirical findings about the relationship between international trade and the relative earnings of individuals in Ecuador can be summarized as follows. In terms of exposure, export exposure is pro-middle class—in the sense that foreign demand tends to raise the relative demand for the factors owned by individuals in the middle of Ecuador's income distribution—whereas import exposure is pro-rich—in the sense that cheaper foreign goods tends to raise the relative demand for the factors owned by individuals at the top of that distribution. In terms of overall incidence, the import channel is the dominant

force, making trade increase earnings inequality in Ecuador.

Section 2 lays out the theoretical foundations of our analysis. We consider an economy with price-taking consumers, each endowed with primary factors of production, and price-taking firms, each endowed with a constant-returns-to-scale technology. In this general neoclassical environment, we show that domestic factor prices,  $w$ , must solve

$$L(w, p^*) = \bar{L} - L^*,$$

where  $p^*$  is the vector of import prices;  $L^*$  is the factor content of exports, as in [Leontief \(1953\)](#);  $\bar{L}$  is the total supply of domestic factors; and  $L(\cdot, \cdot)$ , is the domestic factor demand system that arises from domestic preferences and technology. This novel structural relationship summarizes how competitive markets determine domestic factor prices, regardless of whether an economy is open or closed, and provides the bedrock of our subsequent analysis. It underpins how we measure export and import exposure across individuals—by computing the extent to which variation in  $L^*$  and  $p^*$  shifts the demand for their factor services—as well as how we estimate the overall incidence of such exposure—by calculating the changes in factor prices that obtain when  $L^*$  and  $p^*$  are sequentially taken to their autarkic limits,  $L^* \rightarrow 0$  (the export channel) and  $p^* \rightarrow \infty$  (the import channel).<sup>1</sup>

Section 3 introduces an empirical model of Ecuador’s domestic factor demand in which both export and import channels may be active. It is designed to harness the richness of our firm-level micro-data in a parsimonious manner. We assume that domestic consumers have nested CES demand for final goods, whereas firms have nested CES demand for intermediate goods and factors. Crucially, we place no restriction on firm-level heterogeneity in demand for domestic factors and foreign goods, or on firms’ export behavior. As such, every individual’s own exposure to exports and imports is similarly unrestricted, while the incidence of such exposure can be inferred in an intuitive manner from the extent to which consumers and firms reallocate expenditure in response to changes in good and factor prices.

Section 4 uses administrative tax data to measure these differences in trade exposure across Ecuador’s income distribution. Starting from the above structural relationship, we say that individuals’ earnings are more exposed to exports if their factor services are disproportionately demanded abroad (i.e. if  $L_f^*/\bar{L}_f$  is high for the factors  $f$  that they own). This is directly observable by applying [Leontief’s \(1953\)](#) procedure at the level of firms and then matching firms to individuals. Likewise, we say that individuals’ earnings are more

---

<sup>1</sup>The critical assumption behind our approach is perfect competition in factor markets, not good markets. We come back to this point in Section 2.4.

exposed to imports if changes in import prices lead to larger shifts in the domestic demand for their factor services (i.e. if  $|d\ln L_f(w, p^*) / d\ln p^*|$  is high for the factors  $f$  that they own). In our empirical model, these differences in substitutability between domestic factors and foreign imports can be measured directly from the covariance between factor shares embodied in different firms' domestic final sales and (direct and indirect) import cost shares of those same firms.

In Ecuador, we find that export exposure is broadly pro middle-class, in the sense that, on average, individuals in the middle of the income distribution export a higher fraction of their factor services, mostly labor, to the rest of the world. In contrast, import exposure is pro-rich because Ecuadorian firms employing more educated workers also tend to import intermediate goods. When imports become cheaper, the relative demand for these workers goes up, benefiting high-income individuals disproportionately more.

To go from exposure to incidence, Section 5 estimates our model of Ecuador's domestic factor demand. Domestic factor demand is a function of two micro-level demand elasticities: the elasticity of substitution between domestic factors of production, within each firm, and the elasticity of substitution between final goods, within each sector. To deal with potential simultaneity bias in the estimation of these demand parameters, we construct shift-share instrumental variables that leverage variation in exposure to export and import shocks across factors and goods. We estimate elasticities of substitution between factors and between goods that are both around 2. Combined with the rest of our micro-level dataset, the values of these two parameters identify Ecuador's domestic factor demand.

Section 6 offers, before proceeding to our counterfactual analysis, a test of the fit of our empirical model. We view this as an important step, distinct from standard practices in the quantitative trade literature, but necessary to establish the credibility of our estimates of the overall incidence of trade on earnings inequality. To do so, we return to the structural relationship between domestic factor prices,  $w$ , foreign import prices,  $p^*$ , and the factor content of exports,  $L^*$ , emphasized by our theoretical analysis. Since we have estimated Ecuador's domestic factor demand system indirectly through the estimation of two micro-level elasticities governing firm- and consumer-level responses, there is a priori no reason why the observed response of domestic factor prices to changes in import prices and the factor content of exports should coincide with the response predicted by our empirical model. In practice, preferences and technology may not be nested CES, and markets may not be competitive and adjust frictionlessly. Remarkably, however, under the same orthogonality conditions imposed to estimate micro-level elasticities, we cannot reject the null that observed and predicted responses of domestic factor prices to import and export shocks are identical, up to a first-order approximation.

Section 7 concludes by using our estimated domestic factor demand system to evaluate the overall incidence of trade on earnings inequality. We do so by comparing the distribution of earnings observed in Ecuador in 2012, the mid-point of our sample, to the counterfactual distribution that would have been observed in the absence of trade. Quantitatively, we find that the import channel dominates the export channel: international trade increases earnings inequality in Ecuador, especially in the upper-half of the income distribution. Specifically, trade generates gains that are around 7% larger for those at the 90th percentile than those at the median, and up to 11% larger in the case of Ecuador’s top-percentile earners for whom capital ownership is particularly important. These findings are qualitatively robust to a range of alternative assumptions about technology, preferences, and factor supply, including the introduction of informal workers in our sample.<sup>2</sup>

## Related Literature

The literature on trade and inequality is rich and varied, from applied theory work (e.g., [Stolper and Samuelson, 1941](#); [Grossman and Rossi-Hansberg, 2008](#); [Helpman et al., 2010](#)) to reduced-form evidence (e.g., [Hanson and Harrison, 1999](#); [Attanasio et al., 2004](#); [Autor et al., 2013](#)) to structural empirical approaches (e.g., [Artuc et al., 2010](#); [Galle et al., 2017](#); [Burstein and Vogel, 2017](#)). A non-exhaustive list of recent surveys includes [Goldberg and Pavcnik \(2007\)](#), [Feenstra \(2010\)](#), [Harrison et al. \(2011\)](#), [Helpman \(2018\)](#), [Muendler \(2017\)](#), [Pavcnik \(2017\)](#), and [Hummels et al. \(2018\)](#).

Our analysis is most closely related to the “factor content approach” to trade and inequality, whose empirical application was popularized in the 1990s ([Murphy and Welch, 1991](#); [Borjas et al., 1992](#); [Katz and Murphy, 1992](#); [Wood, 1995](#); [Borjas et al., 1997](#)) despite being the subject of heated debate ([Deardorff, 2000](#); [Krugman, 2000](#); [Leamer, 2000](#)). We offer a generalization of that approach that aims to maintain what we view as its main appeal—an intuitive supply and demand framework—while improving on its theoretical foundations and empirical implementation.

On the theory side, [Deardorff and Staiger \(1988\)](#) provide the foundations of the original factor content approach. In a Heckscher-Ohlin model with Cobb-Douglas preferences and technology, they show that if all sectors are import-competing, then net exports of factor services are sufficient statistics for computing changes in relative factor prices resulting from a hypothetical move to autarky.<sup>3</sup> [Deardorff \(2000\)](#) generalizes this result to the case of

---

<sup>2</sup>While these findings imply that, in Ecuador, rich individuals gain relatively more from trade than poor ones do, the absolute level of gains is positive and large for all individuals in all the variations of our model that we consider.

<sup>3</sup>In addition to providing the theoretical foundations of the original factor content approach, [Deardorff](#)

CES utility and production functions with equal elasticities. Our novel structural relationship provides a generalization of these results that dispenses with parametric restrictions on preferences and technology. It stresses the importance of computing the factor content of gross rather than net exports as a measure of trade exposure. Net exports are sufficient statistics only if domestic and foreign factors are perfect substitutes, an unattractive assumption from an empirical standpoint.<sup>4</sup> More generally, changes in relative factor prices depend on gross factor exports (our export channel) and the elasticity of domestic factor demand with respect to foreign import prices (our import channel).

On the measurement side, we use our structural relationship to construct individual measures of export and import exposures. The original factor content approach focuses on a small number of factors of production, typically college and non-college graduates, and measures the factor content of exports and imports using coarse input-output matrices.<sup>5</sup> It is well known that such data may mask tremendous heterogeneity, both in terms of factor price changes within groups as well as in terms of factor intensity within sectors, in particular between firms that are globally engaged and those that are not (Bernard and Jensen, 1999; Bernard et al., 2007b). In contrast, by combining data on firm-to-firm transactions and firm-level international transactions (as in, for example, Huneus, 2018, Spray and Wolf, 2018, Bernard et al., 2019, Alfaro-Urena et al., 2019, Demir et al., 2020, and Dhyne et al., 2021) with worker-firm and owner-firm matches, we are able to construct an individual-level version of the national income and product accounts and solve the previous factor content measurement issues. This granularity and inclusion of capital earnings also opens up the possibility to study the impact of trade on top income inequality (Piketty and Saez, 2003; Piketty et al., 2018; Smith et al., 2019).

On the estimation side, our structural relationship is valid both for an open and a closed economy. This allows us, before conducting counterfactual analysis by taking relative export exposure and foreign good prices to their autarkic limit values, to test whether our empirical model can replicate, within sample, the observed response of domestic factor prices to changes in these two statistics. It also allows us to resolve a fundamental inconsistency of existing applications of the original factor content approach. The elasticity of substitution that enters Deardorff's (2000) formula is the elasticity of substitution between

---

and Staiger (1988) also offer more general correlation results that relax the Cobb-Douglas assumption.

<sup>4</sup>Focusing on net exports also raises the question of how one should measure the domestic factor content of imports. In the empirically relevant case of no domestic production of some goods, there is no direct way to measure the domestic factors that would be needed to domestically produce imports under autarky. Wood (1995) offers important discussions of this issue as well as a method for indirectly estimating the previous quantities from foreign production data.

<sup>5</sup>This is the same type of data used in Leontief's (1953) original factor content computations and in canonical Heckscher-Ohlin-Vanek tests (Bowen et al., 1987; Trefler, 1993, 1995; Davis and Weinstein, 2001).

domestic factors in a hypothetical autarkic economy, not the elasticity of substitution in the observed trade equilibrium that has been estimated by [Katz and Murphy \(1992\)](#) among others. Indeed, for [Deardorff's \(2000\)](#) formula to be valid, the elasticity of substitution in the observed trade equilibrium should be infinite. Put together, we find that these theoretical and empirical extensions to the original factor content approach matter, both qualitatively and quantitatively, for our conclusions.

In emphasizing the economics of factor supply and factor demand, our analysis also relates to [Adao et al. \(2017\)](#) who made the case for estimating global factor demand in order to study the impact of changes in trade costs on (factoral) terms-of-trade between countries. Here, instead, we stress the need to estimate domestic factor demand to study the overall impact of trade on (factoral) terms-of-trade between individuals within a single country. Along the way, we build a bridge between the original factor content approach and recent empirical work based on heterogeneous variation in exposure to a variety of observed trade shocks (e.g., [Autor et al., 2014](#); [Hummels et al., 2014](#); [Pierce and Schott, 2016](#); [Dix-Carneiro and Kovak, 2017](#)). In contrast to more recent empirical work, and in line with the original factor content approach, we remain interested in the overall impact of trade on earnings inequality, rather than the impact of specific shocks. But in line with more recent empirical work, and in contrast to the original factor content approach, we give center stage to the observed response of factor prices to foreign shocks in order to strengthen the credibility of our empirical conclusions.

Finally, we note that, throughout this paper, we focus on relative rather than real factor prices and that we use the terms “inequality” and “earnings inequality” interchangeably. A number of papers have also studied how international trade may affect the distribution of real income across individuals by differentially affecting the costs of living faced by individuals with heterogeneous or non-homothetic preferences, either by drawing on survey data ([Porto, 2006](#)), cross-country data ([Fajgelbaum and Khandelwal, 2016](#)), or household scanner data ([Borusyak and Jaravel, 2018](#)). Our analysis has nothing to say about the impact of trade on inequality through such cost-of-living considerations.<sup>6</sup>

---

<sup>6</sup>Among the previous papers, [Porto \(2006\)](#) and [Borusyak and Jaravel \(2018\)](#) also evaluate the earnings consequences of heterogeneous exposure to exports and imports across individuals (in the context of Argentina and the US, respectively). We expand on the earnings-channel side of these studies by developing a model that allows for firm-level input-output linkages and firm-level heterogeneity in factor intensity (as observed in our administrative micro data from Ecuador).

## 2 How Does Trade Affect Earnings Inequality?

The goal of this section is to demonstrate how the impact of trade on inequality can be analyzed in terms of factor supply and factor demand, with trade acting as a shifter of factor demand either through (the price of) imports or (the volume of) exports. In line with our subsequent analysis, we focus on a neoclassical environment in Sections 2.1-2.3 and delay the discussion of increasing returns and imperfect competition to Section 2.4.

### 2.1 Neoclassical Environment

Consider an economy, Home, with many consumers, indexed by  $i \in \mathcal{I}$ , and many firms, indexed by  $n \in \mathcal{N}$ , each potentially able to trade with many foreign firms,  $n \in \mathcal{N}^*$ . We do not impose any restrictions on supply and demand conditions in the rest of the world.

**Domestic Consumers.** Consumers own local factors of production,  $f \in \mathcal{F}$ , and choose their consumption of domestic goods,  $q_i \equiv \{q_{ni}\}$ , in order to maximize their utility subject to their budget constraint,

$$\max_{q_i} \{u_i(q_i) | p \cdot q_i = w \cdot \bar{l}_i\}, \quad (1)$$

where  $p \equiv \{p_n\} > 0$  is the vector of domestic good prices;  $w \equiv \{w_f\} > 0$  is the vector of factor prices;  $\bar{l}_i \equiv \{\bar{l}_{fi}\} \geq 0$  is consumer  $i$ 's vector of factor endowments;  $u_i$  is continuous and strictly quasi-concave for all  $i \in \mathcal{I}$ ; and  $\cdot$  denotes the inner product of two vectors.<sup>7</sup> We let  $d_i(p, w)$  denote the unique solution to (1) and  $D(p, w) \equiv \{\sum_{i \in \mathcal{I}} p_n d_{i,n}(p, w)\}$  denote the associated vector of total domestic expenditure.

**Domestic Firms.** Domestic firms  $n \in \mathcal{N}$  choose their output,  $y_n$ , their demand of domestic and foreign intermediates,  $m_n \equiv \{m_{rn}\}$  and  $m_n^* \equiv \{m_{rn}^*\}$ , and their demand of domestic factors,  $l_n \equiv \{l_{fn}\}_{f \in \mathcal{F}}$ , in order to maximize their profits,

$$\max_{y_n, l_n, m_n, m_n^*} \{p_n y_n - w \cdot l_n - p \cdot m_n - p^* \cdot m_n^* | y_n \leq f_n(l_n, m_n, m_n^*)\}, \quad (2)$$

---

<sup>7</sup>Economies with elastic labor supply are nested by treating leisure as an additional non-traded good. Roy models, as in [Ohnsorge and Trefler \(2007\)](#), [Costinot and Vogel \(2010\)](#), and [Grossman et al. \(2017\)](#), are also nested by treating workers with different productivity levels across sectors or occupations as distinct factors of production. Finally, since we will allow for trade in intermediate goods, the assumption that foreign goods do not directly enter the utility function of domestic consumers is also without loss. Imports of final goods are captured by the sales of “domestic” firms that produce using zero domestic factors, zero domestic intermediate goods, and only foreign intermediate goods. In practice, all imports in our dataset are accounted for by firms with at least some domestic value added.



where  $p^* \equiv \{p_n^*\} > 0$  is the vector of foreign good prices and  $f_n$  is continuous, strictly quasi-concave, and homogeneous of degree one.<sup>8</sup> We further assume that some domestic factor or foreign intermediate is essential in production, i.e.,  $f_n(0, m_n, 0) = 0$  for all  $n \in \mathcal{N}$ , and that all goods can be produced, i.e. there exists  $\{l_n, m_n, m_n^*\}$  such that  $f_n(l_n, m_n, m_n^*) > \sum_{r \in \mathcal{N}} m_{nr}$  for all  $n \in \mathcal{N}$ . The associated unit-cost minimization problem is

$$c_n(p, p^*, w) \equiv \min_{l_n, m_n, m_n^*} \{p \cdot m_n + p^* \cdot m_n^* + w \cdot l_n \mid 1 \leq f_n(l_n, m_n, m_n^*)\}.$$

For future reference, we let  $(l_n(p, p^*, w), m_n(p, p^*, w), m_n^*(p, p^*, w))$  denote the unique solution to this problem,  $A(p, p^*, w) \equiv \{x_{fn}(p, p^*, w)\}$  denote the matrix of domestic factor shares,  $x_{fn}(p, p^*, w) \equiv w_f l_{fn}(p, p^*, w) / c_n(p, p^*, w)$ , and  $M(p, p^*, w) \equiv \{x_{nr}(p, p^*, w)\}$  denote the domestic input-output matrix, with  $x_{nr}(p, p^*, w) \equiv p_n m_{nr}(p, p^*, w) / c_r(p, p^*, w)$ .<sup>9</sup>

**Market clearing.** Domestic good and factor market clearing requires

$$y_n = \sum_{r \in \mathcal{N}} m_{nr} + \sum_{i \in \mathcal{I}} q_{ni} + e_n, \text{ for all } n \in \mathcal{N}, \quad (3)$$

$$\sum_{n \in \mathcal{N}} l_{fn} = \bar{L}_f, \text{ for all } f \in \mathcal{F}, \quad (4)$$

where  $e \equiv \{e_n\}_{n \in \mathcal{N}} \geq 0$  is the vector of exports from Home to the rest of the world and  $\bar{L}_f \equiv \sum_{i \in \mathcal{I}} \bar{L}_{fi}$  is the total supply of factor  $f$  at Home.

**Competitive equilibrium.** We are now ready to define a competitive equilibrium.<sup>9</sup>

**Definition 1.** Given  $(p^*, e)$ , a competitive equilibrium at Home corresponds to an allocation  $(\{q_{i,T}\}_{i \in \mathcal{I}}, \{y_{n,T}, l_{n,T}, m_{n,T}, m_{n,T}^*\}_{n \in \mathcal{N}})$  and a vector of prices  $(p_T, w_T)$  such that:  $q_{i,T}$  solves (1) for all  $i \in \mathcal{I}$ ;  $(y_{n,T}, l_{n,T}, m_{n,T}, m_{n,T}^*)$  solves (2) for all  $n \in \mathcal{N}$ ; and conditions (3) and (4) hold.

Throughout our analysis, we assume that factor endowments,  $\{\bar{L}_{fi}\}$ , production functions,  $\{f_n\}$ , and the foreign variables,  $(p^*, e)$ , are such that a competitive equilibrium at Home exists. Note that our definition focuses on domestic equilibrium conditions and treats the price of foreign goods,  $p^*$ , as well as the quantities imported by foreigners,  $e$ , as

<sup>8</sup>Offshoring by domestic firms, as in Grossman and Rossi-Hansberg (2008), is nested by adding services supplied by workers located in the rest of the world to the vector of foreign intermediate goods  $m_n^*$ . Note that in contrast to a standard Heckscher-Ohlin model, we let domestic and foreign goods be imperfect substitutes, an important feature for the impact of trade on inequality, as we discuss in Sections 2.4 and 7.2.

<sup>9</sup>Consistent with the use of firm-level transaction data from VAT records in our empirical analysis, we define cells of the domestic input-output matrix at the “firm-firm” level. While this leads to significantly more entries than in a traditional input-output matrix defined at the “sector-sector” level, we note that this abstracts from any further product-level heterogeneity on either the selling or buying side.

parameters. For the purposes of analyzing how imposing import tariffs on foreign goods or how specific foreign shocks affect inequality, one would need to specify the foreign supply and demand conditions that would ultimately pin down  $p^*$  and  $e$ . For the purposes of estimating the overall impact of trade on inequality, however, one can remain agnostic about such conditions, as we demonstrate next.

## 2.2 Factor Demand, Factor Supply, and Factor Prices

To highlight how factor demand and factor supply considerations determine factor prices and prepare our analysis of the impact of trade on inequality, we propose to eliminate the vector of domestic good prices  $p$  by using the zero profit conditions,  $p_n = c_n(p, p^*, w)$  for all  $n \in \mathcal{N}$ .<sup>10</sup> That is, we view good prices as determined by input prices,  $p^*$  and  $w$ , not the other way around, a point we come back to when discussing [Stolper and Samuelson's \(1941\) Theorem](#) in [Section 2.4](#).

The existence of a unique solution,  $\tilde{p}(p^*, w) > 0$ , to the system of zero-profit conditions derives from [Samuelson's \(1951\) Nonsubstitution Theorem](#).<sup>11</sup> Using the previous solution to eliminate good prices in the demand of domestic consumers and firms, we can then define Home's domestic factor demand system as follows.

**Definition 2.** Home's domestic factor demand system,  $L(p^*, w) \equiv \{L_f(p^*, w)\}$ , is given by

$$\{w_f L_f(p^*, w)\} \equiv A(\tilde{p}(p^*, w), p^*, w) B(\tilde{p}(p^*, w), p^*, w) D(\tilde{p}(p^*, w), w), \quad (5)$$

where  $B(p, p^*, w) \equiv \sum_{j=0}^{\infty} M^j(p, p^*, w)$  is the Leontief inverse associated with  $M(p, p^*, w)$ .

By construction, each entry  $L_f(p^*, w)$  of the vector  $L(p^*, w)$  represents the total quantity of factor  $f$  demanded by domestic firms in order to produce the final goods demanded by domestic consumers, as a function of the vector of foreign import prices,  $p^*$ , and the vector of domestic factor prices,  $w$ . This includes the quantities demanded directly, as well as those demanded indirectly through the production of the intermediates required to produce final goods, the intermediate required to produce those intermediates, etc.

---

<sup>10</sup>For the purposes of characterizing equilibrium factor prices, our focus on equilibria where the zero-profit condition is binding for all domestic firms, including those with zero output, is without loss of generality in the sense that for any competitive equilibrium in which the previous condition is slack for some firms, there exists a competitive equilibrium in which it binds, as established by [Lemma 2](#) in [Appendix A.1](#).

<sup>11</sup>[Acemoglu and Azar \(2020\)](#) (their Theorems 1 and 2) offer a recent proof in an environment with one primary factor of production, labor, and where all goods can be produced using labor only. [Appendix A.1](#) demonstrates how to adapt their proof to the environment of [Section 2.1](#). We thank John Sturm for help with the formal argument and refer the interested reader to [Flynn et al. \(2020\)](#) for further results.

Next, let  $A_T \equiv A(\tilde{p}(p^*, w_T), p^*, w_T)$  and  $B_T \equiv B(\tilde{p}(p^*, w_T), p^*, w_T)$  denote the values of the matrix of domestic factor shares and the Leontief inverse evaluated at the competitive equilibrium. Following [Leontief \(1953\)](#), let us also define the factor content of exports,  $L^* \equiv \{L_f^*\}$ , such that

$$\{w_f L_f^*\} \equiv A_T B_T E, \quad (6)$$

where  $E \equiv \{\tilde{p}_n(p^*, w_T) e_n\}$  is the vector of total foreign expenditure on domestic exports. The next lemma states that in a competitive equilibrium, factor prices must equalize domestic factor demand and domestic factor supply, i.e. total factor supply,  $\bar{L}_f$ , minus the factor content of exports,  $L_f^*$ .

**Lemma 1.** *Under the assumptions of Section 2.1, if  $w_T > 0$  is part of a competitive equilibrium with import prices,  $p^* > 0$ , and factor content of exports,  $L^* \geq 0$ , then  $(p^*, L^*, w_T)$  satisfy*

$$L_f(p^*, w_T) = \bar{L}_f - L_f^* \text{ for all } f \in \mathcal{F}. \quad (7)$$

The proof of Lemma 1 can be found in Appendix A.2. Equation (7) is not an accounting identity. It is a structural relationship between  $p^*$ ,  $L^*$ , and  $w_T$  that depends on the shape of the domestic factor demand system,  $L(\cdot, \cdot)$ . This relationship between domestic factor demand and domestic factor supply summarizes how domestic preferences, domestic technology, and competitive markets interact to determine domestic factor prices, regardless of whether Home is open or closed to trade. We now use it to measure the impact of trade on inequality.

### 2.3 The Overall Incidence of Trade on Earnings Inequality

Measuring the overall incidence of trade on inequality requires the comparison of the factor prices,  $w_T$ , that prevail in some observed equilibrium, where Home can both export and import, to the factor prices,  $w_A$ , that would prevail in a counterfactual autarkic equilibrium, where Home can do neither.

As a matter of theory, this is a simple exercise. Let  $RD_f(p^*, w) \equiv L_f(p^*, w) / L_0(p^*, w)$  denote the domestic relative factor demand for  $f$  relative to factor “0”, which we will use as our numeraire  $w_0 = 1$ ;<sup>12</sup> and let  $RS_f \equiv \bar{L}_f / \bar{L}_0$  denote the total relative supply of factor  $f$ . In the original equilibrium with observed factor prices,  $w_T$ , import prices,  $p^*$ , and factor content of exports,  $L^*$ , Lemma 1 implies the equality of domestic relative factor demand

---

<sup>12</sup>Since both consumers’ and firms’ demand are homogeneous of degree zero in all prices and domestic good prices  $\tilde{p}(p^*, w)$  are homogeneous of degree one in  $(p^*, w)$ , equation (5) implies that the domestic factor demand system,  $L(\cdot, \cdot)$ , is homogeneous of degree zero in  $(p^*, w)$ .

and domestic relative factor supply

$$RD_f(p^*, w_T) = RS_f / REE_f \text{ for all } f \neq 0, \quad (8)$$

where  $REE_f \equiv [1 - (L_0^* / \bar{L}_0)] / [1 - (L_f^* / \bar{L}_f)]$  measures the relative export exposure of factor  $f$ . In the counterfactual autarkic equilibrium, import prices would move above their reservation values, which we denote by  $p_A^* = \infty$ , whereas exports and their factor content would drop to zero,  $L_A^* = 0$ , leading to

$$RD_f(\infty, w_A) = RS_f \text{ for all } f \neq 0. \quad (9)$$

When moving from the trade equilibrium described in equation (8) to the autarkic equilibrium in (9), domestic factor prices shift for two reasons. First, exports and, in turn, the domestic factor services that they embody must go to zero. We refer to this as an *export channel* captured by the shift from the black relative supply curve (to the domestic market) to the red one in Figure 1 as  $REE_f \rightarrow 1$ . Second, domestic demand for foreign goods must go to zero. We refer to this as an *import channel* captured by the shift from the black relative demand curve to the red one in Figure 1 as  $p^* \rightarrow \infty$ .<sup>13</sup>

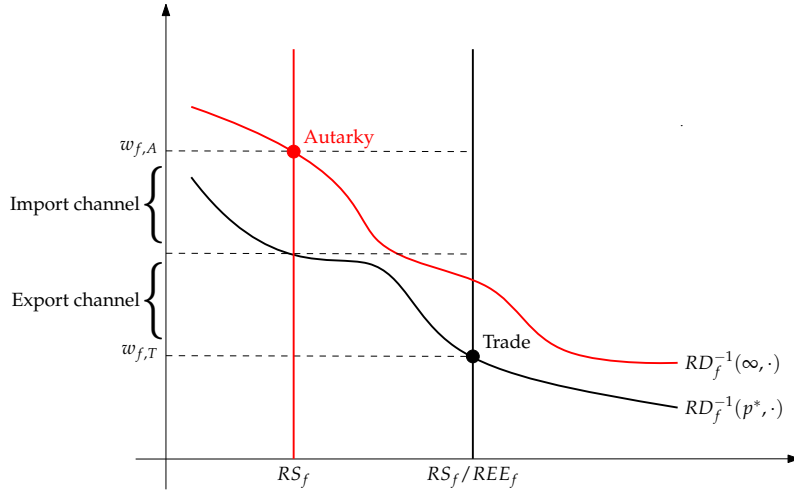
Formally, let  $(\Delta \ln w)_{trade} \equiv \{\ln(w_{f,T} / w_{f,A})\}_{f \neq 0}$  denote the vector of log-differences in domestic factor prices between the autarkic counterfactual equilibrium and the original equilibrium, let  $RD(p^*, w) \equiv \{RD_f(p^*, w)\}_{f \neq 0}$  denote the vector of domestic relative factor demand, and let  $REE \equiv \{REE_f\}$  denote the vector of relative export exposure. Throughout our analysis, we assume that a solution to (8) exists for all  $(p^*, REE)$ , that  $\ln RD$  is continuously differentiable, and that the matrix of domestic price elasticities  $\partial \ln RD / \partial \ln w \equiv \{\partial \ln RD_f / \partial \ln w_g\}$  is invertible. Starting from equation (8) and invoking the Implicit Function Theorem, we therefore obtain the following characterization of the changes in domestic factor prices between the autarkic and trade equilibria.

**Proposition 1.** *Suppose that the assumptions of Section 2.1 hold, that a solution to (8) exists*

---

<sup>13</sup>This decomposition into export and import channels is one among many possible paths to autarky. From a mathematical standpoint, all paths must lead to the same conclusion about the impact of autarky on factor prices. So there is no issue focusing on this particular one; all that matters is that one can solve for  $w$  as a function of  $REE$  and  $p^*$  along this path. From an economic standpoint, though, a distinct question is whether one can engineer shocks to foreign preferences, technology, or factor supply that would independently shift  $REE_f$  and  $p^*$  in this way, while still being consistent with a competitive equilibrium (since  $REE_f$  depends on  $L_f^*$  which is itself a function of  $w$  and  $p^*$ , as described in equation 6). If  $p^*$  were equal to the price vector of all tradable goods, the answer would be no. In that case,  $p^*$  would pin down  $e$ , so  $REE_f$  and  $p^*$  would have to be perfectly correlated along any path to autarky. In our analysis, however,  $p^*$  is defined as the price vector of foreign, not all tradable goods. Hence, in general, there can be foreign shocks that affect  $REE_f$  without affecting  $p^*$  and vice versa, a feature that we will take advantage of in the empirical analysis of Sections 5 and 6.

**Figure 1: The Overall Incidence of Trade on Earnings Inequality**



Notes: At the original equilibrium, domestic factor prices ( $w_T$ ) equate domestic relative factor demand,  $RD_f(p^*, w_T)$ , and its supply,  $RS_f/REE_f$ . The effect of eliminating trade (i.e. determining  $w_A$ ) can be decomposed into an export channel ( $REE_f \rightarrow 1$ , at  $p^*$ ) and an import channel ( $p^* \rightarrow \infty$ , at  $REE_f = 1$ ).

for all  $(p^*, REE)$ , that  $\ln RD$  is continuously differentiable with respect to  $(p^*, w)$ , and that  $\partial \ln RD / \partial \ln w \equiv \{\partial \ln RD_f / \partial \ln w_g\}$  is invertible for all  $(p^*, w)$ . Then differences in domestic factor prices between the trade and autarky equilibria are given by

$$\begin{aligned}
 (\Delta \ln w)_{trade} &= - \underbrace{\int_{(u=0, v=\ln p^*)}^{(u=\ln REE, v=\ln p^*)} \left( \frac{\partial \ln RD}{\partial \ln w} \right)^{-1} du}_{\equiv (\Delta \ln w)_{exports}} \\
 &\quad - \underbrace{\int_{(u=0, v=\infty)}^{(u=0, v=\ln p^*)} \left( \frac{\partial \ln RD}{\partial \ln w} \right)^{-1} \left( \frac{\partial \ln RD}{\partial \ln p^*} \right) dv}_{\equiv (\Delta \ln w)_{imports}}
 \end{aligned}$$

where  $\partial \ln RD / \partial \ln p^* \equiv \{\partial \ln RD_f / \partial \ln p_n^*\}$  is the matrix of foreign price elasticities.

The proof can be found in Appendix A.3. Setting aside potential differences in domestic price elasticities, Proposition 1 implies that factors that benefit the most from opening up to trade are those that tend to be exported more—and hence have higher values of  $REE_f$ —and those that are less substitutable with foreign imports—and hence have lower values of  $\partial \ln RD_f / \partial \ln p_n^*$ . We will use both observations to construct measures of export and import exposures across individuals in Section 4.<sup>14</sup> Having specified a domestic factor

<sup>14</sup>In contrast to the original factor content approach, which we discuss in detail below, Proposition 1 offers an asymmetric treatment of the export channel, which depends on standard factor content calculations, and the import channel, which depends on foreign prices. Provided there exists a one-to-one mapping between

demand system in Section 3 and estimated it in Section 5, we will then use Proposition 1 to compute the full incidence of trade on earnings inequality in Section 7.

## 2.4 Discussion

Before putting Proposition 1 to work, we briefly discuss how our approach relates to previous studies on trade and inequality and the extent to which it can accommodate global value chains, increasing returns, and imperfect competition.

**Comparison to Original Factor Content Approach.** Proposition 1 offers a strict generalization of the factor content approach pioneered by Deardorff and Staiger (1988). Their original result critically relies on the assumption that all imported goods are also produced at Home. In a Heckscher-Ohlin model, this is what occurs when countries are in the same cone of diversification. Under this assumption, domestic firms would be willing to produce the quantities imported by Home at the original trade prices, and domestic consumers would be willing to consume such extra output; as such, the relative domestic factor demand curve is perfectly elastic around the initial trade equilibrium.<sup>15</sup> Factor prices under trade are thus equal to those that would prevail in a hypothetical autarkic equilibrium with factor supply adjusted by *net* export shares of each factor,  $NEE_f$ , and changes in factor prices between trade and autarky can be computed as the changes between two autarkic equilibria with factor supply  $\bar{L}_f$  and  $\bar{L}_f(1 - NEE_f)$ , as described in Figure 2.<sup>16</sup> If technology and preferences are Cobb-Douglas, as in Deardorff and Staiger (1988), or more generally CES with a common elasticity of substitution  $\eta_{agg} > 0$ , as in Deardorff (2000), the domestic factor demand system under autarky,  $RD(\infty, w)$ , is also CES with elasticity of substitution  $\eta_{agg} > 0$ . The impact of trade on inequality is therefore

$$(\Delta \ln w)_{trade} = \ln(RNEE) / \eta_{agg}, \quad (10)$$

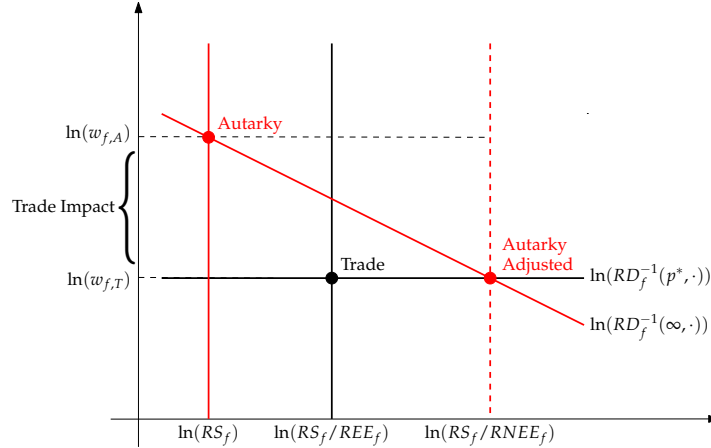
---

foreign import prices and foreign import volumes, one could further change variables to eliminate foreign prices, as in Arkolakis et al. (2012). The import channel would then be measured by taking import volumes to zero rather than import prices to infinity. Not taking that extra step simplifies the economic interpretation of the price elasticities in Section 3 and, in turn, our import exposure measures in Section 4.

<sup>15</sup>A perfectly elastic demand curve arises because domestic and foreign goods are perfect substitutes, which violates the strict quasi-concavity of preferences imposed in Section 2.1. In that case, domestic factor demand is a correspondence rather than a function. In such environments, one can no longer formally invoke the Implicit Function Theorem to describe the impact of trade on factor prices, as we did in Proposition 1. Instead one may consider the limit of environments where domestic and foreign goods are close, but imperfect substitutes, and the assumptions of Proposition 1 hold.

<sup>16</sup>Net exports of factor  $f$  are equal to its gross exports,  $L_f^*$ , minus the amount of factor  $f$  that would be required to produce the vector of Home's imports.

**Figure 2: Original Factor Content Approach**



Notes: Following [Deardorff and Staiger \(1988\)](#), when Home produces all imported goods and hence  $RD_f(p^*, w_T)$  is perfectly elastic around the trade equilibrium, the impact of trade on factor prices is equal to the effect in autarky, i.e. for  $RD_f(\infty, w)$ , of a hypothetical shift in  $RS_f$  by the amount of the relative *net* export exposure ( $RNEE_f$ ). Illustrated for the [Deardorff \(2000\)](#) case in which  $RD_f(\infty, w)$  is isoelastic.

with  $RNEE \equiv \{(1 - NEE_0) / (1 - NEE_f)\}_{f \neq 0}$ .<sup>17</sup> This is the limit of the general formula for  $(\Delta \ln w)_{trade}$  in [Proposition 1](#) in an environment with nested CES preferences, as the elasticity of substitution between goods from different countries is taken to infinity.<sup>18</sup>

**Comparison to Price Approach.** [Lemma 1](#) emphasizes two sufficient statistics of foreign shocks: import prices and the factor content of exports. They are, by no means, the only ones. In a neoclassical environment, we know that the vector of all good prices, both domestic and foreign, also are sufficient statistics of foreign shocks, as reflected in the zero-profit condition,  $p_n = c_n(p, p^*, w)$ . This is the equilibrium relationship behind [Stolper and Samuelson's \(1941\)](#) Theorem (and the relationship pinning down the level of  $w_T$  in [Figure 2](#)). This is also the starting point of a number of empirical “product-price studies” reviewed in [Slaughter \(2000\)](#), such as [Lawrence and Slaughter \(1993\)](#), [Leamer \(1998\)](#), and [Feenstra](#)

<sup>17</sup>[Burstein and Vogel \(2017\)](#) offer the following generalization of the previous formula. As a matter of accounting, they note that the value of payments received by a given factor are always equal to the payments made by firms to that factor. Since this accounting identity holds both under trade and autarky, it follows that changes in the payments received by a factor between trade and autarky can always be expressed as the changes in the payments made by firms to that factor. It also follows that if one decomposes the latter into [Deardorff's \(2000\)](#) original formula and a residual, then [Deardorff's \(2000\)](#) formula holds whenever that residual is zero. Compared to [Burstein and Vogel \(2017\)](#), who emphasize that the previous residual is non-zero in their structural model, one can view [Proposition 1](#) as providing a general structural interpretation of that residual.

<sup>18</sup>For empirical purposes, a challenge in applying this formula is that  $\eta_{agg}$  is *not* the elasticity of substitution between factors in the trade equilibrium. Indeed, for the original factor content approach to be valid, the latter elasticity should be infinite. Instead,  $\eta_{agg}$  is the slope of  $RD(w, \infty)$ , the red demand curve in [Figure 2](#), an issue already emphasized in [Leamer \(2000\)](#).

and Hanson (1999), that, like the aforementioned factor content approach, aimed to shed light on the impact of trade on inequality.

If prices are sufficient statistics, a skeptical reader may ask: why not stop there rather than introduce the factor content of exports? The answer depends on the counterfactual question of interest. If the goal is to uncover the changes in factor prices that would have taken place in a counterfactual economy subject to the observed product-price changes, but absent any technological changes, the zero-profit condition would be enough. This is not, however, the question that we are interested in. Like the original factor content approach, Proposition 1 is interested in the counterfactual factor prices that would be observed in the absence of trade. This requires taking a stand on more than domestic technology, which solely drives  $\{c_n(p, p^*, w)\}$ , but also on the domestic preferences that contribute, alongside technology, to the domestic factor demand system,  $L(p^*, w)$ , as can be seen from equation (5). And while we do not know what domestic good prices would be under autarky, we know that the factor content of exports would be zero.<sup>19</sup>

**Global Value Chains.** The factor content calculations carried out in Section 2.2 use a single domestic input-output matrix, as in Leontief's (1953) original work, not a global one, as in subsequent Heckscher-Ohlin-Vanek tests, such as Trefler and Zhu (2010), or recent work on global value chains, such as Johnson and Noguera (2012). Neither Lemma 1 nor Proposition 1, however, require the assumption that foreign imports have zero domestic value added. The existence of global value chains does not affect Home's factor demand,  $L(p^*, w)$ , which only depends on domestic preferences and technology, as described in equation (5); and it does not affect the fact that foreign prices  $p^*$  and exports  $e$  would converge to infinity and zero, respectively, under autarky. Hence, our analysis is fully consistent with the existence of global value chains.<sup>20</sup>

**Non-Neoclassical Environments.** So far we have focused on neoclassical environments, with constant returns to scale and perfect competition in both good and factor markets. As shown in our working paper, Adao et al. (2020b), only the last of these assumptions

---

<sup>19</sup>We have nothing to add to the relative merits of these alternative counterfactual questions and refer the interested reader to the discussion of this point in Deardorff (2000), Krugman (2000), and Leamer (2000).

<sup>20</sup>As a matter of definition, one could instead define Home's domestic factor demand system inclusive of the domestic factors embodied in foreign imports and used for domestic consumption. This is the strategy that Adao et al. (2017) followed to study the impact of arbitrary changes in trade costs. For the purposes of the present paper, which is only to construct autarky counterfactuals, this is an inferior strategy. It would imply a higher data cost, since global input-output matrices are necessary to track the domestic factors embodied in foreign imports and used for domestic consumption, but lead to the same conclusions, since foreign technologies are ultimately irrelevant under autarky.



is necessary to define a domestic factor demand system and generalize Proposition 1 to environments with increasing returns to scale and imperfectly competitive good markets, such as Yeaple (2005), Bernard et al. (2007a), Sampson (2014), Harrigan and Reshef (2016), Antras et al. (2017a), and Fieler et al. (2018). Theoretically, the only distinction is that the vector of foreign prices that appears as a shifter of domestic factor demand should now be the vector of foreign *factor* prices, which is still taken as given by (foreign) firms, rather than the vector of foreign good prices.<sup>21</sup>

### 3 An Empirical Model of Domestic Factor Demand

Proposition 1 gives center stage to relative domestic factor demand,  $RD(p^*, w)$ . We now describe an empirical version of the model in Section 2 that allows  $RD(p^*, w)$  to be estimated from firm- and individual-level micro-data. Despite the parametric restrictions introduced, our model remains considerably more general than the original factor content approach: it does not require factor demand to be perfectly elastic; it does not impose any restriction on the heterogeneity in factor intensity across firms; and it allows arbitrary input-output linkages both between and within sectors.

#### 3.1 Parametric Restrictions

Consider a parametric version of Section 2's environment in which Home's preferences and technology are nested CES.

**Preferences.** All domestic consumers  $i \in \mathcal{I}$  have the same nested CES utility function over the goods produced by domestic firms  $n \in \mathcal{N}_k$  in different sectors  $k \in \mathcal{K}$ ,

$$u_i = \prod_{k \in \mathcal{K}} (u_{i,k})^{\alpha_k}, \quad (11)$$

$$u_{i,k} = \left( \sum_{n \in \mathcal{N}_k} \theta_{nc}^{\frac{1}{\sigma}} q_{i,n}^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}}, \quad (12)$$

---

<sup>21</sup>This distinction is moot for imperfectly competitive models with a pure export channel, i.e.  $(\Delta \ln w)_{imports} = 0$ , a case that arises whenever relative domestic factor demand is independent of foreign prices. This occurs most notably in multi-factor extensions of Melitz (2003) that maintain CES preferences across all goods, e.g. Sampson (2014), Harrigan and Reshef (2016), and Antras et al. (2017a). Indeed, when each firm employs a distinct type of workers, Proposition 1 implies  $(\Delta \ln w)_{trade} = \ln REE / \eta_{agg}$ , where  $\eta_{agg}$  is equal to the elasticity of substitution between goods produced by different firms (and hence the different factors they employ). Compared to the original factor content approach, in this case, it is *gross* rather than *net* export exposure that determines the distributional impact of trade.

where  $\alpha_k, \theta_{nc} \geq 0$  are exogenous preference parameters, such that  $\sum_{k \in \mathcal{K}} \alpha_k = 1$  and  $\sum_{n \in \mathcal{N}_k} \theta_{nc} = 1$ ; and  $\sigma > 0$  is the elasticity of substitution between goods produced by different firms from the same sector. Thus, total domestic expenditure is equal to

$$D_n(p, w) = \frac{\alpha_k \theta_{nc} p_n^{1-\sigma} (w \cdot \bar{L})}{\sum_{r \in \mathcal{N}_k} \theta_{rc} p_r^{1-\sigma}}, \text{ for all } n \in \mathcal{N}_k \text{ and } k \in \mathcal{K}. \quad (13)$$

**Technology.** All domestic firms have a nested CES production function over domestic factors  $f \in \mathcal{F}$ , the goods produced by domestic firms  $n \in \mathcal{N} = \cup_{k \in \mathcal{K}} \mathcal{N}_k$ , and the goods produced by foreign firms  $n \in \mathcal{N}^*$ ,

$$y_n = \varphi_n (\bar{l}_n)^{\beta_n} (\bar{m}_n)^{1-\beta_n}, \quad (14)$$

$$\bar{m}_n = \left( \prod_{r \in \mathcal{N}} m_{rn}^{\theta_{rn}} \right)^{\Theta_n} \left( \prod_{r \in \mathcal{N}^*} (m_{rn}^*)^{\theta_{rn}^*} \right)^{1-\Theta_n}, \quad (15)$$

$$\bar{l}_n = \left( \sum_{f \in \mathcal{F}} \theta_{fn}^{\frac{1}{\eta}} l_{fn}^{\frac{\eta-1}{\eta}} \right)^{\frac{\eta}{\eta-1}}, \quad (16)$$

where  $\varphi_n, \beta_n, \Theta_n, \theta_{fn}, \theta_{rn}, \theta_{rn}^* \geq 0$  are exogenous technology parameters, with  $\beta_n \in [0, 1]$ ,  $\Theta_n \in [0, 1]$ ,  $\sum_{r \in \mathcal{N}} \theta_{rn} = \sum_{r \in \mathcal{N}^*} \theta_{rn}^* = \sum_{f \in \mathcal{F}} \theta_{fn} = 1$ , and  $(1 - \beta_n)\Theta_n < 1$ , so that either domestic factors or foreign intermediates are required in production; and  $\eta > 0$  is the elasticity of substitution between domestic factors. Thus, shares of costs spent on domestic factors, domestic intermediates, and foreign intermediates are equal to

$$x_{fn}(p, p^*, w) = \frac{\beta_n \theta_{fn} w_f^{1-\eta}}{\sum_{g \in \mathcal{F}} \theta_{gn} w_g^{1-\eta}}, \text{ for all } f \in \mathcal{F} \text{ and } n \in \mathcal{N}, \quad (17)$$

$$x_{rn}(p, p^*, w) = (1 - \beta_n) \Theta_n \theta_{rn}, \text{ for all } r \in \mathcal{N} \text{ and } n \in \mathcal{N}, \quad (18)$$

$$x_{rn}^*(p, p^*, w) = (1 - \beta_n)(1 - \Theta_n) \theta_{rn}^*, \text{ for all } r \in \mathcal{N}^* \text{ and } n \in \mathcal{N}, \quad (19)$$

whereas unit costs are equal to

$$c_n(p, p^*, w) = \varphi_n \left[ \sum_{f \in \mathcal{F}} \theta_{fn} w_f^{1-\eta} \right]^{\frac{\beta_n}{1-\eta}} \left[ \left( \prod_{r \in \mathcal{N}} (p_r)^{\theta_{rn}} \right)^{\Theta_n} \left( \prod_{r \in \mathcal{N}^*} (p_r^*)^{\theta_{rn}^*} \right)^{1-\Theta_n} \right]^{1-\beta_n}, \text{ for all } n \in \mathcal{N}, \quad (20)$$

with  $\varphi_n \equiv \varphi_n^{-1} (\beta_n)^{-\beta_n} [(\prod_{r \in \mathcal{N}} (\theta_{rn})^{\theta_{rn}} \Theta_n)^{\Theta_n} (\prod_{r \in \mathcal{N}^*} (\theta_{rn}^*)^{\theta_{rn}^*} (1 - \Theta_n))^{(1-\Theta_n)} (1 - \beta_n)]^{-(1-\beta_n)}$  an adjusted measure of firm  $n$ 's productivity. We note that, because of the previous Cobb-Douglas assumptions, both the domestic input-output matrix,  $M(p, p^*, w) = \{(1 - \beta_r) \Theta_r \theta_{nr}\}$ ,

as well as its Leontief inverse,  $B(p, p^*, w) = \{b_{nr}\}$ , are independent of all prices.<sup>22</sup>

**Relative Domestic Factor Demand.** Starting from the definition of domestic factor demand in equation (5) and using equations (13), (17), (18), and (20) to substitute for domestic expenditure, factor cost shares, and domestic prices, we obtain the following characterization of relative domestic factor demand.

**Proposition 2.** *Suppose that (11), (12), (14), (15), and (16) hold. Then for any factor  $f \neq 0$ , relative domestic factor demand is equal to*

$$RD_f(p^*, w) = \left( \frac{w_f}{w_0} \right)^{-\eta} \frac{\sum_{n \in \mathcal{N}} \theta_{fn} \tilde{w}_n^{\eta-1}(w) \beta_n [\sum_{k \in \mathcal{K}, r \in \mathcal{N}_k} b_{nr} \alpha_k \theta_{rc} \tilde{P}_k^{\sigma-1}(p^*, w) \tilde{p}_r^{1-\sigma}(p^*, w)]}{\sum_{n \in \mathcal{N}} \theta_{0n} \tilde{w}_n^{\eta-1}(w) \beta_n [\sum_{k \in \mathcal{K}, r \in \mathcal{N}_k} b_{nr} \alpha_k \theta_{rc} \tilde{P}_k^{\sigma-1}(p^*, w) \tilde{p}_r^{1-\sigma}(p^*, w)]'}$$

where the price indices,  $\tilde{w}_n(w)$  and  $\tilde{P}_k(p^*, w)$ , and domestic prices,  $\tilde{p}(p^*, w)$ , satisfy

$$\begin{aligned} \tilde{w}_n(w) &\equiv \left( \sum_{f \in \mathcal{F}} \theta_{fn} w_f^{1-\eta} \right)^{\frac{1}{1-\eta}}, \\ \tilde{P}_k(p^*, w) &\equiv \left( \sum_{n \in \mathcal{N}_k} \theta_{nc} \tilde{p}_n^{1-\sigma}(p^*, w) \right)^{\frac{1}{1-\sigma}}, \\ \tilde{p}_n(p^*, w) &\equiv \exp \left\{ \sum_{r \in \mathcal{N}} b_{rn} [\ln \phi_r + \beta_r \ln \tilde{w}_r(w) + \sum_{l \in \mathcal{N}^*} (1-\beta_r)(1-\Theta_r) \theta_{lr}^* \ln p_l^*] \right\}. \end{aligned}$$

The formal proof can be found in Appendix A.4. Although factor demand within each domestic firm is CES, Proposition 2 shows that if firms are heterogeneous in their factor intensities,  $\theta_{fn} \neq \theta_f$ , then Home's domestic factor demand is not.<sup>23</sup> Rather, nested CES preferences and technology aggregate up to a nested CES factor demand system, with two elasticities,  $\sigma$  and  $\eta$ , that are unrestricted and will form the basis of our estimation in Section 5. This allows departures from the Independence of Irrelevant Alternatives (IIA) such that, as emphasized in the import channel from the previous section, changes in foreign import prices may shift relative domestic factor demand. We now turn to the economic considerations that will shape the strength of this import channel.

<sup>22</sup>We also note that our neoclassical model does not feature the fixed costs of exporting and importing that would lead to the endogenous selection of firms into exporting and importing in monopolistically competitive models of trade as in Melitz (2003) and Antras et al. (2017b), for example. Here, firms are indifferent between exporting or selling domestically and spend an exogenous share of their cost on imports.

<sup>23</sup>The only exception is the Cobb-Douglas case:  $\eta = \sigma = 1$ . Note that this special case differs from the environment studied in Deardorff and Staiger (1988) who assume that goods produced by domestic and foreign firms are perfect substitutes within each sector—in our notation, this corresponds to  $\sigma = \infty$ .

## 3.2 Elasticities with Respect to Foreign Import Prices

Our next proposition characterizes the matrix of foreign price elasticities,  $\partial \ln RD / \partial \ln p_n^*$ , as a function of (direct plus indirect) granular purchase shares that are observable in the dataset we describe in Section 4.1. We view it as an important theoretical step before proceeding to our empirical analysis. We will use it to measure which factors, and the individuals who own them, are more exposed to imports in Section 4.4.

**Proposition 3.** *Suppose that (11), (12), (14), (15), and (16) hold. Then for any factor  $f \neq 0$ , the elasticity of relative demand with respect to the price of a foreign good  $p_n^*$  is*

$$\frac{\partial \ln RD_f}{\partial \ln p_n^*} = (\sigma - 1)(IE_{fn} - IE_{0n}),$$

with the measure of import exposure,  $IE_{fn}$ , such that

$$IE_{fn} \equiv - \sum_{k \in \mathcal{K}} \sum_{m \in \mathcal{N}_k} s_{fm} \times (\bar{x}_{nm}^* - \sum_{r \in \mathcal{N}_k} d_{rk} \bar{x}_{nr}^*),$$

where  $s_{fm} \equiv \sum_{v \in \mathcal{N}} x_{fv} b_{vm} D_m / w_f L_f$  is the share of factor  $f$ 's domestic demand used to produce firm  $m$ 's final sales, both directly and indirectly;  $\bar{x}_{nm}^* \equiv \sum_{r \in \mathcal{N}} x_{nr}^* b_{rm}$  is the share of firm  $m$ 's costs spent on imports of good  $n$ , both directly and indirectly; and  $d_{rk} \equiv D_r / (\sum_{m \in \mathcal{N}_k} D_m)$  is the share of sector  $k$ 's final expenditure devoted to firm  $r$ .

Derivations can be found in Appendix A.5. Intuitively, changes in the price of a foreign good  $p_n^*$  affect the relative demand for domestic factors through expenditure switching by domestic consumers, which is captured by  $IE_{fn}$  and whose magnitude depends on the elasticity of substitution between firms  $\sigma$ .<sup>24</sup> This is a smoother version of the standard import competition mechanism emphasized by Stolper and Samuelson's (1941) Theorem and the original factor content approach where domestic and foreign firms are implicitly assumed to be perfect substitutes ( $\sigma = \infty$ ). When the price of a foreign good  $p_n^*$  increases, each firm  $m$  experiences a price increase proportional to its share of total spending, both direct and indirect, on that foreign good,  $\bar{x}_{nm}^* = \sum_{r \in \mathcal{N}} x_{nr}^* b_{rm}$ . In the empirically relevant case of  $\sigma > 1$ , domestic consumers therefore spend less on the domestic firms whose technologies are more intensive in that foreign input than that of their industry competitors, i.e. the firms  $m$  for which  $\bar{x}_{nm}^* - \sum_{r \in \mathcal{N}_k} d_{rk} \bar{x}_{nr}^*$  is high. This triggers a contraction in the domestic demand for the factors that tend to be used to produce the final goods sold by firms more exposed to the im-

<sup>24</sup>The fact that foreign intermediate goods and domestic factors appear in distinct CES nests in equations (14)-(16) explains why  $\eta$  plays no role in Proposition 3.

port price shock, i.e. the factors  $f$  for which  $\sum_{k \in \mathcal{K}} \sum_{m \in \mathcal{N}_k} s_{fm} \times (\bar{x}_{nm}^* - \sum_{r \in \mathcal{N}_k} d_{rk} \bar{x}_{nr}^*)$  is high.<sup>25</sup>

In the absence of intermediate goods,  $IE_{fn}$  takes a particularly simple form. Since all imports are accounted by domestic firms with zero employment of domestic factors (if  $\Theta_m < 1$ ,  $\beta_m = 0$ ), the share of factor  $f$ 's domestic demand used to produce firm  $m$ 's final sales  $s_{fm}$  is zero whenever firm  $m$ 's import share  $\bar{x}_{nm}^*$  is not. In this case, import exposure reduces to  $IE_{fn} = \sum_{k \in \mathcal{K}} \bar{s}_{fk} d_{kn}^*$ , where  $\bar{s}_{fk} \equiv \sum_{r \in \mathcal{N}_k} s_{fr}$  is the share of factor  $f$ 's domestic demand employed in sector  $k$  and  $d_{kn}^*$  is the share of expenditure on imports of good  $n$  in that sector. That is, factors exposed to import competition are those that tend to be employed in sectors where spending shares on imports are higher.

### 3.3 Elasticities with Respect to Domestic Factor Prices

Let us now turn to the matrix of domestic price elasticities,  $\partial \ln RD / \partial \ln w$ . According to Proposition 1, this matrix determines the incidence of shifts in relative export exposure  $REE_f$  and foreign import prices  $p^*$  on domestic factor prices. As shown in Appendix A.6,  $\partial \ln RD / \partial \ln w$  takes the following form.

**Proposition 4.** *Suppose that (11), (12), (14), (15), and (16) hold. Then for any factor  $f \neq 0$ , the elasticity of relative demand with respect to the price of a domestic factor  $w_g$  is equal to*

$$\frac{\partial \ln RD_f}{\partial \ln w_g} = -\eta \mathbb{1}_{\{f=g\}} + (\eta - 1)(DEF_{fg} - DEF_{0g}) + (\sigma - 1)(DEC_{fg} - DEC_{0g})$$

with the two measures of domestic exposures,  $DEF_{fg}$  and  $DEC_{fg}$ , such that

$$DEF_{fg} \equiv \sum_{k \in \mathcal{K}} \sum_{m \in \mathcal{N}_k} r_{fm} \times x_{gm}^D$$

$$DEC_{fg} \equiv - \sum_{k \in \mathcal{K}} \sum_{m \in \mathcal{N}_k} s_{fm} \times (\bar{x}_{gm} - \sum_{r \in \mathcal{N}_k} d_{rk} \bar{x}_{gr}),$$

where  $r_{fm} \equiv \sum_{v \in \mathcal{N}} x_{fv} b_{mv} D_v / w_f L_f$  is the share of factor  $f$ 's domestic demand employed by firm  $m$ ;  $x_{gm}^D \equiv x_{gm} / \sum_{f \in \mathcal{F}} x_{fm}$  is the share of firm  $m$ 's factor costs devoted to factor  $g$ ; and  $\bar{x}_{gm} \equiv \sum_{n \in \mathcal{N}} x_{gn} b_{nm}$  is the share of firm  $m$ 's total cost spent on that factor, both directly and indirectly.

As one would expect, the elasticity of substitution between domestic factors  $\eta$  now also plays a central role. It controls the magnitude of expenditure switching across factors

<sup>25</sup>If  $\sigma < 1$ , the opposite happens. Hence, when foreign prices go down, domestic factors that tend to be employed by firms with higher imports are those for which demand goes down the most. Qualitatively, this is similar to the prediction of offshoring models where opportunities to offshore by some firms tends to reduce the demand for the factors employed by those firms.

within each firm, as can be seen in equation (17). The first term,  $-\eta\mathbb{1}_{\{f=g\}}$ , measures the decrease in the demand for factor  $f$  induced by an increase in its own price, holding fixed the price index of all factors of each firm,  $\tilde{w}_m(w)$ , whereas the second term,  $(\eta - 1)(DEF_{fg} - DEF_{0g})$ , measures the changes in factor demand associated with changes in these price indices.  $DEF_{fg}$  therefore captures the domestic exposure of factor  $f$  to firms' expenditure-switching as the price of factor  $g$  changes. Although factor demand is CES within each firm, the heterogeneity in factor intensity across firms introduces another form of departure from IIA. In the empirically relevant case of  $\eta > 1$ , an increase in the price of a third factor  $g$  leads to an equal amount of expenditure switching towards all other factors within each firm  $m$ , proportional to the share of factor cost,  $x_{gm}^D$ . However, if the domestic demand for factor  $f$  is employed in firms that are on average more intensive in factor  $g$ , i.e. if  $\sum_{k \in \mathcal{K}} \sum_{m \in \mathcal{N}_k} r_{fm} \times x_{gm}^D$  is high, such reallocations increase the aggregate relative demand for factor  $f$ .

The third term in Proposition 4,  $DEC_{fg}$ , has the same interpretation as in the case of the foreign price elasticity of Proposition 3; it captures how changes in the price of a third domestic factor  $g$  affects the relative demand for factor  $f$  through changes in consumer expenditure across domestic firms in a sector. This is the source of departure from IIA in  $RD(p^*, w)$  emphasized earlier for  $\sigma \neq 1$ . The fact that  $\partial \ln RD / \partial \ln w$  is non-diagonal implies that trade may not only affect factor prices because different factors have different export and import exposures, which we will focus on in the next section, but also because they are more or less impacted by changes in the prices of *other* domestic factors, an equilibrium feature that will be active in the empirical and counterfactual exercises of Sections 6 and 7.

## 4 Export Exposure, Import Exposure, and Earnings

We now build on the theoretical results of Sections 2 and 3 to estimate the impact of trade on earnings inequality in Ecuador. In this first empirical section, we use administrative records to construct measures of export and import exposure at different points of Ecuador's income distribution. This will allow us to evaluate whether poor or rich individuals experience larger shifts in the demand for their factor services because of international trade and, in turn, whether they are more or less likely to benefit from it.

### 4.1 Data Sources

Our primary dataset covers Ecuador's formal economy from 2009 to 2015. It tracks the universe of tax IDs—be they from incorporated or non-incorporated privately-owned enterprises, state-owned enterprises, or government agencies—that file a tax return or are

named as a supplier in the return of at least one other tax ID. For expositional purposes, we simply refer to entities with such tax IDs as firms. To those we match all individuals that earn labor income from these firms, or own a share of these firms, or both, over that same period. This gives us an average of 2.9 million individuals per year who are engaged in 1.5 million firms.<sup>26</sup> By its nature, this administrative data provides a comprehensive picture of the formal segment of Ecuador’s private-sector activity, but Section 7.3 introduces a survey-based extension that covers informal activities as well. We describe the key features of our data construction below and report further details in Appendix B. While all these measures are annual, we suppress time subscripts until they are necessary.

**Corporate Income Tax Data.** We use annual corporate income tax forms to measure the revenues  $R_n$ , the total payments to labor and intermediate inputs  $C_n$ , the value of exports  $E_n$ , and the value of imports  $X_n^*$  of domestic firms  $n \in \mathcal{N}$ . Consistent with the neoclassical environment of Sections 2 and 3, we treat the difference  $R_n - C_n$  as payments to other factors (more on that below). Hence revenues  $R_n$  are also equal to total costs. This allows us to compute total import shares  $x_n^* = X_n^*/R_n$  for all domestic firms.

**Value Added Tax Data.** We use tax records related to Ecuador’s valued added tax (VAT) system to measure spending  $X_{rn}$  by a domestic firm  $n$  on intermediate goods from any other domestic firm  $r$ .<sup>27</sup> Given the nature of the VAT transaction data, such spending includes purchases of non-durable materials as well as durable goods like machinery and equipment. This allows us to compute the domestic firm-to-firm input-output matrix  $M$  with elements  $x_{rn} = X_{rn}/R_n$ , as well as the share of any firm  $r$  in the total purchases of domestic inputs by firm  $n$ ,  $\theta_{rn} = X_{rn}/\sum_{m \in \mathcal{N}} X_{mn}$ . By subtracting total sales of intermediate goods and exports from total revenues, we measure sales to domestic consumers as  $D_n = R_n - \sum_{m \in \mathcal{N}} X_{nm} - E_n$ .<sup>28</sup> This allows us, in turn, to compute domestic consumer expenditure shares across sectors,  $\alpha_k = \sum_{r \in \mathcal{N}_k} D_r / \sum_{r \in \mathcal{N}} D_r$ , as well as across firms within sectors,  $d_{nk} = D_n / \sum_{r \in \mathcal{N}_k} D_r$ , with each sector  $k \in \mathcal{K}$  corresponding to one of 62 divisions that firms  $r \in \mathcal{N}_k$  report as their main activity based on the 2-digit ISIC revision 3.1 classification.<sup>29</sup>

<sup>26</sup>While all such firms enter our analysis, the vast majority of these are non-incorporated and/or self-employed individuals, as further detailed below. In practice, few government agencies file tax returns, giving us limited coverage of these agencies and their employees. In the small number of cases for which firms are owned by a holding company, we group them into a single firm.

<sup>27</sup>This merge of corporate income tax and VAT records builds on earlier work by Carrillo et al. (2017).

<sup>28</sup>Whenever this leads to  $D_n < 0$ , we raise the revenues of firm  $n$  to  $R_n = \sum_{m \in \mathcal{N}} X_{nm} + E_n$  so that  $D_n = 0$ .

<sup>29</sup>As described in Appendix B, we further (i) aggregate all firms in the finance sector into a single consolidated firm, (ii) do the same for all state-owned firms and government agencies (apart from the state-owned oil firm, which is Ecuador’s largest exporter), and (iii) create a residual firm (placed into a 63rd sector) whose sales and costs are used to balance all accounting identities in the model.

**Social Security Data.** We use social security records that link individuals to the firms in our sample via labor payments in order to measure spending  $X_{fn}$  by a domestic firm  $n \in \mathcal{N}$  on different labor groups  $f \in \mathcal{F}_{L,SS}$ . We split workers into 73 labor groups. We begin with the three-level classification of education that is known for each worker—less than high school, high school graduate, and college graduate—and then further augment that by the 24 provinces of Ecuador in which each worker earns his or her primary income.<sup>30</sup> This results in 72 labor groups in the social security database. We then create an additional labor group that covers all employed individuals with missing information or those not appearing in social security records,  $\mathcal{F}_{L,NSS}$ .

From the corporate tax forms, we know the total wage payments  $W_n = \sum_{f \in \mathcal{F}_L} X_{fn}$  of each firm  $n$ , with  $\mathcal{F}_L = \mathcal{F}_{L,SS} \cup \mathcal{F}_{L,NSS}$ . For each individual  $i$  in the social security dataset, we also know the wage payments  $W_{in}$  that he or she has received from each firm  $n$ , as well as the labor group  $\mathcal{I}_f$  to which he or she belongs. For each firm  $n$ , we can therefore compute the share of labor payments associated with a particular factor  $f \in \mathcal{F}_{L,SS}$  as  $\sum_{i \in \mathcal{I}_f} W_{in} / \sum_{i \in \mathcal{I}} W_{in}$  and, in turn,  $X_{fn} = (\sum_{i \in \mathcal{I}_f} W_{in} / \sum_{i \in \mathcal{I}} W_{in}) W_n$ . Payments to the residual group of workers not in the social security system are  $X_{Rn} = W_n - \sum_{f \in \mathcal{F}_{L,SS}} X_{fn}$ .

For each individual  $i$ , we let  $Y_{fi}$  denote the labor payments associated with any factor  $f \in \mathcal{F}_L$ . This is either equal to zero, if  $i \notin \mathcal{I}_f$ , or to the sum of labor payments received by individual  $i$  across all domestic firms,  $Y_{fi} = \sum_{n \in \mathcal{N}} (W_{in} / \sum_{j \in \mathcal{I}} W_{jn}) W_n$ , if  $i \in \mathcal{I}_f$ .

**Firm Ownership Data.** We refer to any factor of production not in  $\mathcal{F}_L$  as capital and let  $\mathcal{F}_K$  denote the set of such factors. Further, we assume the existence of two types of capital: “Oil” ( $K_{oil}$ ), which is specific to Ecuador’s large oil sector, and “Not oil” ( $K_{not\ oil}$ ), which is freely mobile across all other sectors. We think of the former type of capital as consisting primarily of oil reserves whose returns are primarily driven by fluctuations in oil prices and unlikely to be correlated with the returns to structure and equipment in other sectors, which is how we think of the second type of capital.

For any firm  $n$  we allocate profits, i.e., the difference  $R_n - C_n$ , as follows. If the firm hires no employees beyond the firm’s owner itself, we treat the firm’s profits as labor income,  $X_{fn} = R_n - C_n$ , accruing to the labor group of the (essentially self-employed) owner. Otherwise, the firm’s profits accrue to  $K_{oil}$  or  $K_{not\ oil}$  depending on the firm’s sector.<sup>31</sup>

<sup>30</sup>A province in Ecuador is roughly equivalent to a commuting zone in the United States. By allowing labor groups to be province-specific, we treat each of these provinces as a separate local labor market.

<sup>31</sup>Whenever profits are negative, we raise firm  $n$ ’s revenues to  $C_n$  in order to bring  $R_n - C_n$  to zero. Those additional sales are then imputed to the residual consolidated firm, as described in Appendix B. This procedure guarantees that either domestic factors or foreign intermediates are required in production and, thus, the existence of the Leontief inverse matrices used below.



By dividing factor spending by total revenue, we obtain the domestic matrix of factor cost shares  $A$  with elements  $x_{fn} = X_{fn}/R_n$  for all domestic factors  $f \in \mathcal{F} = \mathcal{F}_L \cup \mathcal{F}_K$ . The share of firm  $n$ 's costs attributable to primary factors is then given by  $\beta_n = \sum_{f \in \mathcal{F}} x_{fn}$ .

For each individual  $i$ , we then measure capital payments using an administrative ownership database that reports the personal tax IDs of each firm's owners, as well as their corresponding ownership shares.<sup>32</sup> Using those reported shares, we compute the share of each individual  $i$  in the capital payments of firm  $n$ ,  $\theta_{ni}$ . The capital payments of individual  $i$  associated with the oil sector are  $Y_{K_{oil}i} = \sum_{n \in \mathcal{N}_{oil}} \theta_{ni} X_{K_{oil}n}$ , whereas her capital payments associated with the rest of the economy are  $Y_{K_{not\ oil}i} = \sum_{n \notin \mathcal{N}_{oil}} \theta_{ni} X_{K_{not\ oil}n}$ .

The total income of individual  $i$  is then given by  $Y_i = \sum_{f \in \mathcal{F}} Y_{fi}$ , with  $\omega_{fi} = Y_{fi}/Y_i$  denoting the share of her earnings associated with factor  $f$ .<sup>33</sup>

**Customs Data.** We use international trade data from two sources: (i) Ecuadorian firm-level customs transaction records, available from 2009-2011; and (ii) country-level trade from CEPII's BACI dataset, available from 2009-2015. Both datasets report trade flows at the HS6 digit level ( $\mathcal{HS}$ ). These datasets allow us to construct instrumental variables in Section 5 as well as to measure spending  $X_{rn}^*$  by each domestic firm  $n \in \mathcal{N}$  on any product  $r \in \mathcal{HS}$ . Treating each product in the custom records as the counterpart of a foreign firm in the model ( $\mathcal{N}^* = \mathcal{HS}$ ), we can then measure  $\theta_{rn}^* = X_{rn}^*/\sum_{m \in \mathcal{N}^*} X_{mn}^*$  and  $x_{rn}^* = \theta_{rn}^* x_n^*$  for all  $r \in \mathcal{N}^*$  and  $n \in \mathcal{N}$ .

## 4.2 Summary Statistics

Before using the previous data sources to measure the export and import exposures of individuals at different income levels, we provide a few summary statistics about Ecuador's pattern of trade and its income distribution.

**Pattern of Trade.** Ecuador's main export item is oil, which accounts for 54% of total exports in 2009-2011. Besides oil, Ecuadorian exports are biased towards other primary products, such as bananas and other fruits (11%), fish products (10%), and flowers (4%). Ecuador's imports derive predominantly from manufactured products, including machinery and equipment (21%), chemicals (14%), and vehicles (13%), as described in Figure C.1.

<sup>32</sup>This database is only available from 2011 to 2015. For 2009 and 2010, we use the firm's ownership structure reported in 2011.

<sup>33</sup>Since each individual is in only one labor group, she has at most three positive values of  $\omega_{fi}$ : that associated with her labor group and those associated with the two types of capital. In 2012, 7.1% of individuals had positive amounts of both labor and capital income, and this number rises to 42.6% among the top 5% of the income distribution.

This broad pattern of trade—exports of primary products in exchange for imports of manufacturing goods—is by no means unique to Ecuador, but a common feature in many low- and middle-income countries around the globe, as Figure C.2 illustrates.

**Income Distribution.** Appendix B.2.2 presents additional statistics regarding the distribution of earnings among sample individuals in 2012, the midpoint of our dataset, as well as how their sources of earnings vary.<sup>34</sup> Our sample shows the high level of income inequality in Ecuador, similar to much of Latin America. While annual reported income was \$4,874 for the median sample individual, it was \$25,989 and \$187,074 for the individuals in the 90th and 99th percentiles of the income distribution.<sup>35</sup> Also apparent is the strong correlation of educational attainment and capital earnings with total earnings. There are substantially fewer individuals with less than a college degree above the median of the income distribution. Capital income is especially relevant among the highest earners: those in the top 1% of the income distribution, on average, derive 85.3% of their income from capital.

### 4.3 Export Exposure Across the Distribution of Earnings

**From Factor to Individual Export Exposure.** In Section 2, we have defined the relative export exposure of a factor  $f$  as  $REE_f \equiv [1 - (L_0^*/\bar{L}_0)]/[1 - (L_f^*/\bar{L}_f)]$ , where  $L_f^*$  is the factor content of exports, as described in equation (6). As established in Proposition 1, this exposure captures one of the two channels through which international trade may shift factor demand. To construct the individual-level counterpart of these factor demand shifts, we therefore start from the export exposure of each factor appearing in  $REE_f$ , i.e., the ratio of the value of factor  $f$ 's services that are exported, directly and indirectly, to the total value of its services,

$$EE_f \equiv L_f^*/\bar{L}_f = \left( \sum_{n \in \mathcal{N}} x_{fn} \sum_{r \in \mathcal{N}} b_{nr} E_r \right) / \left( \sum_{n \in \mathcal{N}} X_{fn} \right),$$

where we have used the definition of the factor content of exports in equation (6).<sup>36</sup> We then define the export exposure of an individual  $i \in \mathcal{I}$  as

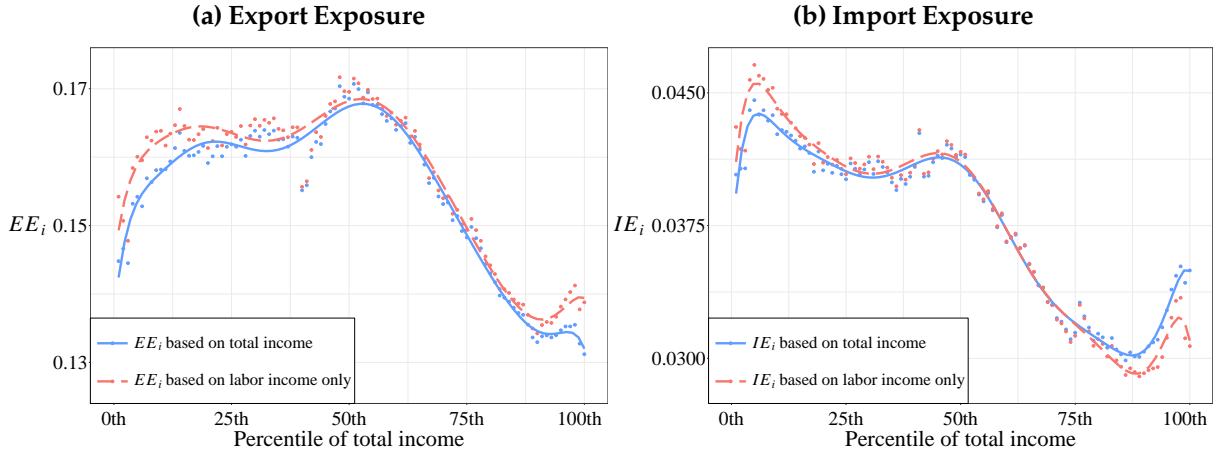
$$EE_i = \sum_{f \in \mathcal{F}} \omega_{fi} \times EE_f, \quad (21)$$

<sup>34</sup>For the purposes of calculating these statistics, we restrict attention to individuals with strictly positive income for whom we have both location and education information.

<sup>35</sup>All nominal values are reported in U.S. dollars (the official currency of Ecuador since 2000).

<sup>36</sup>In practice, we calculate the Leontief inverse matrix  $B_T$  whose entries appear here (and elsewhere below) as the truncated infinite series,  $B_T = \sum_{j=0}^J M_T^j$  for  $J = 10$ . The resulting measures of export exposure are essentially invariant to the extent of truncation for  $J > 10$ .

**Figure 3: Distribution of Trade Exposure Across Individuals, 2012**



*Notes:* In panel (a), the blue dots report the average value of export exposure  $EE_i$ , computed as in equation (21), across all individuals in 2012 whose total income lies within each percentile of the total income distribution. The solid blue line indicates a fitted 10<sup>th</sup>-order polynomial. The red dots (and dashed red line) are analogous but report export exposure of labor income only, that is,  $EE_i$  computed giving no weight to capital in individuals' income and only including individuals with positive labor income. Panel (b) does the same for import exposure  $IE_i$ , as per equation (23).

where  $\omega_{fi} = Y_{fi}/Y_i$  is the share of individual  $i$ 's earnings associated with factor  $f$ .

This export exposure measure corresponds to the share of an individual's earnings that derives, either directly or indirectly, from exports rather than domestic consumption. It does not rely on any of the parametric assumptions introduced in Section 3—as discussed in Section 2, it is simply the granular counterpart of Leontief's (1953) factor content of exports. By construction, individuals with higher export exposure  $EE_i$  face relatively higher demand for their factor services in the trade equilibrium relative to autarky. Everything else being equal, they should therefore receive relatively higher earnings under trade.<sup>37</sup>

**Results.** Figure 2a plots (in the solid blue line) the relationship between  $EE_i$  and (total) income in our sample in 2012.<sup>38</sup> Export exposure in Ecuador is evidently pro-middle class. The average share of (direct plus indirect) exports in total earnings varies between 16% and 17% among individuals between the 10th and 50th percentiles of the income distribution. As we move to income percentiles above the median of the income distribution, the share of exports in total income consistently falls. It is only 13.6% among those with the 10%

<sup>37</sup>By everything else being equal, we formally mean abstracting from other shifts in factor demand (i.e.,  $p^*$ -shifts) and abstracting from heterogeneity in the incidence of  $REE$ -shifts, either due to  $\partial \ln RD / \partial \ln w$  being non-diagonal or to the diagonal elements of  $\partial \ln RD / \partial \ln w$  being heterogeneous.

<sup>38</sup>The corresponding figures for all other years in our sample can be found in Appendix C.2. Table C.1 also reports moments of the distribution of export exposure across individuals.

highest earnings in our sample.<sup>39</sup>

Figure 2a also shows (in the dashed red line) the distribution of export exposure of labor income—that is, computed using only the export exposure of the labor type owned by each individual, excluding capital income. The fact that the red line is consistently above the blue line indicates that labor earnings are, on average, more exposed to exports than are capital earnings. The difference is clearer at the top of the income distribution because the richest individuals earn relatively larger shares from capital. However, the small difference between the two curves indicates that the export exposure of capital is just slightly lower than that of the labor factors of those in high-income percentiles.

Qualitatively, the fact that the richest individuals in Ecuador are the least exposed to exports resonates well with classical two-by-two Heckscher-Ohlin predictions. Since Ecuador is scarce in high-skilled workers relative to the rest of the world, one expects the factor services of these workers, who are prevalent at the top of the income distribution, to be exported less. It is worth emphasizing that this occurs even though we do not restrict exporting firms to have the same skill-intensity as other firms in a given industry, unlike in standard factor content computations.

#### 4.4 Import Exposure Across the Distribution of Earnings

**From Factor to Individual Import Exposure.** Changes in import prices are the second source of factor demand shifts emphasized by Proposition 1. In Section 3, we have already characterized how relative domestic factor demand responds to changes in the price of individual goods. To explore how import exposure varies across the income distribution, we propose to focus on the impact of a uniform change in foreign import prices:  $d\ln p_n^* = d\ln p^*$  for all  $n \in \mathcal{N}^*$ . For such a shock, Proposition 3 implies that

$$\frac{d\ln RD_f}{d\ln p^*} = (\sigma - 1)(IE_f - IE_0), \quad (22)$$

where  $IE_f$  is equal to the sum of  $IE_{fn}$  across all foreign goods,

$$IE_f = - \sum_{k \in \mathcal{K}} \sum_{m \in \mathcal{N}_k} s_{fm} \times (\bar{x}_m^* - \sum_{r \in \mathcal{N}_k} d_{rk} \bar{x}_r^*),$$

---

<sup>39</sup>The range of export exposure among factors is considerably wider, ranging from 0.9% to 70.2%. Naturally, alternative definitions of factors would lead to alternative values of individual-level exposure. To take an extreme example, if one were to assume that labor is firm-specific, so that there are as many labor groups as firms in our economy, then  $EE_i$  would only be a function of the exports, both direct and indirect, of the firm employing individual  $i$ . Figure C.5 describes how export exposure would look across the income distribution under this alternative scenario. For the interested reader, Figure C.6 also documents the role played by the oil sector in our measures of export exposure by replicating Figure 2a with oil exports set to zero.

with  $\bar{x}_m^* \equiv \sum_{r \in \mathcal{N}} x_r^* b_{rm}$  the share of firm  $m$ 's costs spent, both directly and indirectly, on all imports. To go from factor exposure to individual exposure, we again take averages across factors, weighted by each individual's factor income shares,

$$IE_i = \sum_{f \in \mathcal{F}} \omega_{fi} \times IE_f. \quad (23)$$

In the empirically relevant case of  $\sigma > 1$ , individuals with higher import exposure  $IE_i$  tend to experience a decrease in the domestic relative demand for their factors when import prices increase from their finite value in the trade equilibrium ( $p^* < \infty$ ) to infinity in the autarky equilibrium ( $p^* \rightarrow \infty$ ). Everything else being equal, this should lead to lower relative factor prices and relative earnings for these individuals.

**Results.** Figure 2b reports the average import exposure for individuals in different percentiles of the income distribution.<sup>40</sup> The downward-sloping solid blue line indicates that low-income individuals are more exposed to import competition, and are hence more likely to experience smaller gain from trade, than are high-income individuals. Qualitatively, this contrasts with classical two-by-two Heckscher-Ohlin predictions—where scarce high-skill, high-income individuals would be those losing from trade in Ecuador—and arises because much of Ecuador's imports are machinery and equipment used by firms employing high-skill workers.<sup>41</sup> Quantitatively, import exposure ranges from 0.045 at the bottom to 0.03 at the top, revealing that domestic factors tend to be used in the production of goods  $m$  with import shares lower than the sector average, i.e. those for which  $\bar{x}_m^* - \sum_{r \in \mathcal{N}_k} d_{rk} \bar{x}_r^* \leq 0$ . For an elasticity of substitution  $\sigma$  around 2, as we estimate in Section 5, this implies that a 10% increase in the price of foreign goods would increase the demand for low-income individuals by about 0.15% relative to high-income individuals.

Note that the red dashed curve is steeper than the blue solid curve. This reflects the

---

<sup>40</sup>Again, Appendix C.2 reports the corresponding figures for all other years, along with summary statistics of the import exposure distribution across individuals. It should be clear that our individual-level measure of import exposure, like the measure of export exposure introduced earlier, critically depends on our factor definition, which affects the values of the shares  $s_{fm}$  entering  $IE_f$ . Here, labor groups are education- and-region specific, like in a Heckscher-Ohlin model with perfect factor mobility across sectors, but not industry-specific, like in a Ricardo-Viner model. Hence, even in the absence of intermediate goods,  $IE_i$  would not be equal to the import share of the industry in which worker  $i$  is employed, but rather to a weighted sum of import shares across sectors, with weights given by the employment shares of the factor that she owns.

<sup>41</sup>Burstein et al. (2013) and Parro (2013) emphasize the same complementarity between skilled-labor and imported intermediates. In their model, there is a representative firm with nested CES technology, with skilled and unskilled labor appearing in different nests, and with imports of capital equipment only appearing in one of these nests, as in Krusell et al. (2000). In our model, complementarity instead arises from the observed heterogeneity in firms' factor intensity and the positive correlation between skill intensity and import intensity, as discussed in Section 3.2.

fact that capital is more exposed to import competition than the labor factors owned by individuals at the top of the income distribution and less exposed than those owned by individuals at the bottom. The proximity of the two curves, however, again indicates small differences between the import exposures of workers and capital owners.

Overall, Figures 2a and 2b paint a nuanced picture of the exposure to international trade across Ecuador's income distribution. Export exposure is broadly pro-middle class, with the richest individuals in Ecuador exporting the smallest fraction of their factor services, as one might have expected in a country scarce in high-skilled workers. Import exposure, on the other hand, is broadly anti-poor in the sense that cheaper imports tend to reduce the relative domestic demand for the factor services of poor individuals. To go from differences in export and import exposures to the overall incidence of international trade, we require an estimate of Ecuador's factor demand system, to which we now turn.

## 5 Estimation of Ecuador's Factor Demand System

The model in Section 3 describes an economy in which  $RD(p^*, w)$  takes a nested CES form featuring two micro-level elasticities of substitution: that between primary factors in domestic production ( $\eta$ ) and that between firms' products in domestic consumption ( $\sigma$ ). In this section, we use firm-level micro-data to estimate these two parameters.

### 5.1 Elasticity of Substitution Between Factors

**Empirical Specification.** Equation (17) implies a log-linear relationship between factor expenditure,  $X_{fn,t}$ , and factor price,  $w_{f,t}$ , within each firm  $n$ ,

$$\ln X_{fn,t} = (1 - \eta) \ln w_{f,t} + \zeta_{n,t} + \ln \theta_{fn,t},$$

where  $\zeta_{n,t} \equiv \ln(\beta_{n,t} \theta_{fn,t} R_{n,t} / \sum_{f \in \mathcal{F}} \theta_{fn,t} w_{f,t}^{1-\eta})$  collects firm-year specific terms and  $\eta$  is the elasticity of substitution between factors to be estimated. For the purposes of estimating  $\eta$ , we let the demand shock  $\theta_{fn,t}$  be a function of a factor-specific term,  $\zeta_f$ , a vector of observables that we denote  $\text{Controls}_{f,t}$  and to which we return below, as well as a residual productivity shock,  $\epsilon_{fn,t}$ ,

$$\ln \theta_{fn,t} = \zeta' \text{Controls}_{f,t} + \zeta_f + \epsilon_{fn,t}.$$

Combining the two previous equations, we obtain our empirical specification,

$$\ln X_{f,n,t} = (1 - \eta) \ln w_{f,t} + \zeta' \text{Controls}_{f,t} + \zeta_{n,t} + \zeta_f + \epsilon_{f,n,t}, \quad (24)$$

where firm-level factor expenditures  $X_{f,n,t}$  are given by the procedure from Section 4.1; the wages  $w_{f,t}$  of each labor group  $f \in \mathcal{F}_L$  are obtained by dividing total payments by the total number of workers in that group,  $w_{f,t} = (\sum_{n \in \mathcal{N}} X_{f,n,t}) / \bar{L}_{f,t}$ ; and the price of each type of capital  $f \in \mathcal{F}_K$  is measured as the total factor payments  $w_{f,t} = \sum_{n \in \mathcal{N}} X_{f,n,t}$ , since we have no physical measure available for the supply of capital.

**IV Strategy.** OLS estimates of  $\eta$  based on equation (24) suffer from simultaneity bias because factor prices  $w_{f,t}$  themselves depend on the domestic productivity shocks  $\{\epsilon_{f,n,t}\}$ . This occurs because relative domestic factor demand  $RD_{f,t}$  depends on these shocks, as can be seen from Proposition 2, and domestic factor prices depend on  $RD_{f,t}$  through the factor market clearing condition (8). We therefore develop instrumental variables (IVs) based on the differential exposure of factors to export and import shocks.

Our IVs take the commonly used “shift-share” form, based here on differential exposure of factors and firms to foreign shocks at the product  $v$  level. In particular, we define the following shift-share variables:

$$\hat{E}_{f,t} = \sum_{v \in \mathcal{HS}} EE_{fv,t_0} \times (\text{Export Shock})_{v,t}, \quad (25)$$

$$\hat{I}_{f,t} = \sum_{v \in \mathcal{HS}} IE_{fv,t_0} \times (\text{Import Shock})_{v,t}, \quad (26)$$

where  $\mathcal{HS}$  denotes the set of all 6-digit HS products and the “share” terms,  $EE_{fv,t_0}$  and  $IE_{fv,t_0}$ , are the product-level analogs of the factor trade exposures presented in Section 4, computed in an initial period  $t_0$ .<sup>42</sup> Turning to the “shifters”, we seek determinants of the relative export and import growth of each variety  $v$  that are plausibly derived from global shocks. To this end, we set  $(\text{Export Shock})_{v,t}$  equal to the log of global total export value (from all origins and destinations other than Ecuador) for each product  $v \in \mathcal{HS}$  at date  $t$  minus the average of the same variable across all products at that date. Similarly we set  $(\text{Import Shock})_{v,t}$  as the average across origin countries of log unit values of global imports (again, excluding Ecuador) for each product  $v \in \mathcal{HS}$  at date  $t$  minus the average of the same

<sup>42</sup>That is,  $EE_{fv,t_0} = (\sum_{n \in \mathcal{N}} x_{fn,t_0} \sum_{r \in \mathcal{N}} b_{nr,t_0} E_{rv,t_0}) / (\sum_{n \in \mathcal{N}} X_{fn,t_0})$  is the share of product  $v$  exports in factor  $f$ 's income in the initial period  $t_0$ , where  $E_{rv,t_0}$  denotes the exports of product  $v$  by firm  $r$  at time  $t_0$ , and  $IE_{fv,t_0} = -\sum_{k \in \mathcal{K}} \sum_{m \in \mathcal{N}_k} s_{fm,t_0} \times (\bar{x}_{vm,t_0}^* - \sum_{r \in \mathcal{N}_k} d_{rk} \bar{x}_{vr,t_0}^*)$ , where  $\bar{x}_{vm,t_0}^*$  denotes the share of firm  $m$ 's costs spent share of product  $v$  at time  $t_0$ , both directly and indirectly.

variable across all products at that date.<sup>43</sup>

We include in the vector Controls $_{f,t}$  each factor  $f$ 's overall exposure to exports at date  $t_0$ ,  $EE_{f,t_0} = \sum_{v \in \mathcal{HS}} EE_{fv,t_0}$ , interacted with a time dummy, as well as each factor  $f$ 's overall exposure to imports at date  $t_0$ ,  $IE_{f,t_0} = \sum_{v \in \mathcal{HS}} IE_{fv,t_0}$ , interacted again with a time dummy. This ensures that our estimates are unaffected by domestic shocks that might disproportionately affect factors that are more exposed to international trade.

Conditional on the controls in our specification, the exclusion restriction that underpins our IV estimates of  $\eta$  is that shocks to domestic factor demand in Ecuador—formally, the structural residuals  $\epsilon_{fn,t}$  of (24)—are uncorrelated with product-level export and import shocks. This orthogonality assumption holds if domestic shocks in Ecuador are not large enough to affect world-level trade flows (which is reasonable given the small size of the Ecuadorian economy) and are uncorrelated with the foreign shocks determining changes in exports and imports in the rest of the world (which is reasonable given that, as we show in Appendix C.5, those are mostly driven by the idiosyncratic component of trade flows of large countries). The logic of our IV strategy also requires that (Export Shock) $_{v,t}$  and (Import Shock) $_{v,t}$  do affect the export values and import unit values of different products in Ecuador, a fact that we verify in the “zeroth-stage” regressions shown in Appendix C.4.

**Results.** Table 1 reports OLS and IV estimates (using  $\hat{E}_{f,t}$  and  $\hat{I}_{f,t}$  as IVs) of  $\eta$ . We take  $t_0$  to be 2009-2011, so that initial shares in our IVs and controls are averaged over that period. This reduces the noise in the years right after the trade collapse of 2008-2009.

The OLS estimate in column (1) is lower than the IV estimate in column (2), consistent with a positive correlation between factor demand shocks and factor prices, as one would expect from the factor market clearing condition. The IV estimate of  $\hat{\eta} = 2.10$  implies that the capital and labor groups that we consider are substitutes.<sup>44</sup> This estimate is about twice as large as the Cobb-Douglas value of  $\eta = 1$  assumed in Deardorff and Staiger (1988). It is significantly higher than the U.S. plant-level elasticity of substitution between capital and

---

<sup>43</sup>By demeaning both export and import shocks, we aim to isolate variation in shock realization across products, as discussed in Adao et al. (2019) and Borusyak et al. (2021). Many others have used import and export shocks in the rest of the world as part of their shift-share IV strategies. On the export side, our shock is similar to the measures used in Aghion et al. (2018) and Huneus (2018). On the import side, Hummels et al. (2014) have used growth in export supply to the rest of the world for product-country pairs as the shifter in a firm-level shift-share IV for imported input costs. Our focus on the unit values of imported inputs by firms is similar to Amiti et al. (2016) and Huneus (2018).

<sup>44</sup>Standard errors are clustered by factor. This reflects the variation in our IVs while accounting for auto-correlation in residuals. Adao et al. (2019) point out that the correlation of residuals is a threat to the performance of traditional inference procedures in shift-share specifications. Implementing their standard error formulas is not feasible here because of the high number of fixed-effects and the impossibility of separately computing product exposure shares, due to the high-dimension of the input-output matrix  $M$ .



**Table 1: Elasticity Estimates**

|                         | Elasticity of Substitution<br>Between Factors ( $\eta$ ) |                | Elasticity of Substitution<br>Between Goods ( $\sigma$ ) |                |
|-------------------------|--|----------------|--|----------------|
|                         | OLS  | 2SLS           | OLS  | 2SLS           |
|                         | (1)  | (2)            | (3)  | (4)            |
| Parameter estimate      | 1.34<br>(0.19)   | 2.10<br>(0.34) | 1.04<br>(0.04)   | 2.11<br>(0.55) |
| First-stage F statistic | -  | 10.0           | -  | 16.4           |

*Notes:* Sample of incorporated firms with more than one employee and (in columns 1 and 2) positive payments for more than one factor and (in 3 and 4) positive final sales. All specifications use a balanced panel from 2009-2015 of (in columns 1 and 2) 627,355 factor-firm-year observations and (in 3 and 4) 181,671 firm-year observations. Specifications control for: (i) fixed effects for (in columns 1 and 2) factor and firm-year and (in 3 and 4) firm and sector-year; and (ii) year indicators interacted with (in columns 1 and 2) factor exposure at  $t_0$  to exports and imports and (in 3 and 4) firm cost shares at  $t_0$  spent on primary factors. Observations weighted by (in columns 1 and 2) initial factor-firm payments and (in 3 and 4) initial firm final sales, with both sets of weights winsorized at the 95th percentiles. Standard errors in parentheses are clustered (in columns 1 and 2) by factor (of which there are 75) and (in 3 and 4) by firm (25,953).

labor of 0.3–0.5 in [Oberfield and Raval \(2021\)](#), but it is close to the range of existing estimates of the (aggregate) elasticity of substitution between educational groups surveyed in [Acemoglu and Autor \(2011\)](#).

The previous IV estimate of  $\eta$  is robust to various alternative specifications, as shown in Appendix C.5. Table C.3 evaluates alternative sets of controls, samples of firms, and sample periods, whereas Table C.4 considers alternative IVs based on only export or import shocks, or that attempt to purge the IVs of common shocks to all countries.

## 5.2 Elasticity of Substitution Between Goods

**Empirical Specification.** To estimate  $\sigma$ , we turn to the final demand equation (13), which describes substitution between goods produced by different domestic firms  $n$  within each sector  $k$ . This relates domestic expenditure,  $D_{n,t}$ , to the domestic price,  $p_{n,t}$ , via

$$\ln D_{n,t} = (1 - \sigma) \ln p_{n,t} + \zeta_{k,t} + \ln \theta_{nc,t},$$

where  $\zeta_{k,t} \equiv \ln(\alpha_{k,t}(w_t \cdot \bar{L}_t) / \sum_{r \in \mathcal{N}_k} \theta_{rc,t} p_{r,t}^{1-\sigma})$  now subsumes industry-year terms. In line with our estimation of the elasticity of substitution between factors, we let the good demand shock  $\ln \theta_{nc,t}$  be a function of a firm-specific term,  $\zeta_n$ , a vector of observables,  $\text{Controls}_{n,t}$ ,

to be described below, and a residual preference shock,  $\epsilon_{nc,t}$ . This leads to

$$\ln D_{n,t} = (1 - \sigma) \ln p_{n,t} + \zeta' \text{Controls}_{n,t} + \zeta_{k,t} + \zeta_n + \epsilon_{nc,t}. \quad (27)$$

The only conceptual difference between the estimation of  $\eta$  and  $\sigma$  is the measurement of prices: we lack data on domestic prices  $p_{n,t}$ . To address this issue, we again use the fact that, because of zero profits, domestic prices must be equal to unit costs,  $\tilde{p}_n(p^*, w)$ , which only depend on observed input prices, as described in Proposition 2. After standard manipulations in Appendix A.7, we obtain

$$\ln p_{n,t} = \sum_{r \in \mathcal{N}} b_{rn,t} \left[ \beta_{r,t} \ln w_{r,t}^D + \sum_{l \in \mathcal{N}^*} x_{lr,t}^* \ln p_{l,t}^* \right] + \rho_{n,t}. \quad (28)$$

where  $w_{r,t}^D$  is a revealed measure of the CES price index for domestic factors in firm  $r$  such that  $\ln w_{r,t}^D \equiv \sum_{f \in \mathcal{F}} x_{fr,t}^D \left( \ln w_{f,t} + \frac{1}{\eta-1} \ln x_{fr,t}^D \right)$ ;  $p_{l,t}^*$  is the unit value of Ecuador's imports of product  $l$  in year  $t$  and the associated import share  $x_{lr,t}^*$  is measured as  $\theta_{lr,t_0}^* x_{r,t}^*$ ; and  $\rho_{n,t} \equiv \sum_{r \in \mathcal{N}} b_{rn,t} \left[ \frac{1}{1-\eta} \sum_{f \in \mathcal{F}} x_{fr,t}^D \ln \theta_{fr,t} + \ln \phi_{r,t} \right]$  is a cost shifter determined by firm  $n$ 's technology parameters and those of its suppliers.<sup>45</sup>

Substituting for domestic prices in (27) using (28), we finally obtain

$$\ln D_{n,t} = (1 - \sigma) \sum_{r \in \mathcal{N}} b_{rn,t} \left[ \beta_{r,t} \ln w_{r,t}^D + \sum_{l \in \mathcal{N}^*} x_{lr,t}^* \ln p_{l,t}^* \right] + \zeta' \text{Controls}_{n,t} + \zeta_{k,t} + \zeta_n + \epsilon_{n,t}, \quad (29)$$

where  $\epsilon_{n,t} \equiv \epsilon_{nc,t} + \rho_{n,t}$  is a combination of the firm-specific demand and cost shocks.

**IV Strategy.** Like in Section 5.1, OLS estimates of  $\sigma$  suffer from simultaneity bias because factor price indices  $\{w_{r,t}^D\}$  themselves depend on the firm-specific shocks  $\{\epsilon_{n,t}\}$  again through the relative factor demand in Proposition 2 and the factor market clearing condition in (8). Here, OLS estimates may also be biased if Ecuador's import prices  $\{p_{n,t}^*\}$  respond to Ecuador's domestic conditions  $\{\epsilon_{n,t}\}$ . Both sources of bias can be addressed by developing IVs based on the differential exposure of firms to foreign shocks. Equation (29) suggests two types of instruments: price-shifters for the domestic factors used by different firms within each sector and analogous price-shifters for their imports.

To construct domestic price-shifters, we propose to use firm-level averages of the two

<sup>45</sup>Our Ecuadorian firm- and product-level customs transaction records are only available from 2009-2011, hence our choice to use  $\theta_{lr,t_0}^*$  rather than  $\theta_{lr,t}^*$ . Note that this restriction is irrelevant for the measures of import exposures presented in Section 4.4 since they focus on uniform changes in import prices whose impact only depends on firms' total import shares,  $x_{r,t}^*$ , which are available in all years.

factor-specific instruments described in (25) and (26):

$$\hat{E}_{n,t} = \sum_{f \in \mathcal{F}} x_{fn,t_0}^D \times \hat{E}_{f,t}, \quad (30)$$

$$\hat{I}_{n,t} = \sum_{f \in \mathcal{F}} x_{fn,t_0}^D \times \hat{I}_{f,t}, \quad (31)$$

where the weights correspond to the initial spending shares across domestic factors in firm  $n$  in period  $t_0$ . To construct foreign price-shifters, we simply use the average of product-level price shocks in the rest of the world weighted by firm  $n$ 's initial import shares,

$$\hat{P}_{n,t}^* = \sum_{v \in \mathcal{HS}} \theta_{vn,t_0}^* \times (\text{Import Shock})_{v,t}. \quad (32)$$

Finally, we include in  $\text{Controls}_{n,t}$  the shares of firm  $n$ 's costs at  $t_0$  spent on primary factors,  $\beta_{n,t_0}$ , interacted with time dummies. For our IVs to be valid, foreign shocks must therefore be uncorrelated with firms' preference and cost shocks,  $\epsilon_{nc,t}$  and  $\rho_{n,t}$ , conditional on industry-time and firm fixed effects as well as differential initial exposures to changes in domestic factor prices. Such an orthogonality assumption holds under the same sufficient conditions discussed above for the estimation of  $\eta$ .

**Results.** Columns (3) and (4) of Table 1 report the OLS and IV (using  $\hat{E}_{n,t}$ ,  $\hat{I}_{n,t}$ , and  $\hat{P}_{n,t}^*$  as IVs) estimates of  $\sigma$ . Again we take  $t_0$  to be 2009-2011 as in Table 1, so that initial shares in our IVs and controls are averaged over that period.<sup>46</sup>

Again, the OLS estimate of  $\sigma$  in column (3) is lower than the corresponding IV estimate, consistent with a positive correlation between demand shocks and prices. In column (4), our IV estimate of  $\hat{\sigma} = 2.11$  contrasts sharply with the assumption of  $\sigma = \infty$  in the original factor content approach of [Deardorff and Staiger \(1988\)](#). This value is also lower than the elasticity of substitution between U.S. firms in [Hottman et al. \(2016\)](#) who report a median elasticity of substitution between U.S. firms, within AC Nielsen product group categories, of 3.9. This is expected since such product groups are more narrowly defined than the 2-digit industries used in our specification.<sup>47</sup> Our estimate of  $\sigma$  is also lower than those

---

<sup>46</sup>Our estimate of  $\sigma$  depends (via the construction of  $p_{n,t}$ ) on our estimate of  $\eta$ , for which we use the baseline value of  $\eta = 2.10$ . As a result, the standard error for  $\sigma$  is subject to generated regressor bias. In our context, however, the potential for such bias does not appear to be substantial because the estimate of  $\sigma$  is not very sensitive to the value of  $\eta$ . For example, when considering 100 equally spaced values of  $\eta$  on its 95% confidence interval, the smallest and largest values of  $\sigma$  we obtain are 2.08 and 2.11. Section 7.3 considers the robustness of our counterfactual simulations to the values of  $\sigma$  used across a considerably wider range.

<sup>47</sup>Recall also that our sample covers final sales of domestic firms in all sectors, including retail (54.3% of final sales) but also firms in construction (10.7%) and other services (18.2%). In Section 7.3, we explore the

indirectly inferred from average markups under the assumption of monopolistic competition, as in [Oberfield and Raval \(2021\)](#) and [Blaum et al. \(2018\)](#). As with the elasticity of substitution between factors  $\eta$ , [Appendix C.5](#) documents the robustness of our results across alternative samples, specification details, IV sets, and IV constructions ([Tables C.5 and C.6](#)).

## 6 Fit of the Factor Demand Model: A Test

In [Section 2](#), we have established how a country’s factor demand system determines the incidence of foreign shocks, measured either as changes in the factor content of exports or import prices, on domestic factor prices. In [Section 3](#), we have imposed specific parametric assumptions on preferences and technology that allow us to identify (as proved in [Appendix D.1.1](#)) the aggregate relative factor demand  $RD(p^*, w)$  by combining the rich micro data presented in [Section 4](#) with the two elasticities of substitution,  $\eta$  and  $\sigma$ , estimated in [Section 5](#). Going from micro to macro in this way, however, begs the question of whether the “true” relative factor demand system in Ecuador looks anything like what our parametric model predicts. That is, can our estimated factor demand system actually fit the observed relationship between domestic factor prices and foreign shocks?

### 6.1 Goodness of Fit Test

To address this question, we follow the same approach as in [Proposition 1](#), but instead of integrating hypothetical shocks along the path to autarky, we restrict ourselves to the shocks observed within our sample. Starting from any equilibrium at date  $\tau$  and differentiating the factor market clearing condition in [equation \(8\)](#) implies that, up to a first-order approximation, changes in factor prices between date  $\tau$  and  $\tau+1$  can be expressed as

$$\Delta \ln w_\tau = - \left( \frac{\partial \ln RD}{\partial \ln w} \right)_\tau^{-1} \left[ \Delta \ln REE_\tau + \left( \frac{\partial \ln RD}{\partial \ln p^*} \right)_\tau \Delta \ln p^*_\tau \right] + \varepsilon_{\tau+1},$$

where  $\Delta$  refers to changes between two consecutive periods, e.g.  $\Delta \ln w_\tau = \ln w_{\tau+1} - \ln w_\tau$ , and the vector of structural demand shocks,  $\varepsilon_{\tau+1}$ , comprises both relative supply and relative domestic demand shocks.<sup>48</sup> Summing across all years between  $\tau = t_0$  and  $t - 1$ , we then obtain the level of domestic factor prices,  $\ln w_{f,t}^{model}$ , predicted by our model in response

---

sensitivity of our conclusions to more flexible specifications that allow different degrees of substitutability within different broad sectors as well as a distinct treatment of retail activity.

<sup>48</sup>Specifically, we have  $\varepsilon_{\tau+1} \equiv \{ \Delta \ln(\bar{L}_{f,\tau}/\bar{L}_{0,\tau}) \} - (\partial \ln RD / \partial \ln w)_\tau^{-1} (\partial \ln RD / \partial \ln \bar{\Theta})_\tau \Delta \ln \bar{\Theta}_\tau$ , with  $\bar{\Theta}_\tau \equiv \{ \theta_{nc,\tau}, \theta_{fn,\tau}, \theta_{rn,\tau}, \Theta_{n,\tau}, \alpha_{n,\tau}, \beta_{n,\tau}, \varphi_{n,\tau} \}$  the full vector of preference and technological shifters.

to a sequence of foreign shocks,  $\{\Delta \ln REE_\tau, \Delta \ln p_\tau^*\}_{\tau=t_0}^{t-1}$ ,

$$\ln w_{f,t}^{model} \equiv \sum_{\tau=t_0}^{t-1} - \left( \frac{\partial \ln RD}{\partial \ln w} \right)_\tau^{-1} \left[ \Delta \ln REE_\tau + \left( \frac{\partial \ln RD}{\partial \ln p^*} \right)_\tau \Delta \ln p_\tau^* \right] + \ln w_{f,t_0}, \quad (33)$$

where  $(\partial \ln RD / \partial \ln w)_\tau$  and  $(\partial \ln RD / \partial \ln p^*)_ \tau$  are constructed using our preferred estimates of the micro-level elasticities,  $\hat{\eta} = 2.10$  and  $\hat{\sigma} = 2.11$ , from Section 5.

To test our factor demand model, we can therefore estimate the testing specification

$$\ln w_{f,t} = \beta_{fit} \ln w_{f,t}^{model} + \epsilon_{f,t}, \quad (34)$$

with the structural error term  $\epsilon_{f,t} \equiv \sum_{\tau=t_0}^{t-1} \epsilon_{f,\tau+1}$ . The fit coefficient  $\beta_{fit}$  should be equal to one under the null that our model is correctly specified.<sup>49</sup> Since the changes in relative export exposures  $\Delta \ln REE_t$  and foreign import prices  $\Delta \ln p_t^*$  that enter  $\ln w_{f,t}^{model}$  may be correlated with domestic demand shocks  $\epsilon_{f,t}$  in Ecuador, we build the following IV for  $\ln w_{f,t}^{model}$ ,

$$\ln \hat{w}_{f,t}^{model} \equiv \sum_{\tau=t_0}^{t-1} - \left( \frac{\partial \ln RD}{\partial \ln w} \right)_{t_0}^{-1} \left[ \Delta \ln \widehat{REE}_\tau + \left( \frac{\partial \ln RD}{\partial \ln p^*} \right)_{t_0} \Delta \ln \hat{p}_\tau^* \right] + \ln w_{f,t_0}, \quad (35)$$

where  $\widehat{REE}_\tau \equiv \{[1 - (\hat{E}_{0,\tau}/Y_{0,\tau})]/[1 - (\hat{E}_{f,\tau}/Y_{f,\tau})]\}$  is the shifter of relative export exposure, with  $\hat{E}_{f,t}$  given by equation (25), and  $\hat{p}_\tau^* \equiv \{(\text{Import Shock})_{v,\tau}\}_{v \in \mathcal{HS}}$  is the shifter of foreign import prices appearing in equation (32).

Since the parametric model of Section 3 includes sufficient taste and technology heterogeneity to match all data points at the micro and macro level, as is common in quantitative trade and spatial models, one may wonder how testing is possible. The idea behind our test is that while one can always recover domestic residuals  $\hat{\epsilon}_{f,t}$  such that equation (34) holds for  $\beta_{fit} = 1$ , such recovered residuals do not have to be orthogonal to our IV,  $\ln \hat{w}_{f,t}^{model}$ .<sup>50</sup> The flip-side of this observation is that when imposing the orthogonality between  $\ln \hat{w}_{f,t}^{model}$  and  $\epsilon_{f,t}$ , the estimated  $\beta_{fit}$  does not have to equal one. So our test has power against the null.

<sup>49</sup>As noted in Table 2, we always include factor and time fixed effects when estimating (34), so that estimates of  $\beta_{fit}$  are not sensitive to choices of the units of account for each factor (due to the factor fixed effect) nor choices of the numeraire for each period (due to the time fixed effect). There is a long tradition of such ‘‘slope’’ tests in the field of international trade. For example, Davis and Weinstein (2001) use such a specification to test the predictions of the Heckscher-Ohlin-Vanek model, Costinot and Donaldson (2012) do so to test the predictions of the Ricardian model, Kovak (2013) does so to test a regional specific-factors model, and Adao et al. (2020a) do so to test the ability of different spatial models to replicate observed responses of regional outcomes to trade shocks.

<sup>50</sup>Even though we have relied on the same exogenous source of variation to estimate our two micro-level elasticities,  $\ln w_{f,t}^{model}$  is a non-linear function of  $\hat{\eta}$  and  $\hat{\sigma}$  that uses the full structure of the domestic factor system,  $RD$ , not just the linear component used in Section 5 to estimate  $\eta$  and  $\sigma$  within each CES nest.

## 6.2 Test Results

Table 2 reports our estimates of  $\beta_{\text{fit}}$ . Once again we take  $t_0$  to be 2009-2011 as when estimating  $\eta$  and  $\sigma$ , so that initial shares in our IVs and controls are averaged over that period.

**Table 2: Goodness of Fit Tests**

|   | $\Delta$ Log of observed factor price |                |                |                |                |
|---|---------------------------------------|----------------|----------------|----------------|----------------|
|   | (1)                                   | (2)            | (3)            | (4)            | (5)            |
| $\Delta$ Log of predicted factor price    | 1.10<br>(0.15)                        | 1.61<br>(0.62) | 1.26<br>(0.62) | 1.04<br>(0.16) | 0.89<br>(0.20) |
| P-value ( $H_0: \beta_{\text{fit}} = 1$ ) | [0.53]                                | [0.33]         | [0.68]         | [0.79]         | [0.58]         |
| First-stage F statistic                   | 2,103.9                               | 205.0          | 189.6          | 304.7          | 125.9          |

*Notes:* All specifications use a balanced panel of 525 factor-year observations from 2009-2015 and are estimated with year and factor fixed effects. Columns 2-5 add, cumulatively, controls for interactions between year indicators and: (2)  $EE_{f,t_0}$  and  $IE_{f,t_0}$ ; (3) capital factor indicators; (4) province indicators; and (5) education level indicators. Observations are weighted by initial factor payments (winsorized at the 95th percentile). Standard errors in parentheses are clustered by factor (of which there are 75).

Remarkably, as seen in column (1), despite the strong parametric restrictions imposed in Section 3, we obtain  $\hat{\beta}_{\text{fit}} = 1.10$ . This implies that we fail to reject the null of  $\beta_{\text{fit}} = 1$  at standard levels (p-value = 0.57), a finding that continues to hold (though with a larger coefficient and standard error) when we control for initial levels of each factor's export and import exposure interacted with time dummies in column (2). Reassuringly, adding additional fixed effects (in columns 3-5) that probe the model's fit for different subsets of factors (across education groups, geographical groups, and capital relative to labor) causes  $\hat{\beta}_{\text{fit}}$  to range from 0.89 to 1.26.

One remaining question is the extent to which this failure to reject the parametric model simply reflects a test that lacks power. That is, although we cannot reject the macro-level predictions of our nested CES model using our preferred estimates of micro-level elasticities,  $\hat{\eta} = 2.10$  and  $\hat{\sigma} = 2.11$ , the same tests conducted using any arbitrary values of  $\eta$  and  $\sigma$  might also be successful. Figure C.7 in Appendix C.7 shows that this is not so. This analysis conducts the same macro tests as in Table 2 but at alternative values of  $\eta$  and  $\sigma$ . These results clearly indicate that  $\hat{\beta}_{\text{fit}}$  departs from one as we move away from our baseline estimates of  $\eta$  and  $\sigma$ . At the 5% significance level, in specifications based on column (1), we typically reject specifications with  $\eta > 8$  or  $\sigma > 6$ . Recall that, in contrast, the original factor content approach assumes  $\sigma \rightarrow \infty$ .

## 7 The Overall Incidence of Trade on Earnings Inequality

We have established that the magnitude of the factor price responses to foreign shocks predicted by our model are consistent with those observed in the data. This strengthens the credibility of our parametric assumptions and their quantitative implications, at least within the range of observed export and import shocks. With this in mind, we now turn to a full quantification of the distributional consequences of international trade. We solve for the changes between the observed distribution of earnings in Ecuador and the counterfactual distribution that would be observed if Ecuador were under autarky, as a result of both the export and import channels described in Proposition 1.

### 7.1 Baseline Results

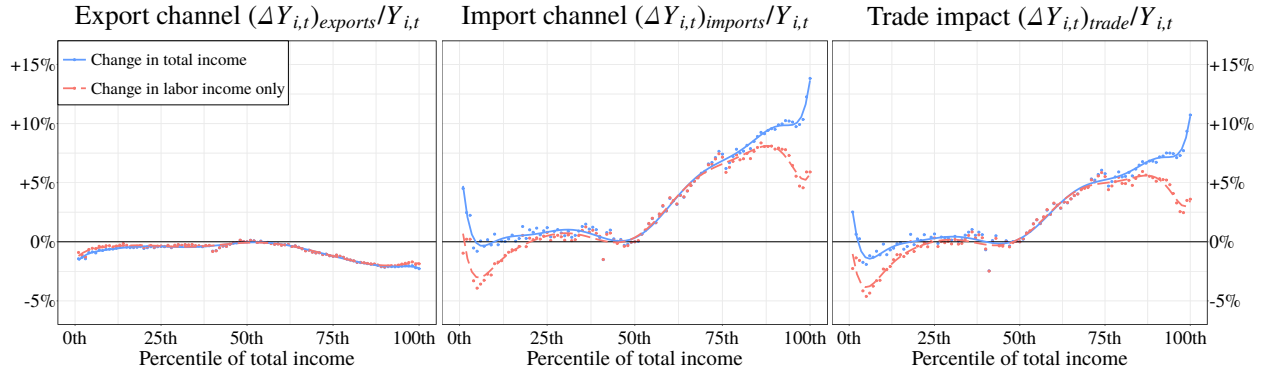
For our baseline results, we focus on the Ecuadorian economy at date  $t = 2012$ , the midpoint of our sample. In order to quantify the overall impact of trade on inequality at that date, we apply Proposition 1 and compute  $(\Delta \ln w_t)_{trade} = \{\ln w_{f,t} - \ln(w_{f,t})_A\}_{f \in \mathcal{F}}$ , as well as the export and import channels,  $(\Delta \ln w_t)_{exports}$  and  $(\Delta \ln w_t)_{imports}$ . This amounts to integrating over a sequence of small shocks to  $REE$  and  $p^*$ , just as in the goodness of fit test of Section 6.1, but now such that the shocks go from the initial equilibrium ( $p^* = p_t^*, REE = REE_t$ ) to the autarky counterfactual equilibrium ( $p^* = \infty, REE = 1$ ) rather than to the values observed at a later year.<sup>51</sup> Given changes in factor prices, the proportional changes in earnings of individual  $i$  between trade and autarky,  $(\Delta Y_{i,t})_{trade} / Y_{i,t} = [Y_{i,t} - (Y_{i,t})_A] / Y_{i,t}$ , as well as the changes in earnings associated with the export and import channels,  $(\Delta Y_{i,t})_{exports} / Y_{i,t}$  and  $(\Delta Y_{i,t})_{imports} / Y_{i,t}$ , can be computed using the share of different factors  $f$  in individual  $i$ 's earnings in the initial equilibrium,  $\omega_{fi,t} \equiv Y_{fi,t} / Y_{i,t}$ .<sup>52</sup>

Figure 4 plots these counterfactual earnings changes for every percentile of income earner in our sample, always normalizing changes in the median income to zero (by subtracting the average earnings changes for individuals at the median percentile). We begin with the total (i.e. labor plus capital) gains from trade that individuals experience (the solid blue line). There is a clear tendency here for the export channel (left panel) to decrease earnings inequality, especially in the upper-half of the income distribution, since export-

<sup>51</sup>A common issue in quantitative trade modeling concerns how to introduce trade imbalances in the context of a static economy. Following standard practices discussed in Costinot and Rodríguez-Clare (2014), we implicitly treat imbalances as lump-sum transfers between Ecuador and the rest of the world. Since preferences are homothetic and technology has constant returns in our empirical model, the magnitude of such transfers affects neither our estimates of Ecuador's relative factor demand nor our counterfactual factor prices. The same is true for remittances from Ecuadorian migrants abroad.

<sup>52</sup>Appendix D.1.2 contains further details about the algorithm for calculating counterfactual factor price changes and Appendix D.1.3 does the same for changes in individual earnings.

**Figure 4: Trade and Earnings Inequality, Baseline**



Notes: Blue dots correspond to the total (including both labor and capital) income change for each individual, averaged within each percentile and normalized to zero at the median percentile, between 2012 and the counterfactual autarkic equilibrium. Positive numbers therefore reflect larger gains from trade than at the median. Red dots do the same but for labor income only. Lines indicate fitted 10<sup>th</sup>-order polynomials. Trade impact is the sum of the export and import channels. All changes are expressed as percentages.

channel gains from trade are smaller for the rich than they are for the middle-class. By contrast, the import channel (middle panel) is broadly increasing throughout the income distribution, leading to higher inequality. The incidence of both channels on earnings inequality are very much in line with the biases of the export and import exposure measures displayed in Figures 2a and 2b.<sup>53</sup> The existence of these opposing forces means that, in the case of Ecuador, an empirical analysis that might focus on only one of these two channels would miss an important part of the distributional consequences of international trade.

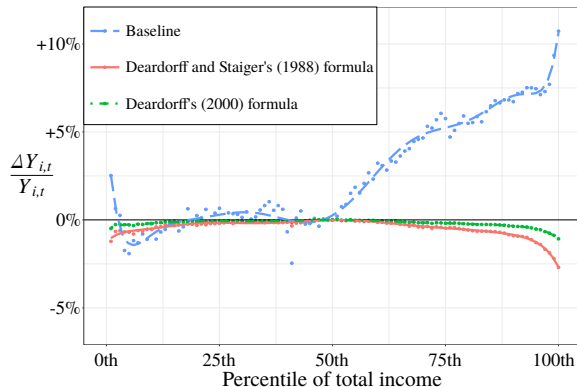
The right-hand panel of Figure 4 combines the offsetting export and import channels. Evidently, it is the individuals in the top of Ecuador’s income distribution who gain disproportionately more from trade since the import channel is larger in magnitude. Despite these offsetting effects, the magnitude of the net impact can be substantial. In the top half of the income distribution, our estimates imply income gains from trade that are 7% larger for individuals at the 90th percentile, compared to those at the median percentile, and 11% larger for those at the top percentile.

Figure 4 also shows the distinction between total (in solid blue) and labor-only (in dashed red) earnings, which highlights the role played by inequalities in capital ownership. A substantial contribution to differences in gains from trade derives from the strong import channel that benefits the capitalists who are among Ecuador’s richest individuals.

<sup>53</sup>To explore systematically the connection between the exposure measures presented in Section 4 and the full impact of trade computed in this section, we regress  $(\Delta Y_{i,t})_{trade}/Y_{i,t}$  on the exposure measures  $EE_{i,t}$  and  $IE_{i,t}$  defined in (21) and (23). The results are reported in Table C.8 of Appendix C.8. We find that our exposure measures explain most of the variation in the predicted changes in earnings, with a total  $R^2$  of around 0.9.



**Figure 5: Comparison with Original Factor Content Approach**



*Notes:* Blue dots and the blue solid line display the trade impact on total income at each income percentile (normalized to zero at the median) for the baseline model (with  $\sigma = 2.11$  and  $\eta = 2.10$ ), as in Figure 4. Red dots report the analog for the model in Deardorff and Staiger (1988), computed with the formula in (10) and  $\eta_{agg} = 1$ . Green dots do the same for the model in Deardorff (2000), computed with the formula in (10) and  $\eta_{agg} = 2.53$  (estimated using the strategy in Katz and Murphy, 1992). Lines indicate a fitted 10<sup>th</sup>-order polynomial. All changes are expressed as percentages.

By contrast, the return to highest-income labor is not particularly helped by trade.

## 7.2 Comparison to Predictions from Original Factor Content Approach

As described in Section 2.4, our model is a strict generalization of Deardorff and Staiger’s (1988) pioneering method for using the factor content of trade to predict the distributional effects of trade. Compared to the empirical model that we have estimated, this original approach assumed Cobb-Douglas production functions ( $\eta = 1$ ) and perfect substitution between goods within each sector ( $\sigma \rightarrow \infty$ ), so that all imported goods have perfect substitutes that are produced at Home.

Figure 5 explores the consequences of imposing the previous assumptions—rather than estimating  $\eta$  and  $\sigma$ —by plotting the changes in earnings predicted by the formula displayed in equation (10) for  $\eta_{agg} = 1$ .<sup>54</sup> Figure 5 also plots the more flexible CES version of this formula with  $\eta_{agg} \neq 1$ , as derived in Deardorff (2000). In this second case, we estimate  $\eta_{agg}$  in the same manner as Katz and Murphy (1992), using aggregate national data on three labor groups only, in an attempt to mimic typical implementations of the original factor content approach such as Borjas et al. (1992), as described in Appendix C.6. Doing

<sup>54</sup>To compute the net factor content of exports,  $RNEE_f$ , in equation (10) for each of our 75 factors  $f$ , we construct the sector-level vectors of net exports as well as the counterparts of the matrix of domestic factor shares,  $A$ , and the domestic input-output matrix,  $M$ , by adding up spending across all firms within each 2-digit sector. To go from changes in factor prices to changes in individual earnings, we again follow the procedure described in Appendix D.1.3.

so we obtain an estimate of  $\eta_{agg} = 2.53$ , which is close to the baseline estimate of the firm-level elasticity of substitution reported in Table 1, but slightly higher than the aggregate elasticity of substitution estimated by Katz and Murphy (1992) for the United States.<sup>55</sup>

As is clear from Figure 5, the predictions of our model differ starkly from those of the original factor content approach, with the original approach predicting much smaller effects of trade. This is a direct manifestation of Trefler’s (1995) “missing trade”: for most countries, with Ecuador being no exception, measures of the net factor content of trade are close to zero. So when a country’s imports are assumed to be perfect substitutes for domestic production, equation (10) mechanically implies that trade must have limited distributional consequences. In contrast, when a country’s imports substitute imperfectly for its domestic goods, its gross export and import flows can play distinct and sizable roles, even if the net factor content of trade is relatively small. We find that these distinct roles are important in the case of Ecuador.

### 7.3 Sensitivity Analysis

The goal of this section is to explore the sensitivity of the results in Figure 4 to variants of our baseline model of Ecuador’s economy. Additional details about these alternative models, as well as their estimation, can be found in Appendices C.9 and D.2. All results focus on the impact of trade effects on total income, with the corresponding results for labor (and thus capital) income reported in Appendix D.2.6.

**Baseline Parameters.** The factor demand system of Section 3.1 contains two key micro-level elasticities: the within-firm elasticity of substitution between factors in production ( $\eta$ ) and the within-industry elasticity of substitution between goods in consumption ( $\sigma$ ). Panel (a) of Figure 6 reproduces the counterfactual results in Figure 4 for a wide range of these parameters. It reports the model’s predictions for high and low values of  $\eta = 0.1$  and 8, compared to a baseline value of  $\eta = 2.10$ , as well as high and low values of  $\sigma = 1.5$  and 6, compared to a baseline value of  $\sigma = 2.11$ .<sup>56</sup> Lower values of either  $\eta$  or  $\sigma$  increase the estimated effects of trade on inequality, largely because they strengthen the import channel, but the qualitative features of relative impacts are similar throughout the income distribution. Notably, changing  $\sigma$  has a larger effect than does  $\eta$ , a finding that echoes our analysis

---

<sup>55</sup>Compared to Katz and Murphy (1992), we estimate the elasticity of substitution between three education groups rather than only two, college and non-college graduates. When restricting ourselves to these two groups, we obtain an elasticity of 1.42, very close to the estimate of 1.41 in Katz and Murphy (1992).

<sup>56</sup>The high values we use here correspond to the largest parameter values under which the goodness of fit tests in Section 6 would fail to reject (see Appendix C.7). They encompass larger values than the maxima of the 95% confidence intervals reported in Table 1.

of the original factor content approach in Section 7.2.

**Technology.** For our second set of robustness checks, we generalize the nested CES production functions of Section 3.1. We first let the elasticity of substitution between capital and labor differ from the elasticity of substitution between different labor groups, which we estimate to be 1.27 and 3.15, respectively. We then allow for a non-unitary elasticity of substitution between domestic intermediates, with an estimated value of 1.36, as well as a non-unitary elasticity of substitution between domestic and foreign intermediates, estimated to be 1.02. Panel (b) of Figure 6 illustrates how these three departures affect our counterfactual results. Again, the qualitative impact of trade on inequality is similar across the earnings distribution, though its magnitude falls slightly when we allow for stronger substitution either between domestic suppliers or between domestic and foreign intermediates. This occurs because the import channel captures factors' exposure to firms that import intermediates, either directly or indirectly, and the incidence of such exposure is weaker when those firms have a greater ability to substitute away from more expensive inputs.

**Preferences.** Our next exercises focus on the specification of preferences. First, we allow for heterogeneity in the elasticity of substitution between goods ( $\sigma_k$ ) within each of four broad sector groups (tradables, retail and wholesale, construction and real estate, and other services), with estimated elasticities that range from 1.5 to 2.2. Second, we consider an alternative treatment of retailing firms. Instead of letting retail firms be in their own CES nest, we assume that consumers have preferences over the products sold by retailers rather than over the retailing firms themselves and reallocate each retailer's sales proportionally to those of its suppliers. As seen in panel (c) of Figure 6, these two alternative assumptions about domestic consumers' preferences again leave the qualitative implications of trade for the income distribution in Ecuador unchanged, but they have distinct effects on the magnitudes, again primarily because of their implications for the import channel.

**Factors of Production.** We conclude by considering alternative treatments of primary factors of production. We first group workers into two education groups (per province) based on college and non-college attainment, which yields an estimated  $\eta$  of 1.96. We then assess the sensitivity of our results to different assumptions about factor mobility across provinces, by making labor groups education-specific rather than province-and-education-specific, and factor mobility across sectors, by allowing all our labor groups (as well as capital) to be specific to the oil sector. Our estimates of  $\eta$  in these cases are 1.58 and 2.0, respectively. Finally, we introduce informal factors that are assumed to be perfect

substitutes for their formal counterparts within each factor group, as in Meghir et al. (2015) and Ulyssea (2018), and employed by a representative informal firm within each sector that only sells to domestic consumers. To measure spending on informal factors, we draw on a representative survey of both formal and informal sector earnings described in Appendix B.4. The results of these five alternative treatments of Ecuador’s factors of production are shown in panel (d) of Figure 6. Again, the qualitative finding that trade openness is pro-rich stands out, with the introduction of factor mobility across provinces somewhat weakening this pattern and the introduction of informal workers substantially strengthening this pattern because higher-income individuals are more likely to be endowed with the factors disproportionately employed in the (trade-exposed) formal sector.

**Summary.** Overall, we draw the following conclusions from Figure 6. First, the total impact of trade on inequality in Ecuador has a similar shape across the income distribution—being pro-rich, particularly at the top—throughout the modeling variations considered. Second, the export channel consistently contributes far less to the total impact than does the import channel. Lastly, the magnitude of the import channel is more sensitive to model features, with the potential to become either stronger (for example when we include informal activities) or weaker (for example when the output of firms is extremely substitutable in final demand) than in our baseline.<sup>57</sup>

## 7.4 Trade and Observed Changes in Inequality

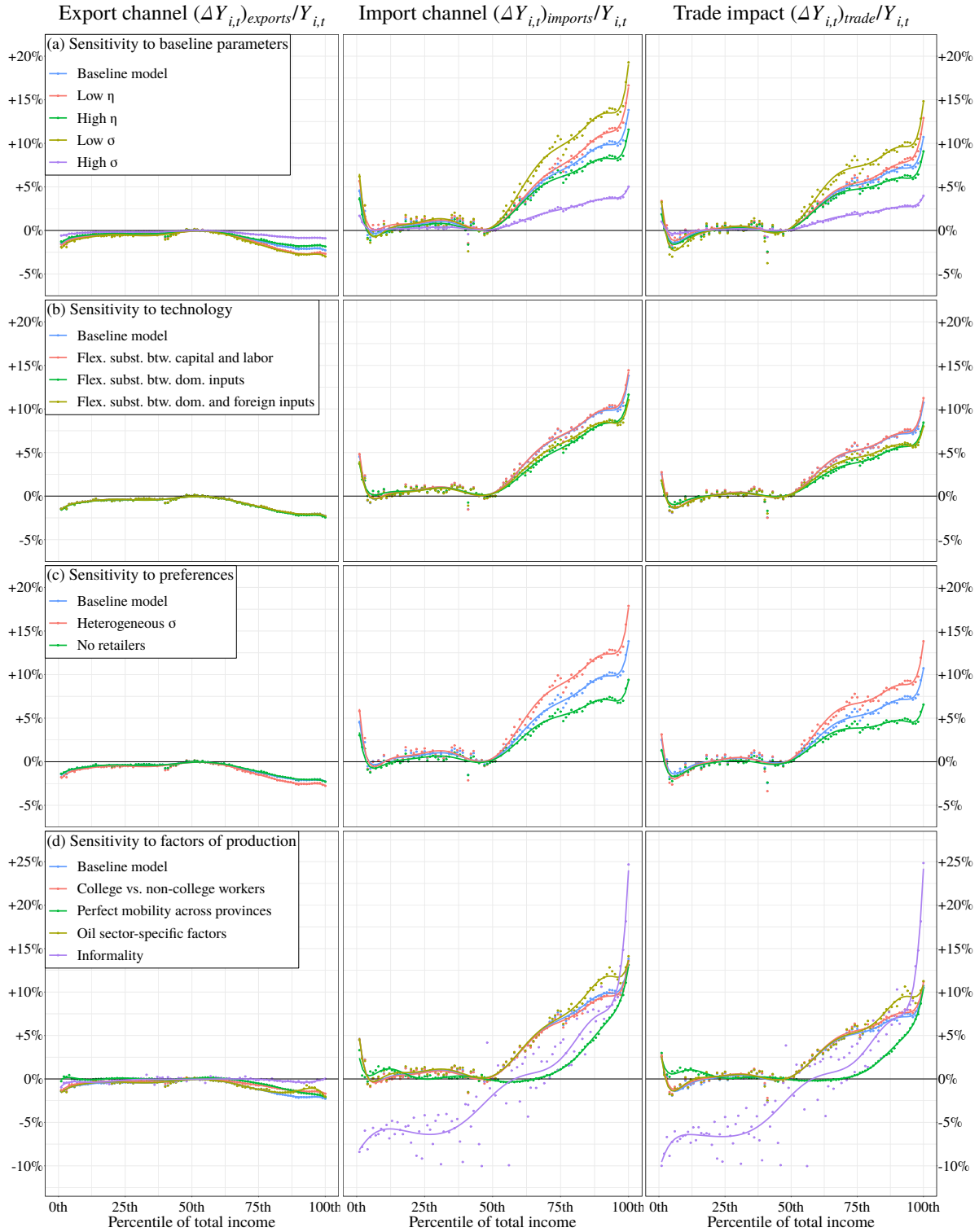
Our analysis above focuses on the difference between autarky and trade at a given point in time, 2012. In Appendix D.3 we repeat such autarky-trade differences throughout the remainder of our sample period (2009-2015) in order to evaluate the contribution of trade to the large reduction in inequality observed in Ecuador over that time.<sup>58</sup> We find that, while trade is a force towards greater earnings inequality in all years, this force is much less potent in 2015 than in 2009. As a result, the drop in inequality would have been significantly

---

<sup>57</sup>The previous conclusions focus on the impact of trade on relative earnings. From an empirical standpoint, one of the main limitations of our dataset is that it does not include household-level consumption data, which prevents us from measuring the distribution of real earnings in Ecuador. Nevertheless, using aggregate expenditure data we can estimate the impact of trade on the cost of living of a representative Ecuadorian consumer. In the baseline model of Section 7.1, this impact is large, with the cost of living going up by 321% under autarky since all firms that import either directly or indirectly can no longer produce. In the extensions of Section 7.3, this number falls to 177% when we introduce a nontraded informal sector and to 30% when we assume a high value of  $\sigma = 6$ . Interestingly, while both extensions predict smaller gains from trade than in our baseline, only the second also predicts smaller changes in inequality, contrary to the presumption that larger gains from trade must go hand in hand with larger distributional effects.

<sup>58</sup>These calculations incorporate informal factors as in Section 7.3.

**Figure 6: Trade and Earnings Inequality, Sensitivity Analysis**



Notes: Dots display the impact on total income at each income percentile (normalized to zero at the median and expressed as percentages). Blue dots denote predicted values for the baseline model (with  $\sigma = 2.11$  and  $\eta = 2.10$ ), as in Figure 4. Panel (a) uses alternative parameter values ( $\eta$  of 0.1 and 8,  $\sigma$  of 1.5 and 6). Panels (b)-(d) use alternative specifications of technology, preferences, and factors as described in Appendices D.2.1 (technology), D.2.1 (preferences), D.2.4 (retailers), and D.2.5 (informality), with the parameter estimates reported in Table C.9. Lines indicate a fitted 10<sup>th</sup>-order polynomial.

mented in the absence of trade, with the 90-10 ratio falling by only 18% in a counterfactually closed Ecuadorian economy instead of the 32% observed in our dataset. As discussed further in Appendix D.3, such inferences about the role played by trade would be markedly dampened if they were based on the original factor content approach.

## 8 Concluding remarks

What is the overall impact of international trade on earnings inequality? Without the ability to observe a given economy both with and without access to global markets, answers to this question inherently draw on a combination of theory and empirics.

Inspired by the original factor content approach to trade and inequality, we have proposed to tackle this classical question as one of factor supply and factor demand. We have developed new measures of export and import exposures across individuals that capture the extent to which the opportunity to export and import shifts the relative demand for the factor services they supply. We have then estimated the overall incidence of international trade on earnings inequality, through both the export and import channels, by estimating the elasticity of domestic demand for these factor services.

Using granular data from Ecuador over the period 2009-2015, we have reached the following empirical conclusions. In terms of exposure, we have found that exports increase the relative demand for the factor services supplied by the middle class, whereas imports increase the relative demand for those supplied by the rich. Given the similarity between the pattern of trade of Ecuador and those of many developing countries that also export commodities in exchange for manufacturing goods, we expect similar biases of export and import exposures to hold more generally. The greater availability of administrative datasets such as ours, combining VAT data with matched employer-employee records in countries like Belgium, Brazil, Chile, Costa Rica, Dominican Republic, and Turkey, provides a rapidly expanding opportunity to explore further which individuals are exposed to international trade around the world, either through exports or imports.

In terms of incidence, we have demonstrated that, within sample, our estimated factor demand system is able to replicate the observed impact of foreign shocks on domestic factor prices. We view this goodness of fit test, which was absent from empirical implementations of the original factor approach, as an important step of our analysis that strengthens the credibility of our empirical model. The broader adoption of such goodness of fit tests could help enhance the credibility of the predictions derived from quantitative trade and spatial models in other contexts as well.

By taking Ecuador to its autarkic limit, we have concluded that the import channel is

the dominant force linking trade to earnings inequality, with the largest gains from trade occurring at the top of the income distribution.

## References

- Acemoglu, Daron and David Autor**, *Skills, Tasks, and Technologies: Implications for Employment and Earnings*, Vol. 4 of *Handbook of Labor Economics*, Elsevier, 2011.
- **and Pablo D. Azar**, “Endogenous Production Networks,” *Econometrica*, 2020, 88 (1), 33–82.
- Adao, Rodrigo, Arnaud Costinot, and Dave Donaldson**, “Nonparametric Counterfactual Predictions in Neoclassical Models of International Trade,” *American Economic Review*, 2017, 107 (3).
- , **Costas Arkolakis, and Federico Esposito**, “General equilibrium effects in space: Theory and measurement,” 2020. Working paper.
- , **Michal Kolesar, and Eduardo Morales**, “Shift-Share Designs: Theory and Inference,” *The Quarterly Journal of Economics*, 2019, 134 (4), 1949–2010.
- , **Paul Carillo, Dave Donaldson, and Dina Pomeranz**, “International Trade and Earnings Inequality: A New Factor Content Approach,” *NBER working paper 28263*, 2020.
- Aghion, Philippe, Antonin Bergeaud, Matthieu Lequien, and Marc J Melitz**, “The heterogeneous impact of market size on innovation: evidence from French firm-level exports,” 2018. NBER.
- Alfaro-Urena, Alonso, Isabela Manelici, and Jose P. Vasquez**, “The Effects of Joining Multinational Supply Chains: New Evidence from Firm-to-Firm Linkages,” 2019.
- Amiti, Mary, Oleg Itskhoki, and Jozef Konings**, “International shocks and domestic prices: how large are strategic complementarities?,” Technical Report, NBER 2016.
- Antras, Pol, Alonso de Gotari, and Oleg Itskhoki**, “Globalization, Inequality and Welfare,” *Journal of International Economics*, 2017, 108, 387–412.
- , **Teresa C. Fort, and Felix Tintelnot**, “The Margins of Global Sourcing: Theory and Evidence from U.S. Firms,” *American Economic Review*, 2017, 107 (9), 2514–64.
- Arkolakis, Costas, Arnaud Costinot, and Andres Rodríguez-Clare**, “New Trade Models, Same Old Gains?,” *American Economic Review*, 2012, 102 (1), 94–130.
- Artuc, E., S. Chaudhuri, and John McLaren**, “Trade Shocks and Labor Adjustment: A Structural Empirical Approach,” *American Economic Review*, 2010, 100 (3), 1008–1045.

- Attanasio, Orazio, Pinelopi Goldberg, and Nina Pavcnik**, "Trade Reforms and Wage Inequality in Colombia," *Journal of Development Economics*, 2004, 74 (2), 331–366.
- Autor, David, David Dorn, and Gordon Hanson**, "The China syndrome: Local labor market effects of import competition in the United States," *American Economic Review*, 2013, 103, 2121–2168.
- , —, —, and **Jae Song**, "Trade Adjustment: Worker-Level Evidence," *Quarterly Journal of Economics*, 2014, 129 (4), 1799–1860.
- Bernard, Andrew B. and J. Bradford Jensen**, "Exceptional Exporter Performance: Cause, Effect, or Both," *Journal of International Economics*, 1999, 47, 1–25.
- , **Emmanuel Dhyne, Glenn Magerman, Kalina Manova, and Andreas Moxnes**, "The Origins of Firm Heterogeneity: A Production Network Approach," 2019. NBER Working Paper 25441.
- , **Stephen J. Redding, and Peter Schott**, "Comparative Advantage and Heterogeneous Firms," *Review of Economic Studies*, 2007, 74 (1), 31–66.
- Bernard, Andrew, Bradford Jensen, Steve Redding, and Peter J. Schott**, "Firms in International Trade," *Journal of Economic Perspectives*, 2007, 21 (3), 105–130.
- Blaum, Joaquin, Claire Lelarge, and Michael Peters**, "The Gains from Input Trade with Heterogeneous Importers," *American Economic Journal: Macroeconomics*, 2018, 10 (4), 77–127.
- Borjas, George J., Richard B. Freeman, and Lawrence F. Katz**, "On the labor market effects of immigration and trade," in G.J. Borjas and R.B. Freeman, eds., *Immigration and the work force*, NBER, 1992.
- , —, and —, "How much do immigration and trade affect labor market outcomes?," *Brookings Papers on Economic Activity*, 1997, 1, 1–90.
- Borusyak, Kirill and Xavier Jaravel**, "The Distributional Effects of Trade: Theory and Evidence from the United States," *mimeo UCL*, 2018.
- , **Peter Hull, and Xavier Jaravel**, "Quasi-experimental shift-share research designs," *Review of Economic Studies*, 2021. Forthcoming.
- Bowen, Harry P., Edward E. Leamer, and Leo Sveikauskas**, "Multicountry, Multifactor Tests of the Factor Abundance Theory," *American Economic Review*, 1987, 77 (5), 791–809.
- Burstein, Ariel and Jonathan Vogel**, "International Trade, Technology, and the Skill Premium," *Journal of Political Economy*, 2017, 125 (5), 1356–1412.
- , **Javier Cravino, and Jonathan Vogel**, "Importing Skill-Biased Technology," *American Economic Journal: Macroeconomics*, 2013, 5 (2), 32–71.



- Carrillo, Paul, Dina Pomeranz, and Monica Singhal**, “Dodging the taxman: Firm misreporting and limits to tax enforcement,” *American Economic Journal: Applied Economics*, 2017, 9 (2), 144–64.
- Costinot, Arnaud and Andres Rodríguez-Clare**, “Trade Theory with Numbers: Quantifying the Consequences of Globalization,” in Gita Gopinath, Elhanan Helpman, and Kenneth Rogoff, eds., *Handbook of International Economics*, Vol. 4, New York: Elsevier, 2014.
- **and Dave Donaldson**, “Ricardo’s Theory of Comparative Advantage: Old Idea, New Evidence,” *American Economic Review, Papers and Proceedings*, 2012, 102 (3), 453–458.
- **and Jonathan Vogel**, “Matching and Inequality in the World Economy,” *Journal of Political Economy*, 2010, 118 (4), 747–786.
- Davis, Donald R. and David Weinstein**, “An Account of Global Factor Trade,” *American Economic Review*, 2001, 91 (5), 1423–1453.
- Deardorff, Alan**, “Factor Prices and the Factor Content of Trade Revisited: What’s the Use?,” *Journal of International Economics*, 2000, 50 (1), 73–90.
- **and Robert Staiger**, “An Interpretation of the Factor Content of Trade,” *Journal of International Economics*, 1988, 24 (1), 93–107.
- Demir, Banu, Ana Cecilia Fielser, Daniel Yi Xu, and Kelly Kaili Yang**, “O-Ring Production Networks,” 2020. Mimeo Bilkent University.
- Dhyne, Emmanuel, Ayumu Ken Kikkawa, Magne Mogstad, and Felix Tintelnot**, “Trade and Domestic Production Networks,” *Review of Economic Studies*, 2021. Forthcoming.
- Dix-Carneiro, Rafael and Brian K Kovak**, “Trade Liberalization and Regional Dynamics,” *American Economic Review*, 2017, 107 (10), 2908–46.
- Fajgelbaum, Pablo and Amit Khandelwal**, “Measuring the Unequal Gains from Trade,” *Quarterly Journal of Economics*, 2016, 131, 1113–1180.
- Feenstra, Robert C.**, *Offshoring in the global economy: microeconomic structure and macroeconomic implications*, MIT Press, 2010.
- **and Gordon H. Hanson**, “The impact of outsourcing and high-technology capital on wages: Estimates for the United States, 1979-1990,” *Quarterly Journal of Economics*, 1999, 114 (907-940).
- Fielser, Ana Cecilia, Marcela Eslava, and Daniel Yi Xu**, “Trade, Quality Upgrading, and Input Linkages: Theory and Evidence from Colombia,” *American Economic Review*, 2018, 108 (1).
- Flynn, Joel P., Chris Patterson, and John Sturm**, “Fiscal Policy in a Networked Economy,” *mimeo MIT*, 2020.

- Galle, Simon, Andres Rodríguez-Clare, and Moises Yi**, “Slicing the Pie: Quantifying the Aggregate and Distributional Effects of Trade,” 2017. NBER Working Paper 23737.
- Goldberg, Penny and Nina Pavcnik**, “Distributional Effects of Globalization in Developing Countries,” *Journal of Economics Literature*, 2007, 45, 39–82.
- Grossman, Gene M. and Esteban Rossi-Hansberg**, “Trading Tasks: A Simple Theory of Offshoring,” *American Economic Review*, 2008, 98 (5), 1978–1997.
- , **Elhanan Helpman, and Philipp Kircher**, “Matching, Sorting, and the Distributional Effects of International Trade,” *Journal of Political Economy*, 2017, 125 (1), 224–264.
- Hanson, Gordon and Ann Harrison**, “Trade Liberalization and Wage Inequality in Mexico,” *Industrial and Labor Relations Review*, 1999, 52 (2), 271–288.
- Harrigan, James and Ariell Reshef**, “Skill-biased heterogeneous firms, trade liberalization and the skill premium,” *Canadian Journal of Economics*, 2016, 48 (3), 1024–1066.
- Harrison, Ann, John McLaren, and Margaret McMillan**, “Recent Perspectives on Trade and Inequality,” *Annual Review of Economics*, 2011, 3, 261–289.
- Helpman, E., O. Itzhoki, and S. Redding**, “Inequality and Unemployment in a Global Economy,” *Econometrica*, 2010, 78 (4), 1239–1283.
- Helpman, Elhanan**, *Globalization and Inequality*, Harvard University Press, 2018.
- Hottman, Colin, Steve Redding, and David Weinstein**, “Quantifying the Sources of Firm Heterogeneity,” *Quarterly Journal of Economics*, 2016, 131 (3), 1291–1364.
- Hummels, David, Jakob R Munch, and Chong Xiang**, “Offshoring and Labor Markets,” *Journal of Economic Literature*, 2018, 56 (3), 981–1028.
- , **Rasmus Jørgensen, Jakob Munch, and Chong Xiang**, “The Wage Effects of Offshoring: Evidence from Danish Matched Worker-Firm Data,” *American Economic Review*, 2014, 104 (6).
- Huneus, Federico**, “Production Network Dynamics and the Propagation of Shocks,” 2018. Mimeo Central Bank of Chile.
- Johnson, Robert C. and Guillermo Noguera**, “Accounting for Intermediates: Production Sharing and Trade in Value Added,” *Journal of International Economics*, 2012, 86 (2), 224–236.
- Katz, Lawrence and Kevin Murphy**, “Changes in Relative Wages, 1963-1987: Supply and Demand Factors,” *Quarterly Journal of Economics*, 1992, 107 (1), 35–78.

- Kovak, Brian K.**, "Regional Effects of Trade Reform: What Is the Correct Measure of Liberalization?," *American Economic Review*, 2013, 103 (5), 1960–76.
- Krugman, Paul**, "Technology, trade and factor prices," *Journal of International Economics*, 2000, 50, 51–71.
- Krusell, Per, Lee Ohanian, Jose-Victor Rios-Rull, and Giovanni Violante**, "Capital-skill Complementarity and Inequality: A Macroeconomic Analysis," *Econometrica*, 2000, 68 (5), 1029–1053.
- Lawrence, Robert Z. and Matthew J. Slaughter**, "International trade and American wages in the 1980s: Giant sucking sound or small hiccup?," *Brookings Papers on Economic Activity*, 1993.
- Leamer, Edward E.**, "In search of Stolper-Samuelson linkages between international trade and lower wages," in S. Collins, ed., *Imports, exports, and the American worker*, Brookings, 1998.
- , "What's the use of factor contents?," *Journal of International Economics*, 2000, 50, 17–49.
- Leontief, Wassily**, "Domestic production and foreign trade; the American capital position re-examined," *Proceedings of the American Philosophical Society*, 1953, pp. 332–349.
- Meghir, Costas, Renata Narita, and Jean-Marc Robin**, "Wages and Informality in Developing Countries," *American Economic Review*, 2015, 105 (4), 1509–1546.
- Melitz, Marc J.**, "The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity," *Econometrica*, 2003, 71 (6), 1695–1725.
- Muendler, Marc-Andreas**, "Trade, Technology, and Prosperity: An Account of Evidence from a Labor-market Perspective," 2017. WTO Staff Working Paper ERSD-2017-15.
- Murphy, Kevin M. and Finis Welch**, "The Role of International Trade in Wage Differentials," in M. Koster, ed., *Workers and their Wages*, American Enterprise Institute, Washington DC, 1991.
- Oberfield, Ezra and Devesh Raval**, "Micro Data and Macro Technology," *Econometrica*, 2021.
- Ohnsorge, Franziska and Daniel Trefler**, "Sorting It Out: International Trade with Heterogeneous Workers," *Journal of Political Economy*, 2007, 115 (5), 868–892.
- Parro, Fernando**, "Capital-Skill Complementarity and the Skill Premium in a Quantitative Model of Trade," *American Economic Journal: Macroeconomics*, 2013, 5 (2), 72–117.
- Pavcnik, Nina**, "The Impact of Trade on Inequality in Developing Countries," in "Proceedings of Jackson Hole Economic Symposium" 2017, pp. 61–114.
- Pierce, Justin R. and Peter K. Schott**, "The Surprisingly Swift Decline of US Manufacturing Employment," *American Economic Review*, 2016, 106 (7), 1632–62.

- Piketty, Thomas and Emmanuel Saez**, "Income Inequality in the United States, 1913-1998," *Quarterly Journal of Economics*, 2003, 118 (1), 1–39.
- , —, and **Gabriel Zucman**, "Distributional National Accounts: Methods and Estimates for The United States," *Quarterly Journal of Economics*, 2018, 133 (2), 553–609.
- Porto, Guido**, "Using Survey Data to Assess the Distributional Effects of Trade Policy," *Journal of International Economics*, 2006, 70 (1), 140–160.
- Sampson, Thomas**, "Selection into Trade and Wage Inequality," *American Economic Journal: Microeconomics*, 2014, 6 (3), 157–202.
- Samuelson, Paul A.**, "Abstract of a Theorem Concerning Substitutability in Open Leontief Models," in T.C. Koopmans, ed., *Activity Analysis of Production and Allocation*, John Wiley and Sons, 1951.
- Slaughter, Matthew J.**, "What Are the Results of Product-Price Studies and What Can We Learn from Their Differences?," in R.C. Feenstra, ed., *The Impact of International Trade on Wages*, U. Chicago Press 2000.
- Smith, Matthew, Danny Yagan, Owen Zidar, and Eric Zwick**, "Capitalists in the Twenty-First Century," *Quarterly Journal of Economics*, 2019, 134 (4), 1675–1745.
- Spray, John and Sebastian Wolf**, "Industries without Smokestacks in Uganda and Rwanda," in R. Newfarmer, F. Tarp, and J.M. Page, eds., *Industries Without Smokestacks*, OUP, 2018.
- Stolper, Wolfgang F. and Paul A. Samuelson**, "Protection and Real Wages," *Review of Economic Studies*, 1941, 9 (1), 58–73.
- Trefler, Daniel**, "International Factor Price Differences: Leontief Was Right!," *Journal of Political Economy*, 1993, 101 (6), 961–987.
- , "The Case of the Missing Trade and Other Mysteries," *American Economic Review*, 1995, 85 (5).
- and **Susan Zhu**, "The structure of factor content predictions," *Journal of International Economics*, 2010, 82, 195–207.
- Ulyssea, Gabriel**, "Firms, Informality, and Development: Theory and Evidence from Brazil," *American Economic Review*, 2018, 108 (8), 2015–2047.
- Wood, Adrian**, *North-South trade, employment, and inequality: Changing fortunes in a skill-driven world*, Oxford University Press, 1995.
- Yeaple, Stephen Ross**, "A Simple Model of Firm Heterogeneity, International Trade, and Wages," *Journal of International Economics*, January 2005, 65 (1), 1–20.

# A Appendix: Theoretical Results

## A.1 Preliminary

To establish Lemma 1, we make use of the two following results.

**Theorem 1** (Nonsubstitution Theorem). *Suppose that  $f_n$  satisfies the regularity conditions imposed in Section 2.1 for all  $n \in \mathcal{N}$ . Then there exists a unique strictly positive solution  $\tilde{p}(p^*, w_T) \equiv \{\tilde{p}_n(p^*, w_T)\}$  to the fixed point problem,*

$$p_n = c_n(p, p^*, w_T) \text{ for all } n \in \mathcal{N}. \quad (\text{A.1})$$

*Proof.* We follow the same general strategy as in Acemoglu and Azar (2020) and use Tarski's fixed point theorem to establish existence and uniqueness of a strictly positive solution to (A.1).

**Existence:** Our economy is productive in the sense that there exists  $\{l_n, m_n, m_n^*\}$  such that  $f_n(l_n, m_n, m_n^*) > \sum_{r \in \mathcal{N}} m_{nr}$  for all  $n \in \mathcal{N}$ . Let  $l_n^u \equiv l_n / f_n(l_n, m_n, m_n^*)$ ,  $m_n^u \equiv m_n / f_n(l_n, m_n, m_n^*)$ , and  $m_n^{u*} \equiv m_n^* / f_n(l_n, m_n, m_n^*)$  denote the associated vectors of input demand. Consider the hypothetical Leontief economy with unit requirements given by  $l_n^u$ ,  $m_n^u$ , and  $m_n^{u*}$  for all  $n \in \mathcal{N}$ . Since that economy is productive, Corollary 1 p. 297 in Gale (1960) implies the existence of  $B^u \equiv (I - M^u)^{-1}$  with  $M^u \equiv \{m_{rn}^u\}$ . We can therefore construct  $\hat{p} \equiv B^u \{w_T \cdot l_n^u + p^* \cdot m_n^{u*}\}$  that satisfies

$$\hat{p}_n = w_T \cdot l_n^u + p^* \cdot m_n^{u*} + \hat{p} \cdot m_n^u \text{ for all } n \in \mathcal{N}.$$

Since  $f_n(0, m_n, 0) = 0$ , note that  $\hat{p}_n > 0$ . By definition of  $c_n(\hat{p}, p^*, w_T)$ , note also that  $c_n(\hat{p}, p^*, w_T) \leq \hat{p}_n$ . So for any  $\beta \geq 1$ , we must have  $c_n(\beta \hat{p}, p^*, w_T) \leq c_n(\beta \hat{p}, \beta p^*, \beta w_T) \leq \beta \hat{p}_n$ , where the first inequality uses  $c_n(\cdot, \cdot, \cdot)$  increasing and the second  $c_n(\cdot, \cdot, \cdot)$  homogeneous of degree one. Since  $f_n$  is continuous and satisfies  $f_n(0, m_n, 0) = 0$ , there must also exist  $\hat{\alpha} < 1$  such that for all  $\alpha < \hat{\alpha}$  and  $n \in \mathcal{N}$ ,  $c_n(\alpha \hat{p}, p^*, w_T) > \alpha \hat{p}_n$ . Now consider the non-empty complete lattice  $\mathcal{O} \equiv \prod_{n \in \mathcal{N}} [\alpha \hat{p}_n, \beta \hat{p}_n]$ , with  $\alpha \leq \hat{\alpha}$  and  $\beta \geq 1$ . Since  $c(\cdot, p^*, w_T)$  is an increasing function that maps  $\mathcal{O}$  onto itself, Tarski's fixed point theorem implies the existence of a strictly positive solution to (A.1).

**Uniqueness:** Suppose, by contradiction, that there are two strictly positive solutions  $p \neq p'$  to (A.1). Take  $\alpha \leq \hat{\alpha}$  small enough and  $\beta \geq 1$  large enough such that  $p, p' \in \mathcal{O}$ . From Tarski's fixed point theorem, we know that the set of solutions to (A.1) that belong to  $\mathcal{O}$  forms a complete lattice. Thus it admits a smallest element,  $\underline{p} \leq \min\{p, p'\}$  and a largest element  $\bar{p} \geq \max\{p, p'\} > \underline{p}$ . Take  $v \in (0, 1)$  such that  $v\bar{p} \leq \underline{p}$  with at least one good  $n$  such

that  $v\bar{p}_n = \underline{p}_n$ . Then, we have

$$\begin{aligned} c_n(\underline{p}, p^*, w_T) - \underline{p}_n &\geq c_n(v\bar{p}, p^*, w_T) - v\bar{p}_n \\ &= [c_n(v\bar{p}, p^*, w_T) - c_n(v\bar{p}, v p^*, v w_T)] + v c_n(\bar{p}, p^*, w_T) - v\bar{p}_n > 0, \end{aligned}$$

where the first inequality uses  $c_n(\cdot, p^*, w_T)$  increasing, the next equality uses  $c_n(\cdot, \cdot, \cdot)$  homogeneous of degree one, and the final inequality uses  $c_n(v\bar{p}, p^*, w_T) - c_n(v\bar{p}, v p^*, v w_T) > 0$ , since  $f_n(0, m_n, 0) = 0$  for all  $n \in \mathcal{N}$ . This contradicts  $\underline{p}$  being a solution to (A.1).  $\square$

**Lemma 2.** *Suppose that the allocation  $(\{q_{i,T}\}_{i \in \mathcal{I}}, \{y_{n,T}, l_{n,T}, m_{n,T}, m_{n,T}^*\}_{n \in \mathcal{N}})$  and the prices  $(p_T, w_T)$  form a competitive equilibrium at Home. Then under the assumptions of Section 2.1, the same allocation and the prices  $(\tilde{p}(p^*, w_T), w_T)$  also form a competitive equilibrium, with  $\tilde{p}(p^*, w_T) \equiv \{\tilde{p}_n(p^*, w_T)\}$  the unique strictly positive solution to the fixed-point problem,  $p_n = c_n(p, p^*, w_T)$  for all  $n \in \mathcal{N}$ .*

*Proof.* Start from the competitive equilibrium  $(\{q_{i,T}\}_{i \in \mathcal{I}}, \{y_{n,T}, l_{n,T}, m_{n,T}, m_{n,T}^*\}_{n \in \mathcal{N}}, p_T, w_T)$ . The profit-maximization condition (4) requires

$$p_{n,T} \leq c_n(p_T, p^*, w_T) \text{ with equality for all } n \text{ such that } y_{n,T} > 0. \quad (\text{A.2})$$

Let  $\mathcal{N}_0$  denote the set of inactive firms  $n \in \mathcal{N}$  such that  $y_{n,T} = 0$ . We proceed in 4 steps.

**Step 1:**  $p_{n,T} \leq \tilde{p}_n(p^*, w_T)$  for all  $n \in \mathcal{N}$ , with equality for all  $n \notin \mathcal{N}_0$ .

Consider the sequence  $(p^k)_{k \in \mathbb{N}}$ , defined by  $p^0 \equiv p_T$  and  $p_n^{k+1} = h_n(p^k)$ , with  $h_n(p^k) \equiv c_n(p^k, p^*, w_T)$  for all  $n \in \mathcal{N}$ . Since cost functions are increasing,  $h_n$  is increasing, so that  $p^k \geq p^{k-1}$  implies  $p^{k+1} \geq p^k$ . By A.2,  $p^1 \geq p^0$ . It follows that  $(p^k)_{k \in \mathbb{N}}$  is increasing.

Now take  $\beta$  large enough so that  $p_0 \leq \beta \hat{p}$ , with  $\hat{p}$  defined as in the proof of Theorem 1. If  $p^k \leq \beta \hat{p}$ , then  $p^{k+1} = h_n(p^k) \leq h_n(\beta \hat{p}) \leq \beta c_n(\hat{p}, p^*, w_T) \leq \beta \hat{p}$ . It follows that there exists  $\beta$  so that  $(p^k)_{k \in \mathbb{N}}$  is bounded from above by  $\beta \hat{p}$ .

Since  $(p^k)_{k \in \mathbb{N}}$  is increasing and bounded, it must converge to  $p^\infty$ ; and since  $h_n$  is continuous,  $p_n^\infty = h_n(p^\infty)$  for all  $n \in \mathcal{N}$ . By Theorem 1, we therefore have  $p_n^\infty = \tilde{p}_n(p^*, w_T)$ . Since  $(p^k)_{k \in \mathbb{N}}$  is increasing, we conclude that  $p_{n,T} = p_n^0 \leq p_n^\infty = \tilde{p}_n(p^*, w_T)$  for all  $n \in \mathcal{N}$ .

To show that  $p_{n,T} = \tilde{p}_n(p^*, w_T)$  for all  $n \notin \mathcal{N}_0$ , we proceed again by iteration. By definition, we have  $p^0 = p_T$ . We want to show that if  $p_n^k = p_{n,T}$  for some  $n \notin \mathcal{N}_0$ , then  $p_n^{k+1} = p_{n,T}$ . Note that  $p_n^{k+1} = h_n(\{p_{r,T}\}_{r \notin \mathcal{N}_0}, \{p_r^k\}_{r \in \mathcal{N}_0}) \geq h_n(p_T)$ , since  $(p^k)_{k \in \mathbb{N}}$  is increasing. Note also that  $p_n^{k+1} = h_n(\{p_{r,T}\}_{r \notin \mathcal{N}_0}, \{p_r^k\}_{r \in \mathcal{N}_0}) \leq h_n(p_T)$ , since using unit input demands from the original trade equilibrium is still feasible. It follows that  $p_{n,T} = \tilde{p}_n(p^*, w_T)$  for all  $n \notin \mathcal{N}_0$ .

**Step 2:**  $q_{i,T}$  solves (1) for all  $i \in \mathcal{I}$  under the new price  $\tilde{p}(p^*, w_T)$ .

By the good market clearing condition (3),  $q_{ni,T} = 0$  for all  $n \in \mathcal{N}_0$ . By Step 1,  $p_{n,T} = \tilde{p}_n(p^*, w_T)$  for all  $n \notin \mathcal{N}_0$ . So  $q_{i,T}$  satisfies the budget constraint for all  $i \in \mathcal{I}$  under the new price  $\tilde{p}(p^*, w_T)$ . Now suppose, by contradiction, that there exists  $i \in \mathcal{I}$  such that  $q_{i,T}$  does not solve (1) under the new price  $\tilde{p}(p^*, w_T)$ . Take  $q_i$  that solves (1). It therefore satisfies  $u_i(q_i) > u_i(q_{i,T})$ . By Step 1,  $p_{n,T} \leq \tilde{p}_n(p^*, w_T)$  for all  $n \in \mathcal{N}$ . So  $q_i$  also satisfies individual  $i$ 's budget constraint under the original price  $p_T$ . This contradicts  $q_{i,T}$  solving (1) under this price.

**Step 3:**  $(y_{n,T}, l_{n,T}, m_{n,T}, m_{n,T}^*)$  solves (2) for all  $n \in \mathcal{N}$  under the new price  $\tilde{p}(p^*, w_T)$ .

First consider firms  $n \in \mathcal{N}_0$ . Under the new price  $\tilde{p}(p^*, w_T)$ , prices are equal to unit costs, so  $y_{n,T} = l_{n,T} = m_{n,T} = m_{n,T}^* = 0$  is still trivially an equilibrium. Next consider firms  $n \notin \mathcal{N}_0$ . Let  $\bar{l}_{n,T} = l_{n,T}/y_{n,T}$ ,  $\bar{m}_{n,T} = m_{n,T}/y_{n,T}$ , and  $\bar{m}_{n,T}^* = m_{n,T}^*/y_{n,T}$  denote their unit input demand. Since prices are equal to unit costs,  $(q_{n,T}, l_{n,T}, m_{n,T}, m_{n,T}^*)$  solves (2) under the new price  $\tilde{p}(p^*, w_T)$  if and only if  $(\bar{l}_{n,T}, \bar{m}_{n,T}, \bar{m}_{n,T}^*)$  solves the cost minimization problem of firm  $n$  under  $\tilde{p}(p^*, w_T)$ . Suppose, by contradiction, that it does not. Let  $(\bar{l}_n, \bar{m}_n, \bar{m}_n^*)$  denote a solution to that problem. It satisfies

$$\begin{aligned} w_T \cdot \bar{l}_n + p^* \cdot \bar{m}_n^* + p_T \cdot m_n^u &\leq w_T \cdot \bar{l}_n + p^* \cdot \bar{m}_n^* + \tilde{p}(p^*, w_T) \cdot m_n^u \\ &< w_T \cdot \bar{l}_{n,T} + p^* \cdot \bar{m}_{n,T}^* + \tilde{p}(p^*, w_T) \cdot m_{n,T}^u \leq w_T \cdot \bar{l}_{n,T} + p^* \cdot \bar{m}_{n,T}^* + p_T \cdot m_{n,T}^u, \end{aligned}$$

where the first inequality derives from Step 1 and the final inequality derives from Step 1 and the fact that  $m_{rn,T}^u = 0$  for all  $r \in \mathcal{N}_0$  by the good market clearing condition (3). This contradicts  $(\bar{l}_{n,T}, \bar{m}_{n,T}, \bar{m}_{n,T}^*)$  solving the cost minimization problem of firm  $n$  under the original price  $p_T$ .

**Step 4:**  $(\{q_{i,T}\}_{i \in \mathcal{I}}, \{y_{n,T}, l_{n,T}, m_{n,T}, m_{n,T}^*\}_{n \in \mathcal{N}}, \tilde{p}(p^*, w_T), w_T)$  is a competitive equilibrium.

Since  $(\{q_{i,T}\}_{i \in \mathcal{I}}, \{y_{n,T}, l_{n,T}, m_{n,T}, m_{n,T}^*\}_{n \in \mathcal{N}})$  is an equilibrium allocation under the original price  $p_T$ , it satisfies the market clearing conditions (3) and (4). Using Steps 2 and 3, we therefore conclude that  $(\{q_{i,T}\}_{i \in \mathcal{I}}, \{y_{n,T}, l_{n,T}, m_{n,T}, m_{n,T}^*\}_{n \in \mathcal{N}}, \tilde{p}(p^*, w_T), w_T)$  is a competitive equilibrium.  $\square$

## A.2 Proof of Lemma 1

*Proof.* Suppose that  $w_T > 0$  is an equilibrium vector of factor prices. By Lemma 2, there must exist  $\{q_{i,T}\}_{i \in \mathcal{I}}$  and  $\{y_{n,T}, l_{n,T}, m_{n,T}, m_{n,T}^*\}_{n \in \mathcal{N}}$  such that (i)  $q_{i,T}$  solves (1) for all  $i \in \mathcal{I}$  if  $p = \tilde{p}(p^*, w_T)$ ; (ii)  $(y_{n,T}, l_{n,T}, m_{n,T}, m_{n,T}^*)$  solves (2) for all  $n \in \mathcal{N}$  if  $p = \tilde{p}(p^*, w_T)$ ; (iii) the good market clearing condition (3) holds; and (iv) the factor market clearing condition (4) holds.

Condition (i) implies

$$\sum_{i \in \mathcal{I}} q_{ni,T} = \sum_{i \in \mathcal{I}} d_{ni}(\tilde{p}(p^*, w_T), w_T) \text{ for all } n \in \mathcal{N}.$$

Using  $D(p, w) \equiv \{\sum_{i \in \mathcal{I}} p_n d_{i,n}(p, w)\}$ , this can be rearranged in nominal terms as

$$\sum_{i \in \mathcal{I}} \tilde{p}_n(p^*, w_T) q_{ni,T} = D_n(\tilde{p}(p^*, w_T), w_T). \quad (\text{A.3})$$

Condition (ii) implies

$$\begin{aligned} \sum_{n \in \mathcal{N}} l_{fn,T} &= \sum_{n \in \mathcal{N}} l_{fn}(\tilde{p}(p^*, w_T), p^*, w_T) y_{n,T}, \\ \sum_{r \in \mathcal{N}} m_{rn,T} &= \sum_{r \in \mathcal{N}} m_{rn}(\tilde{p}(p^*, w_T), p^*, w_T) y_{n,T}. \end{aligned}$$

Using  $x_{fn}(p, p^*, w) \equiv w_f l_{fn}(p, p^*, w) / c_n(p, p^*, w)$ ,  $x_{rn}(p, p^*, w) \equiv p_r m_{rn}(p, p^*, w) / c_n(p, p^*, w)$ , and  $\tilde{p}(p^*, w_T) = c(\tilde{p}(p^*, w_T), p^*, w_T)$ , we also have, in nominal terms,

$$\sum_{n \in \mathcal{N}} w_{f,T} l_{fn,T} = \sum_{n \in \mathcal{N}} x_{fn}(\tilde{p}(p^*, w_T), p^*, w_T) \tilde{p}_n(p^*, w_T) y_{n,T}, \quad (\text{A.4})$$

$$\sum_{r \in \mathcal{N}} \tilde{p}_r(p^*, w_T) m_{rn,T} = \sum_{r \in \mathcal{N}} x_{rn}(\tilde{p}(p^*, w_T), p^*, w_T) \tilde{p}_n(p^*, w_T) y_{n,T}. \quad (\text{A.5})$$

Combining condition (iii) with (A.3) and (A.5), and using  $E \equiv \{\tilde{p}_n(p^*, w_T) e_n\}$ , further implies

$$\tilde{p}_n(p^*, w_T) y_{n,T} = \sum_{r \in \mathcal{N}} x_{nr}(\tilde{p}(p^*, w_T), p^*, w_T) \tilde{p}_r(p^*, w_T) y_{r,T} + D_n(\tilde{p}(p^*, w_T), w_T) + E_n, \text{ for all } n \in \mathcal{N}.$$

In matrix notation, the value of the vector of gross output that solves the previous system is

$$\{\tilde{p}_n(p^*, w_T) y_{n,T}\} = B(\tilde{p}(p^*, w_T), w_T) (D(\tilde{p}(p^*, w_T), w_T) + E), \quad (\text{A.6})$$

where  $B(p, p^*, w_T) \equiv \sum_{k=0}^{\infty} M^k(p, p^*, w_T)$  is the Leontief inverse associated with the input-output matrix  $M(p, p^*, w_T) \equiv \{x_{rn}(\tilde{p}(p^*, w_T), p^*, w_T)\}$ , whose existence follows from the economy being productive (Corollary 1 p. 297 in Gale, 1960). Using (A.6) to substitute for the value of gross output in (A.4), we obtain

$$\sum_{n \in \mathcal{N}} l_{fn,T} = L_f(p^*, w_T) + L_f^*, \quad (\text{A.7})$$



where domestic factor demand and the factor content of exports are given by

$$\begin{aligned}\{w_f L_f(p^*, w)\} &\equiv A(\tilde{p}(p^*, w), p^*, w) B(\tilde{p}(p^*, w), p^*, w) D(\tilde{p}(p^*, w), w), \\ \{w_{f,T} L_f^*\} &\equiv A(\tilde{p}(p^*, w_T), p^*, w_T) B(\tilde{p}(p^*, w_T), p^*, w_T) E,\end{aligned}$$

with  $A(p, p^*, w) \equiv \{x_{fn}(p, p^*, w)\}$  the matrix of unit factor requirements. Equation (7) follows from (A.7) and the factor market clearing condition (4).  $\square$

### A.3 Proof of Proposition 1

*Proof.* For any value of  $p^* \equiv \{p_n^*\} > 0$  and  $REE \equiv \{(1 - L_0^*/\bar{L}_0)/(1 - L_f^*/\bar{L}_f)\}$ , consider the vector of domestic factor prices  $w \equiv \{w_f\} > 0$  that solves

$$RD_f(p^*, w) = RS_f / REE_f \text{ for all } f \neq 0.$$

Under the assumption  $\ln RD$  is continuously differentiable with respect to  $(p^*, w)$  and that the matrix  $\partial \ln RD / \partial \ln w \equiv \{\partial \ln RD_f / \partial \ln w_g\}$  is invertible for all  $(p^*, w)$ , the Implicit Function Theorem implies the existence of a unique function  $\tilde{w}(REE, p^*)$  such that

$$RD_f(\tilde{w}(REE, p^*), p^*) = RS_f / REE_f \text{ for all } f \neq 0.$$

Moreover,  $\partial \ln \tilde{w} / \partial \ln REE \equiv \{\partial \ln \tilde{w}_f / \partial \ln REE_g\}$  and  $\partial \ln \tilde{w} / \partial \ln p^* \equiv \{\partial \ln \tilde{w}_f / \partial \ln p_n^*\}$  satisfy

$$\frac{\partial \ln \tilde{w}}{\partial \ln REE} = - \left[ \frac{\partial \ln RD}{\partial \ln w} \right]^{-1}, \quad (\text{A.8})$$

$$\frac{\partial \ln \tilde{w}}{\partial \ln p^*} = - \left[ \frac{\partial \ln RD}{\partial \ln w} \right]^{-1} \frac{\partial \ln RD}{\partial \ln p^*}, \quad (\text{A.9})$$

where  $\partial \ln RD / \partial \ln p^* \equiv \{\partial \ln RD_f / \partial \ln p_n^*\}$ . Let  $u \equiv \{\ln REE_f\}$  and  $v \equiv \{\ln p_n^*\}$ . Integrating equations (A.8) and (A.9) between autarky ( $u = 0, v = \infty$ ) and trade ( $u = \ln REE, v = \ln p^*$ ), we obtain

$$\ln w_T - \ln w_A = - \int_{(u=0, v=\infty)}^{(u=\ln REE, v=\ln p^*)} \left( \left[ \frac{\partial \ln RD}{\partial \ln w} \right]^{-1} du + \left[ \frac{\partial \ln RD}{\partial \ln w} \right]^{-1} \frac{\partial \ln RD}{\partial \ln p^*} dv \right).$$

This can be rearranged as  $(\Delta \ln w)_{trade} = (\Delta \ln w)_{exports} + (\Delta \ln w)_{imports}$  with

$$\begin{aligned} (\Delta \ln w)_{exports} &= - \int_{(u=0, v=\ln p^*)}^{(u=\ln REE, v=\ln p^*)} \left[ \frac{\partial \ln RD}{\partial \ln w} \right]^{-1} dv, \\ (\Delta \ln w)_{imports} &= - \int_{(u=0, v=\infty)}^{(u=0, v=\ln p^*)} \left[ \frac{\partial \ln RD}{\partial \ln w} \right]^{-1} \left[ \frac{\partial \ln RD}{\partial \ln p^*} \right] du. \end{aligned}$$

□

## A.4 Proof of Proposition 2

*Proof.* By definition,  $\tilde{p}(p^*, w)$  is the unique solution to the zero-profit conditions

$$p_n = c_n(p, p^*, w) \text{ for all } n \in \mathcal{N}.$$

Using equation (20), this can be rearranged as

$$\ln p_n = \sum_{r \in \mathcal{N}} (1 - \beta_n) \Theta_n \theta_{rn} \ln p_r + \{ \ln \phi_n + \beta_n \ln \tilde{w}_n(w) + \sum_{r \in \mathcal{N}^*} (1 - \beta_n) (1 - \Theta_n) \theta_{rn}^* \ln p_r^* \}, \text{ for all } n \in \mathcal{N},$$

with  $\tilde{w}_n(w) \equiv (\sum_{f \in \mathcal{F}} \theta_{fn} w_f^{1-\eta})^{\frac{1}{1-\eta}}$  denoting the CES price index associated with domestic factor prices. In matrix notation, the previous system can be expressed as

$$\{ \ln p_n \} = M' \{ \ln p_n \} + \{ \ln \phi_n + \beta_n \ln \tilde{w}_n(w) + \sum_{r \in \mathcal{N}^*} (1 - \beta_n) (1 - \Theta_n) \theta_{rn}^* \ln p_r^* \},$$

where  $M'$  is the transpose of the input-output matrix  $M = \{(1 - \beta_n) \Theta_n \theta_{rn}\}$ . The unique solution is such that

$$\begin{aligned} \{ \ln p_n \} &= (I - M')^{-1} \{ \ln \phi_n + \beta_n \ln \tilde{w}_n(w) + \sum_{r \in \mathcal{N}^*} (1 - \beta_n) (1 - \Theta_n) \theta_{rn}^* \ln p_r^* \} \\ &= B' \{ \ln \phi_n + \beta_n \ln \tilde{w}_n(w) + \sum_{r \in \mathcal{N}^*} (1 - \beta_n) (1 - \Theta_n) \theta_{rn}^* \ln p_r^* \}, \end{aligned}$$

where  $B \equiv \{b_{nr}\}$  is the Leontief inverse associated with  $M$ . We therefore have

$$\tilde{p}_n(p^*, w) = \exp \left\{ \sum_{r \in \mathcal{N}} b_{rn} [\ln \phi_r + \beta_r \ln \tilde{w}_r(w) + \sum_{l \in \mathcal{N}^*} (1 - \beta_r) (1 - \Theta_r) \theta_{rl}^* \ln p_l^*] \right\}. \quad (\text{A.10})$$

Starting from the definition of domestic factor demand in equation (5) and combining (A.10) with the vector of domestic expenditure associated with (13), the matrix of factor

shares,  $A(p, p^*, w)$ , associated with (17), and the Leontief inverse associated with (18), we obtain the desired result.  $\square$

## A.5 Proof of Proposition 3

*Proof.* In Proposition 2, we have established that

$$RD_f(p^*, w) = \left(\frac{w_f}{w_0}\right)^{-\eta} \frac{\sum_{m \in \mathcal{N}} \theta_{fm} Z_m(p^*, w)}{\sum_{m \in \mathcal{N}} \theta_{0m} Z_m(p^*, w)},$$

with  $Z_m(p^*, w)$  a function of  $\{\tilde{w}_n(w), \tilde{P}_k(p^*, w), \tilde{p}_n(p^*, w)\}$ ,

$$Z_m(p^*, w) \equiv \sum_{k \in \mathcal{K}, r \in \mathcal{N}_k} \alpha_k \theta_{rc} \beta_m b_{mr} \tilde{w}_m^{\eta-1}(w) \tilde{P}_k^{\sigma-1}(p^*, w) \tilde{p}_r^{1-\sigma}(p^*, w).$$

Differentiating the two previous expressions with respect to  $p_n^*$  we get

$$\frac{\partial \ln RD_f}{\partial \ln p_n^*} = \sum_{m \in \mathcal{N}} (r_{fm} - r_{0m}) \frac{\partial \ln Z_m}{\partial \ln p_n^*}, \quad (\text{A.11})$$

$$\frac{\partial \ln Z_m}{\partial \ln p_n^*} = \sum_{k \in \mathcal{K}, r \in \mathcal{N}_k} z_{mr} (1 - \sigma) \left( \frac{\partial \ln \tilde{p}_r}{\partial \ln p_n^*} - \frac{\partial \ln \tilde{P}_k}{\partial \ln p_n^*} \right) \quad (\text{A.12})$$

with the shares  $r_{fm}$  and  $z_{mr}$  given by

$$r_{fm} \equiv \frac{\theta_{fm} Z_m}{\sum_{n \in \mathcal{N}} \theta_{fn} Z_n} = \frac{x_{fm} (\sum_{k \in \mathcal{K}, r \in \mathcal{N}_k} b_{mr} D_r)}{\sum_{n \in \mathcal{N}} x_{fn} (\sum_{k \in \mathcal{K}, r \in \mathcal{N}_k} b_{nr} D_r)},$$

$$z_{mr} \equiv \frac{b_{mr} P_k^{\sigma-1} p_r^{1-\sigma} \alpha_k \theta_{rc}}{\sum_{k \in \mathcal{K}, r \in \mathcal{N}_k} b_{mn} P_k^{\sigma-1} p_n^{1-\sigma} \alpha_k \theta_{nc}} = \frac{b_{mr} D_r}{\sum_{k \in \mathcal{K}, r \in \mathcal{N}_k} b_{mn} D_n}.$$

We know that

$$\tilde{P}_k(p^*, w) \equiv \left( \sum_{n \in \mathcal{N}_k} \theta_{nc} \tilde{p}_n^{1-\sigma}(p^*, w) \right)^{\frac{1}{1-\sigma}},$$

$$\tilde{p}_n(p^*, w) \equiv \exp \left\{ \sum_{r \in \mathcal{N}} b_{rn} [\ln \phi_r + \beta_r \ln \tilde{w}_r(w)] + \sum_{l \in \mathcal{N}^*} (1 - \beta_r) (1 - \Theta_r) \theta_{lr}^* \ln p_l^* \right\}.$$

Differentiating the two previous expressions with respect to  $p_n^*$  we get

$$\frac{\partial \ln \tilde{P}_k}{\partial \ln p_n^*} = \sum_{m \in \mathcal{N}_k} d_{mk} \frac{\partial \ln \tilde{p}_m}{\partial \ln p_n^*}, \quad (\text{A.13})$$

$$\frac{\partial \ln \tilde{p}_r}{\partial \ln w_n^*} = \sum_{m \in \mathcal{N}} x_{nm}^* b_{mr}. \quad (\text{A.14})$$

Proposition 3 directly follows from equations (A.11), (A.12), (A.13), and (A.14).  $\square$

## A.6 Proof of Proposition 4

*Proof.* The same algebra as in the proof of Proposition 3 now implies

$$\frac{\partial \ln RD_f}{\partial \ln w_g} = -\eta \mathbb{1}_{\{f=g\}} + \sum_{m \in \mathcal{N}} (r_{fm} - r_{0m}) \frac{\partial \ln Z_m}{\partial \ln w_g}, \quad (\text{A.15})$$

$$\frac{\partial \ln Z_m}{\partial \ln w_g} = (\eta - 1) \frac{x_{gm}}{\sum_{f \in \mathcal{F}} x_{fm}} \quad (\text{A.16})$$

$$+ \sum_{k \in \mathcal{K}, r \in \mathcal{N}_k} z_{mr} (1 - \sigma) \left( \frac{\partial \ln \tilde{p}_r}{\partial \ln w_g} - \frac{\partial \ln \tilde{P}_k}{\partial \ln w_g} \right),$$

as well as

$$\frac{\partial \ln \tilde{P}_k}{\partial \ln w_g} = \sum_{r \in \mathcal{N}_k} d_{rk} \frac{\partial \ln \tilde{p}_r}{\partial \ln w_g}, \quad (\text{A.17})$$

$$\frac{\partial \ln \tilde{p}_r}{\partial \ln w_g} = \sum_{n \in \mathcal{N}} x_{gn} b_{nr}. \quad (\text{A.18})$$

Proposition 4 directly follows from equations (A.15), (A.16), and (A.18).  $\square$

## A.7 Derivation of Equation (28)

We omit time subscripts for notational convenience. As established in the proof of Proposition 2, domestic good prices satisfy

$$p_n = \exp \left\{ \sum_{r \in \mathcal{N}} b_{rn} [\ln \phi_r + \beta_r \ln \tilde{w}_r(w) + \sum_{l \in \mathcal{N}^*} (1 - \beta_r) (1 - \Theta_r) \theta_{lr}^* \ln p_l^*] \right\}, \quad (\text{A.19})$$

where  $\tilde{w}_r(w) \equiv (\sum_{f \in \mathcal{F}} \theta_{fr} w_f^{1-\eta})^{\frac{1}{1-\eta}}$  is the CES price index associated with domestic factor prices. For an arbitrary factor  $f$ , equation (17) implies

$$\ln \tilde{w}_r(w) = \ln w_f + \frac{1}{\eta-1} \ln x_{fr}^D + \frac{1}{1-\eta} \ln \theta_{fr},$$

with  $x_{fr}^D \equiv x_{fr} / \sum_{g \in \mathcal{F}} x_{gr}$ . Averaging the previous expression across factors and using firm  $r$ 's factor cost shares as weights, we get

$$\ln \tilde{w}_r(w) = \ln w_r^D + \zeta_r, \quad (\text{A.20})$$

with  $\ln w_r^D \equiv \sum_{f \in \mathcal{F}} x_{fr}^D (\ln w_f + \frac{1}{\eta-1} \ln x_{fr}^D)$  and  $\zeta_r \equiv \frac{1}{1-\eta} \sum_{f \in \mathcal{F}} x_{fr}^D \ln \theta_{fr}$ . Substituting for the log of the CES factor price index in equation (A.19) and using  $x_{lr}^* = (1-\beta_r)(1-\Theta_r)\theta_{lr}^*$  implies

$$\ln p_n = \sum_{r \in \mathcal{N}} b_{rn} \left[ \beta_r \ln w_r^D + \sum_{l \in \mathcal{N}^*} x_{lr}^* \ln p_l^* \right] + \rho_n,$$

with  $\rho_n \equiv \sum_{r \in \mathcal{N}} b_{rn} (\zeta_r + \ln \phi_r)$ .

## B Appendix: Data Construction

In this appendix we provide further details about the data construction described in Section 4.1, as well as additional descriptive statistics not reported in the main text.

### B.1 Firm-level Data

This section describes our methodology for constructing firm-level variables (available from 2009 to 2015). Our sample of firms  $\mathcal{N}$  includes the full sample of firm IDs constructed from groups of tax IDs in the data that share the same ownership structure (in a particular sense described below). This set also considers a residual firm that we construct to create the accounting identities in our model. We consider the tax IDs that either file income tax forms or are named as the seller in the itemized VAT purchase annexes filed by entities filing income tax forms. All incorporated firms, state-owned firms and certain branches of government file a detailed tax form (F101) and are required to submit monthly purchase annexes independent of their revenues and/or costs. Unincorporated firms (largely self-employed individuals) instead file a simplified tax form (F102) if their annual revenue exceeds a standardized deduction amount (which was approximately \$10,000 in our sample period). They are obligated to keep accounting records and file monthly purchase annexes if they have yearly revenues greater than \$100,000, or yearly costs and expenses greater than \$80,000, or begin economic activities with a capital of at least \$60,000.<sup>59</sup> All other self-employed individuals (the vast majority) do not file purchase annexes.

#### B.1.1 Transaction Data

We use the information in the purchase annex to measure transactions between tax IDs. For each transaction, the data contains information on the tax ID of the buyer, the tax ID of the seller, the amount of the transaction, the VAT paid, whether the transaction was subject to a tax rate of 12% or 0%, and the transaction's date. This amount of detail allows us to, after dropping negative valued transactions, enforce the transaction value to be consistent with the VAT paid when this is positive. In each year, we compute the total value of annual transactions between tax ID pairs based on the registered date.<sup>60</sup> We only consider transactions that are not subject to future amendments, and have different tax IDs for buyer and seller.<sup>61</sup>

---

<sup>59</sup>Many firms that fall below these thresholds do voluntarily file purchase annexes, but for such smaller firms (whose aggregate presence in the economy is limited, by nature) the records on intermediate purchases may be incomplete.

<sup>60</sup>When this is missing we use the purchase date. When both are missing we drop the transaction.

<sup>61</sup>We also manually exclude 38 transactions that appear to reflect data entry errors because they are above 1 billion dollars and are more than three times larger than the total cost reported in the buyer's tax form.

We implement three adjustments to the transaction data in order to minimize reporting errors. First, we drop monthly transactions whose values are more than 10% higher than the buyer’s total annual cost as reported in its tax form. Second, we drop all transactions associated with tax IDs that do not file a tax form but do file a purchase annex. Third, we assume that sellers who appear in the purchase annex of other firms but who do not have a tax filing themselves must have an annual revenue below the minimum filing threshold; we therefore exclude all transactions associated with non-tax filing sellers whose total transaction sales are above a threshold (which we set at \$20,000 to be conservative).

Table B.1 reports the number and value of the transactions dropped in each of these three steps (after excluding the 38 transactions above one billion dollars). These steps retain approximately 85–90% of the (buyer-seller-year aggregated) transactions in each year, which corresponds to around 75% of the total transaction value in the original sample.

**Table B.1: Summary Statistics, Transactions Data**

|                                 | 2009      | 2010      | 2011      | 2012       | 2013       | 2014       | 2015       |
|---------------------------------|-----------|-----------|-----------|------------|------------|------------|------------|
| Initial number of transactions  | 8,677,431 | 9,364,802 | 8,613,543 | 11,522,840 | 13,079,139 | 14,054,238 | 13,637,666 |
| Share deleted:                  |           |           |           |            |            |            |            |
| due to criterion 1              | 0.032     | 0.023     | 0.018     | 0.038      | 0.030      | 0.029      | 0.034      |
| in addition, due to criterion 2 | 0.100     | 0.101     | 0.123     | 0.084      | 0.077      | 0.074      | 0.106      |
| in addition, due to criterion 3 | 0.009     | 0.008     | 0.030     | 0.006      | 0.008      | 0.008      | 0.014      |
| Share deleted due to 1, 2 or 3  | 0.140     | 0.132     | 0.171     | 0.129      | 0.115      | 0.110      | 0.154      |
| as share of total value         | 0.229     | 0.229     | 0.302     | 0.282      | 0.263      | 0.251      | 0.255      |
| Valid transactions              | 7,458,601 | 8,130,942 | 7,138,729 | 10,037,436 | 11,577,381 | 12,505,186 | 11,531,092 |

*Notes:* The reported number of transactions is that obtained after first summing up all transactions that occurred within each buyer-seller pair (separately by year).

### B.1.2 Grouping Tax IDs Into Firms

We start by grouping corporate tax IDs into firms based on their ownership structure. This draws on a unique ownership annex that every incorporated firm must file, which reports the personal and corporate tax IDs of each owner of the filing tax ID, as well as their corresponding ownership shares of each owner.<sup>62</sup> We merge a tax ID into a parent tax ID when-

<sup>62</sup>This dataset is available to us from 2011-2015 so we use firms’ 2011 ownership information in 2009 and 2010. In the first four years of our sample, firms were required to report the identity of their owners at the time of incorporation, with the Ecuadorian tax authority responsible for periodically updating potential changes in ownership structure; starting in 2015, the final year of our sample, firms were further required to report any changes in ownership in their annual filings. For unincorporated firms, the firm’s tax ID corresponds to the personal tax ID of the owner.

ever the parent tax ID owns more than 50% of the tax ID's shares. For each firm group, we compute all financial variables by summing the values of the same variable across all tax IDs in the firm group. We assume that the firm's ownership structure, as well as the firm's sector and location, is given by that of the highest-level holding firm.

Over the entire period, there are 13,030 corporate tax IDs in firm groups with multiple tax IDs, which amounts to 0.31% of the total number of corporate tax IDs in our data. Table B.2 shows that, in each year, more than 50% of the firm groups have only two tax IDs. This procedure yields a dataset with 4,201,841 unique firm IDs (the vast majority of which reflect self-employment, as we discuss below) that are active at least once between 2009 and 2015, which is 7,408 fewer than before the grouping process.

**Table B.2: Summary Statistics, Corporate Tax ID Grouping**

|                             | 2009      | 2010      | 2011      | 2012      | 2013      | 2014      | 2015      |
|-----------------------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| Grouping sample             |           |           |           |           |           |           |           |
| Group size distribution     |           |           |           |           |           |           |           |
| 50 <sup>th</sup> percentile | 2         | 2         | 2         | 2         | 2         | 2         | 2         |
| 75 <sup>th</sup> percentile | 3         | 3         | 3         | 3         | 3         | 3         | 3         |
| 90 <sup>th</sup> percentile | 5         | 5         | 5         | 5         | 5         | 5         | 5         |
| Unique corporate tax IDs    | 8,115     | 8,115     | 8,115     | 5,214     | 5,431     | 5,715     | 5,894     |
| Unique firm IDs             | 2,785     | 2,785     | 2,785     | 2,458     | 2,597     | 2,739     | 2,837     |
| Full sample                 |           |           |           |           |           |           |           |
| Unique corporate tax IDs    | 1,193,068 | 1,294,694 | 1,253,722 | 1,608,082 | 1,703,797 | 1,717,356 | 1,759,809 |
| Unique firm IDs             | 1,187,738 | 1,289,364 | 1,248,392 | 1,605,326 | 1,700,963 | 1,714,380 | 1,756,752 |
| Difference                  | 5,330     | 5,330     | 5,330     | 2,756     | 2,834     | 2,976     | 3,057     |

*Notes:* The "grouping sample" comprises the sample of corporate tax IDs that are part of a firm ID group of at least size 2. The "full sample" contains all corporate tax IDs and firm IDs in our final dataset.

### B.1.3 Construction of Firm-level Variables

We now describe our procedure to create the revenue and cost variables of each firm in a given year. Our goal is to combine the information in the tax forms and purchase annexes in order to create revenue and cost variables that are consistent with our theory. Specifically, we assume that a firm's revenue  $R_n$  is the sum of its exports  $E_n$ , its final sales  $D_n$ , and its intermediate sales to other domestic firms  $\sum_{m \in \mathcal{N}, m \neq n} M_{nm}$ :

$$R_n = E_n + D_n + \sum_{m \in \mathcal{N}, m \neq n, R} M_{nm} + M_{nR}, \quad (\text{B.1})$$



where  $M_{nR}$  are sales to a consolidated residual firm that we use to account for inconsistencies in the data.

We construct the firm's cost items in such a way as to equalize revenues and (full factor) costs. The firm's total cost is the sum of the firm's profit  $\Pi_n$ , its labor cost  $W_n$ , its imports  $X_n^*$ , and its input purchases from other domestic suppliers  $\sum_{m \in \mathcal{N}, m \neq n} M_{mn}$ :

$$R_n = \Pi_n + W_n + X_n^* + \sum_{m \in \mathcal{N}, m \neq n, R} M_{mn}. \quad (\text{B.2})$$

This treats the firm's profits as a "cost" that is simply its payments to its owners (i.e. to a capital factor).

To construct each of these variables, we classify firms into four categories according to the type of information available: (1) firms reporting positive corporate revenue or cost in their F101 or F102, (2) firms only reporting positive personal revenue or costs in their F102, (3) firms that are identified as sellers in the purchase annex of a buying firm and do not themselves file tax forms or a purchase annex, and (4) two consolidated firms and a residual firm described further below. We now describe our procedure for constructing the revenue and cost structure in the economy for each of these four categories.

**Firms of Type 1 and 2.** We start by defining the items in the firm's revenue stream in (B.1). For each firm ID, we compute the sum across the firm's tax IDs of their reported (on forms F101/2) total revenue  $R_n^{tax}$  and exports  $E_n^{tax}$ . We use the purchase annex to compute sales of firm ID  $n$  to each other firm ID  $m$ ,  $M_{nm}^{PA}$ . We then compute the variables as follows. First, we specify exports and intermediate sales as reported in the tax form and purchase annex:  $E_n = E_n^{tax}$  and  $M_{nm} = M_{nm}^{PA}$  for all  $n \in \mathcal{N}$  and  $n \neq R$ . Second, we attribute any residual revenue to final sales:

$$D_n \equiv \max \left\{ 0, R_n^{tax} - E_n^{tax} - \sum_{m \in \mathcal{N}, m \neq R} M_{nm}^{PA} \right\}.$$

We then construct the items in the firm's cost structure in (B.2). For each firm ID, we specify the firm's payroll and imports using the sum across the firm's tax IDs of the values reported in their tax forms of wage bill and imports:  $W_n = W_n^{tax}$  and  $X_n^* = X_n^{tax,*}$ .<sup>63</sup> We then use the definitions (B.1) and (B.2) to compute revenue, profits and sales to the residual firm

<sup>63</sup>For the case of the single state-owned oil producer in Ecuador, we obtain this wage bill, export, and import information from the social security and customs datasets due to this firm's incomplete cost information on its own tax filing early in our sample period. Further, in 2010 and 2011, because of the firm's restructuring process, we do not observe a reliable value for the firm's final sales so we set this to zero; such sales are a small share of the firm's total sales in other years.

such that the firm at least breaks even. Specifically, we define

$$\tilde{\Pi}_n \equiv E_n^{tax} + D_n + \sum_{m \in \mathcal{N}, m \neq n, R} M_{nm}^{PA} - \left( W_n^{tax} + X_n^{tax,*} + \sum_{m \in \mathcal{N}, m \neq n, R} M_{mn}^{PA} \right), \quad (\text{B.3})$$

and define

$$\begin{aligned} \Pi_n &= \tilde{\Pi}_n \quad \text{and} \quad M_{nR} = 0 && \text{if} \quad \tilde{\Pi}_n > 0 \\ \Pi_n &= 0 \quad \text{and} \quad M_{nR} = -\tilde{\Pi}_n && \text{if} \quad \tilde{\Pi}_n \leq 0, W_n + X_n^* > 0 \\ \Pi_n &= \epsilon \quad \text{and} \quad M_{nR} = -\tilde{\Pi}_n + \epsilon && \text{if} \quad \tilde{\Pi}_n \leq 0, W_n + X_n^* = 0 \end{aligned} \quad (\text{B.4})$$

where  $\epsilon$  denotes a small positive constant.<sup>64</sup> Finally, we compute  $R_n$  using the accounting relation in (B.1).

To understand these expressions, consider a firm whose revenue from domestic and foreign sales is strictly above its costs from labor, imports and intermediates. In this case, profits are defined as the difference between revenue and costs, implying sales to the residual firm of zero. Whenever the difference between revenue and costs is negative, we create additional sales to the residual firm, so that profits are zero if  $W_n + X_n^* > 0$  or  $\epsilon$  if  $W_n + X_n^* = 0$ . This adjustment is necessary to guarantee the existence of the Leontief inverse,  $B \equiv (I - M)^{-1}$ , by imposing the requirement that the share of the firm's costs from intermediate inputs is strictly below one,  $\sum_{m \in \mathcal{N}} x_{mn} < 1$  for all  $n$ .

**Firms of Type 3.** Since firms of type 3 file neither a tax form nor a purchase annex, we do not have all the cost and revenue items described above for firms of type 1 or 2. Thus, for every firm  $n$  of type 3, we specify  $E_n = D_n = X_n^* = 0$  and  $M_{mn} = 0$  for all  $m \in \mathcal{N}$ . In addition, we define the firm's labor cost  $W_n$  as the sum across all the firm's tax IDs of their wage bill in the social security database. We set labor payments to zero if none of the firm's tax IDs can be found in the social security database. This implies that  $\tilde{\Pi}_n \equiv \sum_{m \in \mathcal{N}, m \neq n, R} M_{nm}^{PA} - W_n$ . We then compute profits and residual sales using the procedure in (B.4) and revenue using the accounting relation in (B.1).

**Other Firms.** We construct two consolidated firms, "financial" and "public", and a residual firm. The first consolidated firm consists of all tax IDs reporting their main activity to be in the financial sector. The second one consists of all tax IDs that are flagged as either a state-owned firm or a government agency. However, because Ecuador's state-owned oil firm is a major exporter, we exclude it from the consolidated public firm and treat it as an ordinary firm (though one owned by the government rather than any individual). For both

<sup>64</sup>In practice, because of numerical rounding, we set  $\epsilon$  to \$10 if the maximum of revenue and costs is less than or equal to \$5, or  $\epsilon$  equal to 0.1% of the maximum of revenue and costs otherwise.

of these consolidated firms, we construct the firm's revenue and cost following the same procedure as that adopted for the firms of type 1 and 2.

Lastly, we compute outcomes for a residual firm. We compute the intermediates purchases of this residual firm using  $M_{nR}$  as implied by the procedure above. In order to guarantee that this firm breaks even, we specify that its final sales cover intermediate purchases,  $D_n = \epsilon + \sum_{n \in \mathcal{N}} M_{nR}$ .

#### B.1.4 Summary Statistics

**Sample of Firms** We now present simple summary statistics about our sample of firms,  $\mathcal{N}$ , that includes firms of types 1-3 as well as the two consolidated firms and the residual firm. Table B.3 reports the counts of firms of types 1-3 (by year), with shares broken down by single-person firms (those that correspond to self-employed individuals working in their own firm).<sup>65</sup> In addition, Figure B.1 illustrates how several of our key variables (revenues, costs, imports, exports, labor payments, and capital payments/profits) are distributed across: (i) corporate firms; (ii) single-person firms; and (iii) the two consolidated firms and the residual firm. These findings indicate how corporate firms account for only 5% of firm tax IDs, but are responsible for more than 75% of the aggregate revenue in our sample. Such firms also account for essentially all of Ecuador's exports and imports. On the other hand, the vast majority of firms in our sample are of types 2 and 3. These firms are predominantly self-employed individuals. Depending on the year, about half of the incorporated firms filing tax forms (type 2), and 96-98% of the firms not filing tax forms (type 3), are single-person firms. Such firms account for a tiny share of exports, imports and a small share of total revenue; however, they are responsible for a slightly higher share of final sales and profits.

**Firm Revenues and Costs.** Table B.4 reports the distribution of revenue and cost characteristics for firms of different types (in the pooled sample of firm-year combinations). Evidently, the revenue distribution is very skewed for all firm types. Firms of type 1 are larger and obtain a higher share of their revenue from final sales. These firms account for almost all of the country's exports and imports, but this is concentrated in just a few firms—for instance, more than 95% of the firms of type 1 do not export or import. For firms of types 2 and 3, most of the revenues come from intermediate sales. These firms tend to have low cost shares stemming from hired labor or the purchase of intermediates, as most are self-employed individuals that do not have any reported input purchases. Indeed, by

---

<sup>65</sup>We define define single-person firms as either (a) firms with labor cost of zero and no entries in the social security database, or (b) those firms with a single employee in the social security database where employee is also registered as the firm's owner.

**Table B.3: Summary Statistics, Firm Counts by Firm Type**

|                              | 2009    | 2010    | 2011    | 2012    | 2013    | 2014    | 2015    |
|------------------------------|---------|---------|---------|---------|---------|---------|---------|
| Panel A: Firms of type 1     |         |         |         |         |         |         |         |
| Number of firms              | 84,795  | 88,200  | 94,796  | 115,716 | 121,734 | 127,797 | 118,459 |
| Share of single-person firms | 30%     | 27%     | 24%     | 25%     | 23%     | 23%     | 23%     |
| Panel B: Firms of type 2     |         |         |         |         |         |         |         |
| Number of firms              | 390,319 | 422,932 | 368,193 | 625,678 | 640,305 | 686,208 | 648,257 |
| Share of single-person firms | 62%     | 58%     | 50%     | 46%     | 46%     | 44%     | 42%     |
| Panel C: Firms of type 3     |         |         |         |         |         |         |         |
| Number of firms              | 711,639 | 777,260 | 784,375 | 863,379 | 938,371 | 899,844 | 989,417 |
| Share of single-person firms | 98%     | 98%     | 96%     | 98%     | 97%     | 97%     | 97%     |

*Notes:* Firms of type 1 are those reporting corporate revenues or costs in their tax forms. Firms of type 2 are those only reporting personal revenues or costs in their tax forms. Firms of type 3 are those not filing tax forms but mentioned as sellers in the purchase annex of other firms. Single-person firms are either (i) firms with labor cost of zero and no entry in the social security database, or (ii) firms where the sole listed employee is the firm's owner itself.

definition, type 3 firms have no reported costs due to intermediates.

## B.2 Payments to Factors and Individuals

In order to connect firm payments to factors of production and individual factor endowments, we use two databases: the social security employer-employee database (IESS) that allows us to match workers to each firm, and the ownership survey that allows us to match owners to each firm. Our sample of individuals  $\mathcal{I}$  includes all individuals with positive income in the social security and ownership dataset that are associated with a firm in our sample (excluding the consolidated financial, residual and public firms). We assign workers to provinces based on the location of their main employer defined as the firm ID from which the individual earns most of her income.<sup>66</sup> We also create a residual agent that receives all factor payments made by firms in our sample to individuals that are either absent from our sample or in our sample, but with missing demographic information.<sup>67</sup>

<sup>66</sup>The firm's location (as reported in its tax filing) will reflect that of its headquarters, which may not correspond to the location of every establishment in a multi-establishment firm. Section B.4.1 compares factor payments derived from the administrative data discussed here to that in a nationally representative earnings survey, which provides reassurance that such measurement error is unlikely to be large.

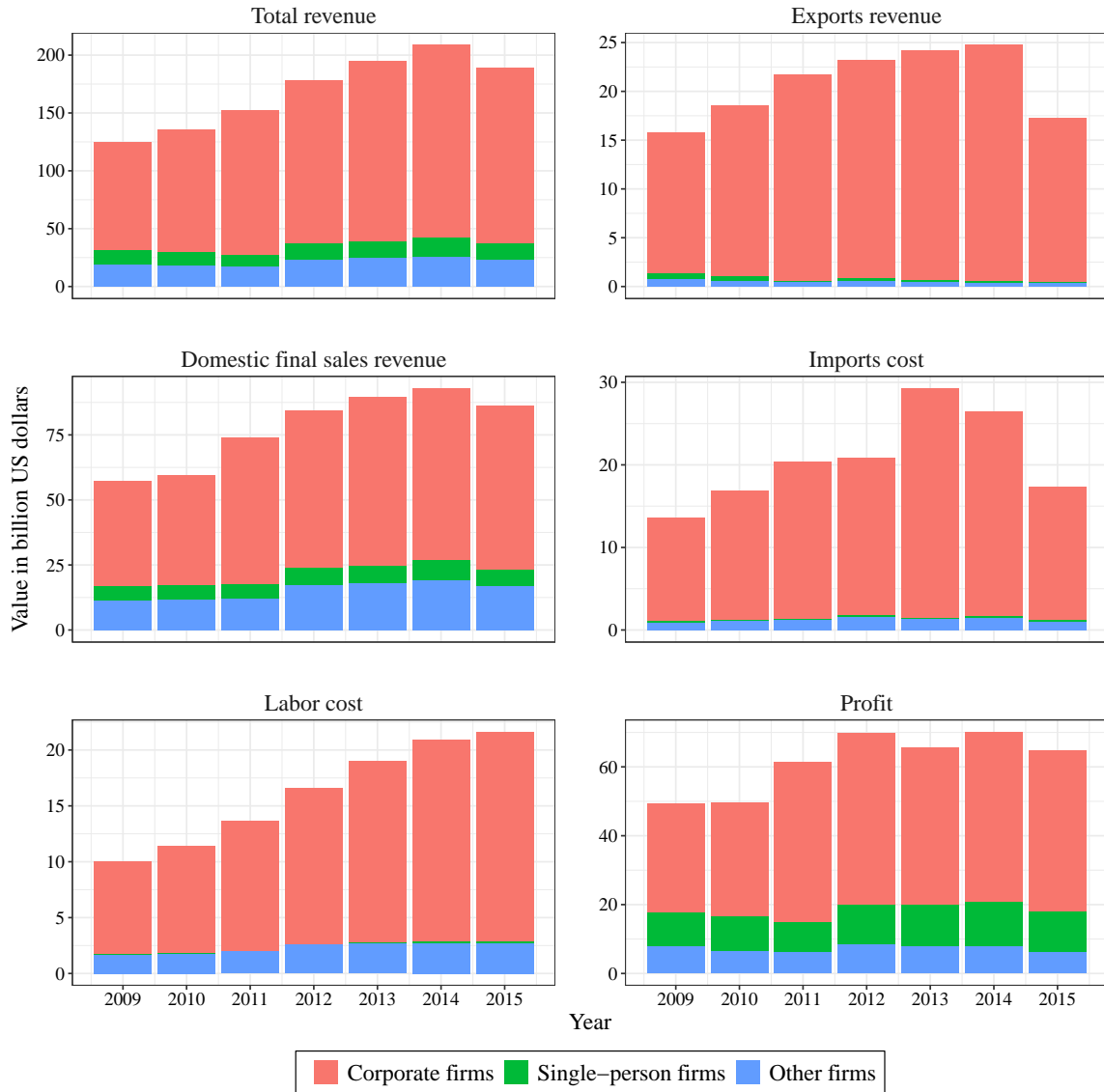
<sup>67</sup>In practice, capital payments to the residual agent include profits received by the foreign owners of Ecuadorian firms as well as the Ecuadorian government. Such capital payments may also arise in the presence of minority shareholders for publicly-listed firms (of which there are relatively few in Ecuador).

**Table B.4: Summary Statistics, Firm-Level Data**

|                                 | Percentiles of distribution |                  |                  |                  |                  |                  |                  |
|---------------------------------|-----------------------------|------------------|------------------|------------------|------------------|------------------|------------------|
|                                 | 10 <sup>th</sup>            | 25 <sup>th</sup> | 50 <sup>th</sup> | 75 <sup>th</sup> | 90 <sup>th</sup> | 95 <sup>th</sup> | 99 <sup>th</sup> |
| Panel A: Firms of type 1        |                             |                  |                  |                  |                  |                  |                  |
| Revenues, USD                   | 5,000                       | 37,948           | 150,391          | 437,514          | 1,298,151        | 2,699,949        | 13,687,005       |
| Share of revenues derived from: |                             |                  |                  |                  |                  |                  |                  |
| Final sales                     | 0.00                        | 0.10             | 0.62             | 0.97             | 1.00             | 1.00             | 1.00             |
| Interm. sales                   | 0.00                        | 0.00             | 0.16             | 0.73             | 0.99             | 1.00             | 1.00             |
| Exports                         | 0.00                        | 0.00             | 0.00             | 0.00             | 0.00             | 0.00             | 0.80             |
| Residual sales                  | 0.00                        | 0.00             | 0.00             | 0.00             | 0.30             | 0.97             | 1.00             |
| Share of costs derived from:    |                             |                  |                  |                  |                  |                  |                  |
| Wages                           | 0.00                        | 0.00             | 0.07             | 0.23             | 0.48             | 0.67             | 1.00             |
| Interm. purchases               | 0.00                        | 0.09             | 0.42             | 0.75             | 0.94             | 1.00             | 1.00             |
| Imports                         | 0.00                        | 0.00             | 0.00             | 0.00             | 0.00             | 0.26             | 0.74             |
| Capital (i.e. profits)          | 0.00                        | 0.03             | 0.25             | 0.66             | 1.00             | 1.00             | 1.00             |
| Panel B: Firms of type 2        |                             |                  |                  |                  |                  |                  |                  |
| Revenues, USD                   | 1,451                       | 2,926            | 9,644            | 26,220           | 59,340           | 88,585           | 214,738          |
| Share of revenues derived from: |                             |                  |                  |                  |                  |                  |                  |
| Final sales                     | 0.00                        | 0.00             | 0.32             | 0.97             | 1.00             | 1.00             | 1.00             |
| Interm. sales                   | 0.00                        | 0.00             | 0.10             | 0.81             | 1.00             | 1.00             | 1.00             |
| Exports                         | 0.00                        | 0.00             | 0.00             | 0.00             | 0.00             | 0.00             | 0.00             |
| Residual sales                  | 0.00                        | 0.00             | 0.00             | 0.00             | 1.00             | 1.00             | 1.00             |
| Share of costs derived from:    |                             |                  |                  |                  |                  |                  |                  |
| Wages                           | 0.00                        | 0.00             | 0.00             | 0.49             | 1.00             | 1.00             | 1.00             |
| Interm. purchases               | 0.00                        | 0.00             | 0.00             | 0.00             | 0.00             | 0.00             | 0.00             |
| Imports                         | 0.00                        | 0.00             | 0.00             | 0.00             | 0.00             | 0.00             | 0.00             |
| Capital (i.e. profits)          | 0.00                        | 0.51             | 1.00             | 1.00             | 1.00             | 1.00             | 1.00             |
| Panel C: Firms of type 3        |                             |                  |                  |                  |                  |                  |                  |
| Revenues, USD                   | 23                          | 104              | 510              | 2,347            | 5,765            | 9,014            | 17,302           |
| Residual sales share            | 0.00                        | 0.00             | 0.00             | 0.00             | 0.00             | 0.00             | 0.98             |

*Notes:* Each row reports features of the distribution (pooling across all firm-year observations that appear in the tax data, for the given firm type) of the indicated variable. Firms of type 1 are those reporting corporate revenues or costs in their tax forms. Firms of type 2 are those only reporting personal revenues or costs in their tax forms. Firms of type 3 are those not filing tax forms but mentioned as sellers in the purchase annex of other firms.

**Figure B.1: Aggregate Outcomes by Firm Category**



*Notes:* Single-person firms are either (i) firms with labor cost of zero and no entry in the social security database, or (ii) firms where the sole listed employee is the firm’s owner him/herself. Corporate firms are all firm IDs not classified as single-person firms. “Other firms” consists of the consolidated financial firm, the consolidated public firm, and the residual firm.

### B.2.1 Data Construction

**Firm Shares of Payments to Individuals.** We start by constructing firm payments to labor factors as follows. For every individual  $i \in \mathcal{I}$ , we define the firm’s labor payment share to  $i$  as  $x_{in}^L = W_{in}^{IESS} / W_n^{IESS}$ , where  $W_{in}^{IESS}$  is the value of annual earnings reported by firm  $n$  in the social security database for  $i$ , and  $W_n^{IESS}$  is firm  $n$ ’s total payroll reported in the

IESS.<sup>68</sup> A fraction of such individuals cannot be matched to the Civil Registry, which contains the demographic indicators that we later require, so we assign such individuals to a residual labor agent as  $x_{Rn}^L = 1 - \sum_{i \in \mathcal{I}} x_{in}^L$ . The payment share  $x_{Rn}^L$  is also set equal to one for firms that have positive labor payments in their tax firms but no employees in the social security dataset, as well as for the three consolidated firms in our sample. We consider every single-person firm  $n$  to be a self-employed individual and reclassify the firm's profits as labor payments to the individual-owner; that is,  $W_n = \Pi_n$ ,  $\Pi_n = 0$ , and  $x_{in}^L = 1$  for the individual-owner  $i$ . Finally, we construct the matrix of share of firm-individual labor payment shares as  $x^L \equiv \{x_{in}^L\}_{(i,n) \in \mathcal{I} \times \mathcal{N}}$ .

We then proceed similarly for the case of capital payments to individuals. For every individual  $i \in \mathcal{I}$ , we measure  $\vartheta_{ni}$  as the ownership share of individual  $i$  in firm  $n$ . For a single-person firm, we set  $\vartheta_{ni} = 1$  for the individual-owner. We compute the ownership share of the residual agent as  $\vartheta_{nR} = 1 - \sum_{i \in \mathcal{I}} \vartheta_{ni}$ . These capital ownership shares yield the matrix of shares of capital payments to different individuals in our sample,  $\vartheta \equiv \{\vartheta_{ni}\}_{(i,n) \in \mathcal{I} \times \mathcal{N}}$ .

**Firm Shares of Payments to Factors.** We define labor factors in terms of education-province pairs, and an additional residual labor type. We compute the firm's payments to each factor using the personal information of its employees in the Civil Registry. Specifically, we define  $D_{fi}^L$  as a dummy variable that equals one if individual  $i$  belongs to the group associated with factor  $f$  and the row vector with the dummy variable for different individuals as  $D_f^L \equiv \{D_{fi}^L\}_{i \in \mathcal{I}}$ . For the residual type, the vector has entries equal to one for all individuals in our sample with missing personal information in either the Civil Registry or IESS, as well as the residual agent  $i = R$ . We then compute the firm payment shares to each labor factor as  $\{x_{fn}\}_{n \in \mathcal{N}} = D_f^L x^L \text{diag}(\{W_n / R_n\}_{n \in \mathcal{N}})$  for each  $f \in \mathcal{F}_L$ .

Similarly, we compute the firm payments to different capital types. For each firm  $n$ , we compute  $D_{sn}^K = 1$  if firm  $n$  is in sector  $s$ , and define the row vector containing this dummy for all firms as  $D_s^K \equiv \{D_{sn}^K\}_{n \in \mathcal{N}}$ . We consider two sectors  $s$ : Oil and Non-Oil. Finally, we compute firm payment shares to each capital factor as  $\{x_{fn}\}_{n \in \mathcal{N}} = D_s^K \text{diag}(\{\Pi_n / R_n\}_{n \in \mathcal{N}})$  for each  $f \in \mathcal{F}_K$ .

**Individual Factor Earnings.** The last step is to construct individuals' earnings and earnings from each factor service that they supply. Let  $Y_{fi}$  denote  $i$ 's income associated with

---

<sup>68</sup>In practice the employer-employee database we use is built from two underlying sources. We begin with a database compiled from firms' filings of tax form F107, which lists firms' annual payments to individual employees. We then supplement this with a second database compiled from monthly social security filings, which also report individual-level earnings at each firm, giving priority to the former database in the case of discrepancies. We refer to the combined database as the "social security database", in line with the most commonly available source of employer-employee matched data in other countries.

factor  $f$ , and  $Y_i$  be  $i$ 's total income  $Y_i = \sum_{f \in \mathcal{F}} Y_{fi}$ . For labor factors  $f \in \mathcal{F}_L$ ,  $Y_f = \{Y_{fi}\}_{i \in \mathcal{I}}$  is simply the vector of individual labor payments times the dummy vector indicating which individuals are associated with each group defining factor  $f$  (education-province pair or residual):  $Y_f = D_f^L \text{diag}(x^L \{W_n\}_{n \in \mathcal{N}})$ . For capital factors  $f \in \mathcal{F}_K$ ,  $Y_f = \{Y_{fi}\}_{i \in \mathcal{I}}$  is the product of the matrix of payments individuals get from different firms,  $\vartheta \text{diag}(\{\Pi_n\}_{n \in \mathcal{N}})$ , and the dummy vector indicating whether firms are associated with the oil or the non-oil sectors,  $D_f^K$ :  $Y_f = D_f^K \text{diag}(\{\Pi_n\}_n)(\vartheta)'$ . Finally, we compute, for each individual, the income share associated with each factor,  $\omega_{fi} \equiv Y_{fi}/Y_i$ .

## B.2.2 Summary Statistics

We now present summary statistics regarding our sample of individuals and factors. In the first part of Table B.5, we report the number of individuals in our sample. Across years, the number of individuals in our sample grows reflecting mostly the increase in formalization rates in Ecuador. In 2012, the administrative dataset has approximately 3 million individuals with positive income, accounting for approximately half of Ecuador's employed and/or business-owning population (according to the 2011-12 earnings survey that we describe in Section B.4). We have information on education and province for roughly 90% of the individuals with strictly positive income. The second panel displays statistics for our baseline sample of individuals with strictly positive income and whose labor income can be mapped to an education-province pair. In 2012, there are 2.7 million such individuals in our baseline sample, with 30% of them employed in single-person firms. The last part of the table reports the annual income at different parts of the distribution. In 2012, the median income was around \$4,900. The earnings distribution in this administrative dataset contains many individuals with very low apparent earnings (e.g. 10% with \$275 or less in 2012), but this is largely driven by single-person firms and partially reflects a part-time or seasonal involvement in such activities. The earnings distribution derived from survey data reflecting all types of earnings, described in Section B.4, does not have this same feature.

Figure B.2 reports the share of payments to different factor types by income percentile. It shows that the capital income share is especially important at the top of the distribution, accounting for 38% and 64% of income in the 95 and 99 percentiles, respectively. The plot also shows that individuals with higher education levels are more likely to be at higher income percentiles. Excluding capital income, low-education individuals correspond to 15%-20% of income above the 90th percentile of the distribution, but they account for more than 40% of the income below the 10th percentile. For high-education individuals this pattern is reversed: this group generates around 15-20% of income in the bottom 10 percentiles and almost 50% of income in the top 10 percentiles.



**Table B.5: Summary Statistics, Sample Characteristics Across Individuals**

|  | 2009               | 2010               | 2011               | 2012               | 2013               | 2014               | 2015               |
|--|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|
| Panel A: Full sample of individuals in administrative dataset    |                    |                    |                    |                    |                    |                    |                    |
| Total number of individuals                                      | 2,415,353          | 2,659,960          | 2,892,573          | 3,321,721          | 3,519,478          | 3,643,283          | 3,615,025          |
| with positive income   | 2,257,012<br>(93%) | 2,460,881<br>(93%) | 2,678,434<br>(93%) | 3,002,236<br>(90%) | 3,194,633<br>(91%) | 3,298,941<br>(91%) | 3,287,376<br>(91%) |
| with complete information  | 2,010,127<br>(83%) | 2,211,677<br>(83%) | 2,362,464<br>(82%) | 2,676,358<br>(81%) | 2,718,088<br>(77%) | 2,720,353<br>(75%) | 2,580,298<br>(71%) |
| Panel B: Baseline sample of individuals                          |                    |                    |                    |                    |                    |                    |                    |
| Total number of individuals                                      | 1,981,641          | 2,150,515          | 2,291,202          | 2,613,011          | 2,669,472          | 2,681,918          | 2,565,728          |
| in single-person firms   | 696,199<br>(35%)   | 728,362<br>(34%)   | 587,923<br>(26%)   | 789,962<br>(30%)   | 777,026<br>(29%)   | 720,974<br>(27%)   | 713,180<br>(28%)   |
| Panel C: Percentiles of income in baseline sample ( $Y_i$ ), USD |                    |                    |                    |                    |                    |                    |                    |
| 10 <sup>th</sup>   | 280                | 286                | 306                | 275                | 269                | 305                | 218                |
| 50 <sup>th</sup>   | 4,024              | 4,224              | 4,466              | 4,874              | 5,350              | 5,794              | 6,003              |
| 90 <sup>th</sup>   | 22,038             | 22,897             | 23,250             | 25,989             | 26,915             | 28,217             | 28,442             |
| 99 <sup>th</sup>   | 166,159            | 165,152            | 224,921            | 187,074            | 180,945            | 180,698            | 177,891            |

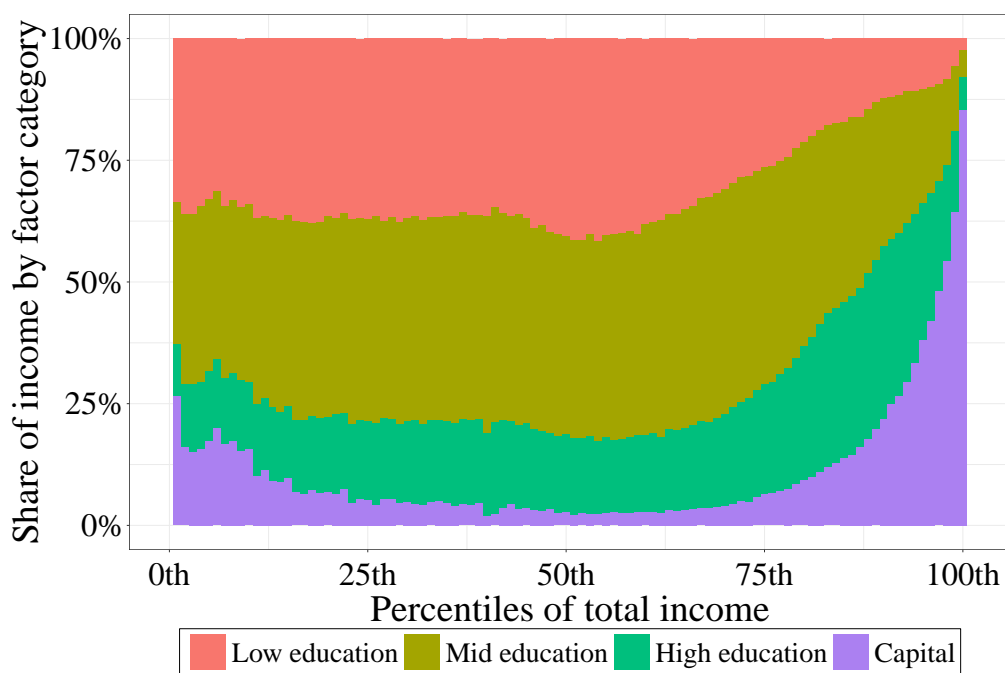
*Notes:* Panel A is based on all individuals in our administrative dataset. Panels B and C are based on our baseline sample of individuals in the administrative dataset who have strictly positive income and whose labor income can be mapped to an education-province pair.

### B.3 International Trade Data

We rely on two sources of international trade data. The first is Ecuador's custom records, which measure firm-level exports and imports in each HS6 product and by the partner country of destination or origin.<sup>69</sup> This dataset covers the universe of Ecuador's exports and imports in 2009-2011. We focus on Ecuador's trade with its 50 largest trade partners, and aggregate all other countries into a group representing the rest of the world. Figure C.1 describes the composition of Ecuador's exports and imports in 2009-2011, based on this customs database. Our second source of trade data is CEPII's BACI dataset, which reports bilateral trade flows worldwide (for 2009-15 and beyond) at the HS6 level.

<sup>69</sup>Ecuador's custom records track products using the 6-digit NANDINA system, which is similar to the 2007 HS 6-digit classification system. We drop trade flows in the case of the 1.4% of NANDINA codes that we cannot match to HS codes.

**Figure B.2: Share of Aggregate Factor Payments by Factor Category, 2012**



*Notes:* Based on baseline sample of individuals in the administrative dataset who have strictly positive income and whose labor income can be mapped to an education-province pair.

## B.4 Earnings Survey Data

This subsection describes the earnings survey data that we use to supplement our baseline analysis in Section 7.3. Section B.4.1 describes Ecuador’s National Survey of Income and Expenditures from Urban and Rural Households (ENIGHUR), a detailed survey carried out in 2011-2012 that we incorporate into our analysis in Section 7.3. Section B.4.2 describes Ecuador’s National Employment, Unemployment and Underemployment Survey (ENEMDU), a shorter survey that was carried out quarterly throughout 2009-2015, which we use in Section D.3. Both surveys were administered by Ecuador’s National Institute of Statistics and Censuses (INEC).

### B.4.1 ENIGHUR Survey

Ecuador’s ENIGHUR survey collected information from 39,617 households during the period between April 2011 and March 2012. Its objective was to measure the distribution, amount and structure of household income and expenses. This dataset is representative at the national level and covers Ecuador’s formal and informal economy. It has information about 153,444 respondents, who resemble Ecuador’s total population (15.24 and 15.47

million in 2011 and 2012, respectively) when we take into account the frequency sampling weights available in the survey.<sup>70</sup> We limit our sample to the group of respondents that were 15 years or older at the moment of being surveyed, and keep only those with positive earnings who are currently working.<sup>71</sup> This results in a sample size of 60,465 respondents, representative of (according to ENIGHUR's estimates) approximately 6.01 million working individuals in Ecuador.

Importantly, the survey reports each respondent  $i$ 's demographics, monthly earnings, and workplace characteristics for each occupation  $o$  (including both employment, self-employment, and operating a business that the respondent owns a share of) in which they were engaged during the week prior to their survey week.<sup>72</sup> We classify each occupation  $o$  for each respondent  $i$  as formal in the following cases: when  $o(i)$  refers to employment at a firm (not a domicile), if that firm either has a taxpayer ID (a Registro Único de Contribuyentes, or RUC) or has more than 100 employees, and  $i$  reports receiving some social security contributions from their employer; when  $o(i)$  refers to employment in domestic work, if the respondent reports receiving some social security contributions from their employer; when  $o(i)$  refers to employment in a branch of government; and when  $o(i)$  refers to operating a firm in which the respondent is a partial owner, if that firm has a RUC or has more than 100 employees. Otherwise, we classify  $o(i)$  as informal.

We then classify  $o(i)$  according to its factor group  $f$  in the same way as in the baseline administrative data. If  $o(i)$  refers to either employment at a firm, or self-employment at respondent  $i$ 's own firm but where  $i$  hires no paid employees, then we classify the factor type as labor of the type corresponding to the respondent's education-province. Otherwise, if  $o(i)$  refers to the operation of a firm that the respondent partially or wholly owns, and that hires employees, we classify the factor type as oil or non-oil capital depending on the sector in which the firm operates. The survey has 544 original (i.e. unweighted) respondents in the median factor group, 138 respondents in the smallest, and 4,049 in the largest.

Based on these definitions and the information on annualized earnings by occupation, we denote  $Y_{if,F}$  as individual  $i$ 's total annual earnings, summed across all occupations  $o(i)$ , from each factor type  $f$  and formality status  $F$ .<sup>73</sup> Then we calculate total earnings as

---

<sup>70</sup>In what follows, all aggregate statistics that we employ are weighted by these sampling weights.

<sup>71</sup>A respondent is defined as currently working if s/he either: (i) worked (as an employee or in the operation of a business that the respondent wholly or partially owns) at least one hour last week; (ii) did not work last week but did an activity to help the household (like helping in a family business); or (iii) did not work last week, but had a job or business to which s/he was surely going to return after a temporary absence (such as an illness or vacation).

<sup>72</sup>The survey questionnaire asks all of the details we require about the respondent's "main" and "secondary" occupation. For "all other occupations" (of which fewer than 1% report having any) the questionnaire does not allow us to classify the occupation(s) as formal or informal, so we code these as informal.

<sup>73</sup>Employment earnings include (annualized rates of) wages, overtime and bonuses in the past month

$Y_i \equiv \sum_{f,F} Y_{if,F}$  and factor earnings shares as  $\omega_{if,F} \equiv Y_{if,F}/Y_i$ . Finally, we calculate the total informal factor earnings within each sector. These ingredients enter the counterfactual calculations reported in Section 7.3.

While our analysis in Section 7.3 uses data on formality from the administrative database and data on informality from the ENIGHUR survey, it is useful to compare their measures of the *formal* earnings of each factor. Figure B.3 does this for 73 factor groups (72 labor groups plus Non-oil capital, since Oil capital is in practice never sampled in the survey, and all individuals have information on both education and province, which avoids the need for a residual labor group) using the 2011 administrative data. The fit among the labor groups is high (the  $R^2$  from the line of best-fit for Figure B.3 is 0.78), so it appears that, despite the possibility of survey misreporting and sampling errors, the administrative and survey datasets are capturing similar notions of formal earnings across the labor factor distribution. However, the capital point is a clear outlier, with far more total capital earnings in the administrative dataset than in the (formal earnings segment of the) ENIGHUR survey. This should be expected given the active definition of capital earnings that is implicit in the earnings survey, as well as the likelihood of a survey failing to capture top earnings, especially among capital owners.

Finally, Figure B.4 reports the share of earnings within each factor group that is earned from the formal economy. The median factor group derives earnings that are 60.4% formal, but there is considerable dispersion across factors in their formal income shares (the minimal share is 18% and the maximum is 96%). There is no systematic relationship between a factor's total (that is, formal plus informal) survey earnings and its formal income share. However, Figure B.4 shows that there does exist a clear (positive) relationship when the formal income share is compared to *per capita* earnings across factor groups.<sup>74</sup>

## B.4.2 ENEMDU Survey

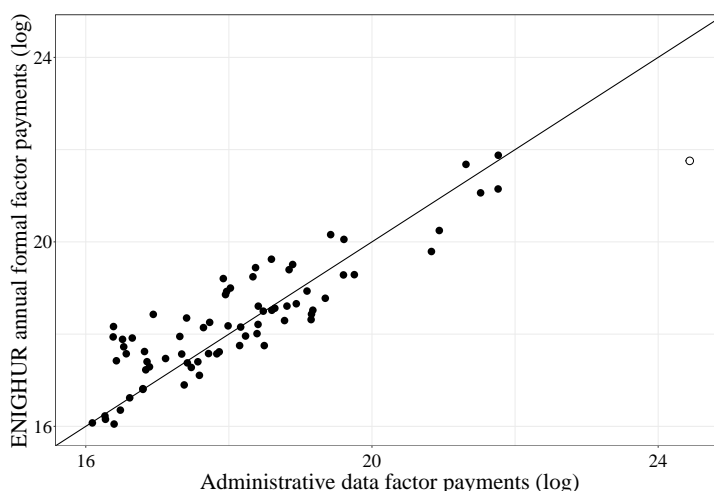
While the ENEMDU survey was conducted quarterly, its fourth quarter editions were more explicitly designed to be representative at the province level (and typically larger) than those in the rest of the year, so we use only the fourth quarter information. This results in a number of respondents (with positive earnings, over the age of 15) ranging from 25,590 to 41,991 depending on the year.

---

as well as total amounts of additional payments (paid leave, retroactive payments, etc.) received in the past year. We calculate (annualized rates of) the earnings of business owners as the firm's profits (over the past year for agricultural businesses, and over the past half-year for non-agricultural businesses) adjusted for the respondent's ownership share (though in the case of agricultural businesses this share is unreported, so we assume it to be 100%).

<sup>74</sup>We calculate *per capita* factor group earnings on the basis of survey respondents' main occupations.

**Figure B.3: Comparison of Administrative and Survey Factor Earnings**



*Notes:* Filled dots correspond to labor factor groups (education-province pairs) while the empty dot represents the non-oil capital factor, and the black line indicates  $y = x$ . The x-axis reports the (log) value of total earnings in each factor group (i.e.  $Y_f = \sum_{i \in \mathcal{I}} Y_{if}$ ) as measured in the administrative data in 2011. The y-axis reports the analogous measurement from the ENIGHUR survey in regards to formal earnings.

This survey shares many features with the ENIGHUR survey described above, so we discuss here only any differences that have implications for our analysis. First, all ENEMDU respondents report their earnings in the past month. Second, unlike the ENIGHUR survey, the ENEMDU survey does not disaggregate business costs so we cannot use reports of positive wage costs to identify businesses that hire employees (and hence are owned by a capital factor); we use the respondent’s occupation description instead.<sup>75</sup> Third, the ENEMDU survey does not report the ownership share of business owners, so we assume that they earn all of their firm’s profits.<sup>76</sup> Finally, ENEMDU provides slightly less information with which to classify employee income as formal or informal.<sup>77</sup>

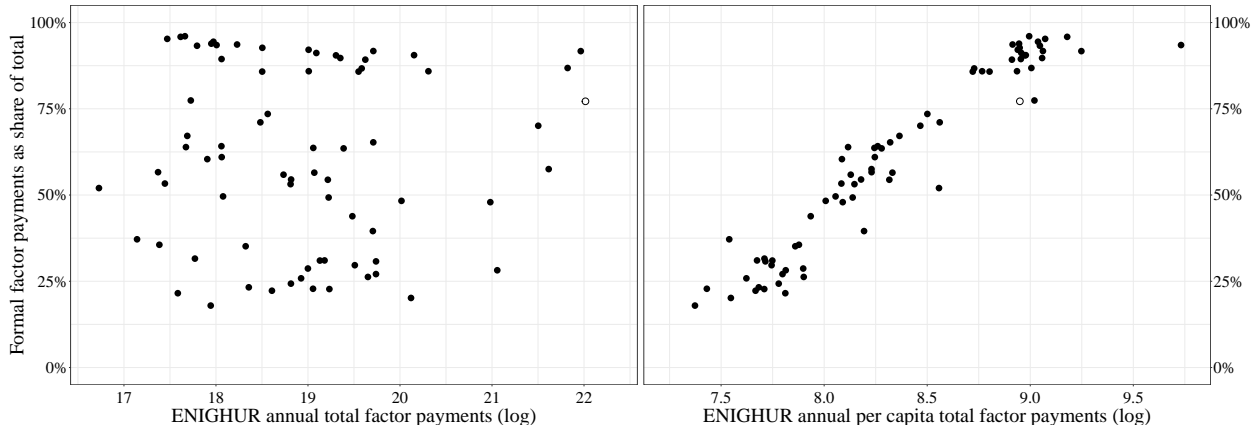
While these differing survey characteristics may result in differing measures of factor earnings in ENEMDU and ENIGHUR, we find that such differences are minimal in practice. Across factor groups, the correlation between total earnings inferred from the 2011

<sup>75</sup>That is, when the occupation is categorized as “patron” the survey questionnaire intends this to refer to a business that typically hires others. By contrast, when the occupation is listed as “self-employed” this refers to a business that has no salaried employees.

<sup>76</sup>In the ENIGHUR survey, which does report ownership shares, the share of total profits accruing to the respondent, aggregating across all respondents and occupations, is 96%.

<sup>77</sup>For employee occupations our previous formality classification requires that both the employee’s firm has formal characteristics and that the employee appears to be enrolled in the social security system. Information on the latter is incomplete in ENEMDU. In particular, for main occupations only the total amount of employer deductions (due to social security payments, income tax payments, etc.) is reported, so we assume that any positive total amount implies social security enrollment. For secondary occupations no such information is reported, so we remove the social security requirement from our formality classification in such cases.

**Figure B.4: Formal Share of Earnings by Factor Group**



Notes: Filled dots correspond to labor factor groups (education-province pairs) while the empty dot represents the non-oil capital factor. The figure on the left reports on the x-axis the (log) value of total earnings in each factor group (i.e.  $Y_f = \sum_{i \in \mathcal{I}} Y_{if}$ ) as measured in the survey data, whereas the one on the right reports the (log) *per capita* earnings in each factor group (i.e.  $Y_f$  divided by the frequency-weighted number of respondents whose main occupation corresponds to factor group  $f$ ) as measured in the survey data. The common y-axis reports the share of the factor group's total earnings that is obtained formally.

ENEMDU survey and those from the 2011-12 ENIGHUR survey is 0.96. Similarly, the correlation between the two surveys' inferred number of individuals whose primary occupation lies within each factor group is 0.97, and the correlation between their inferred share of factor earnings that is formal is 0.96.

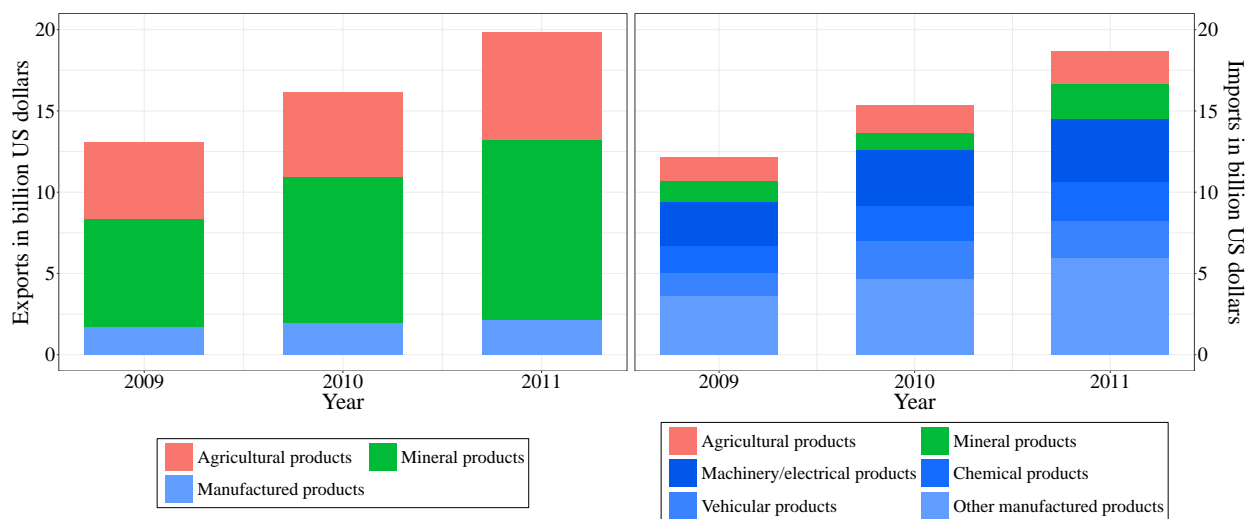
## C Appendix: Empirical Results

### C.1 Summary Statistics

#### C.1.1 Trade flows

We begin with the composition of Ecuador’s trade flows in 2009-2011, as reported in the customs data. Figure C.1 does this for both exports and imports by broad categories.

**Figure C.1: Composition of Ecuador’s Exports and Imports, 2009-2011**

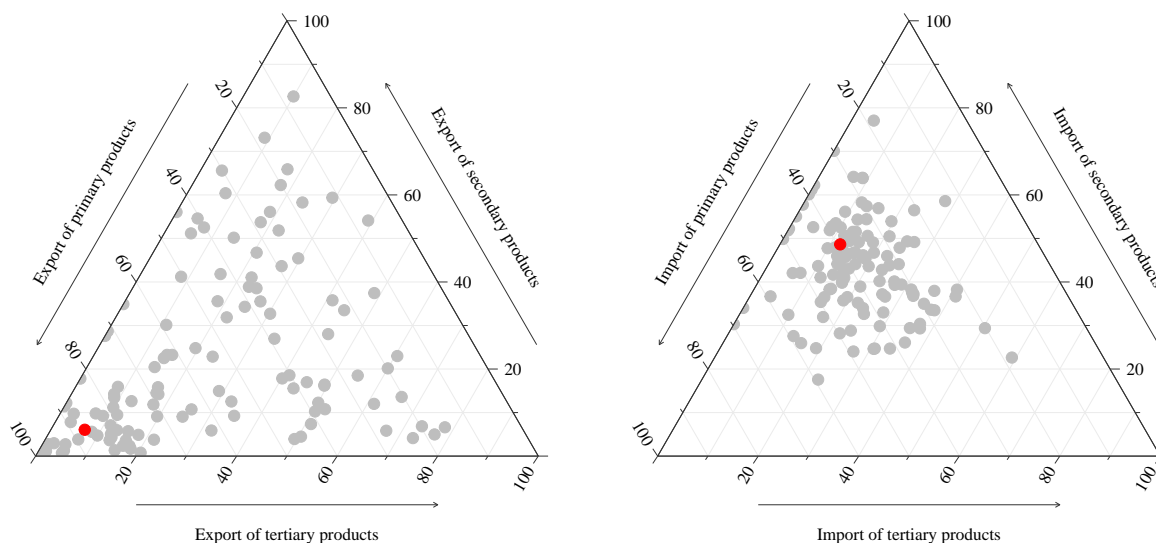


*Notes:* Trade flows by product category computed from firm-level custom records in 2009-2011.

Next, we compare the composition of Ecuador’s trade flows with other countries that are at a similar level of aggregate per capita earnings. We do so using trade data for 2012 from the Atlas of Economic Complexity (AEC) produced by The Growth Lab at Harvard University (2019). While there are many ways to display such comparisons we take a simple approach of aggregating products (based on AEC definitions) into three categories—primary, secondary and tertiary—so that a country’s shares of exports and imports can be plotted on the two-dimensional simplex.<sup>78</sup> Figure C.2 displays in such a simplex the location of every middle- and low-income country in the world (according to World Bank classifications) with a population above 500,000.

<sup>78</sup>Primary products comprise the Agricultural, Stone, Minerals, and Metals categories; secondary products are those from Textiles, Chemicals, Vehicles, Machinery, and Electronics; and tertiary products are those from Services. We omit the category Other (and rescale all shares after doing so).

**Figure C.2: Composition of Trade Among Low- and Middle-Income Countries, 2012**



*Notes:* Trade flows in 2012 for each country (red for Ecuador, gray for all others) as reported by the Atlas of Economic Complexity. Included countries are those that have a population above 500,000 and are not designated as “high income” by the World Bank in 2012.

### C.1.2 Earnings and Trade Exposure

Table C.1 reports summary statistics of the distribution of capital income shares, export exposure and import exposures across individuals in Ecuador from 2009-2015.



**Table C.1: Summary Statistics, Income and Exposure Across Individuals**

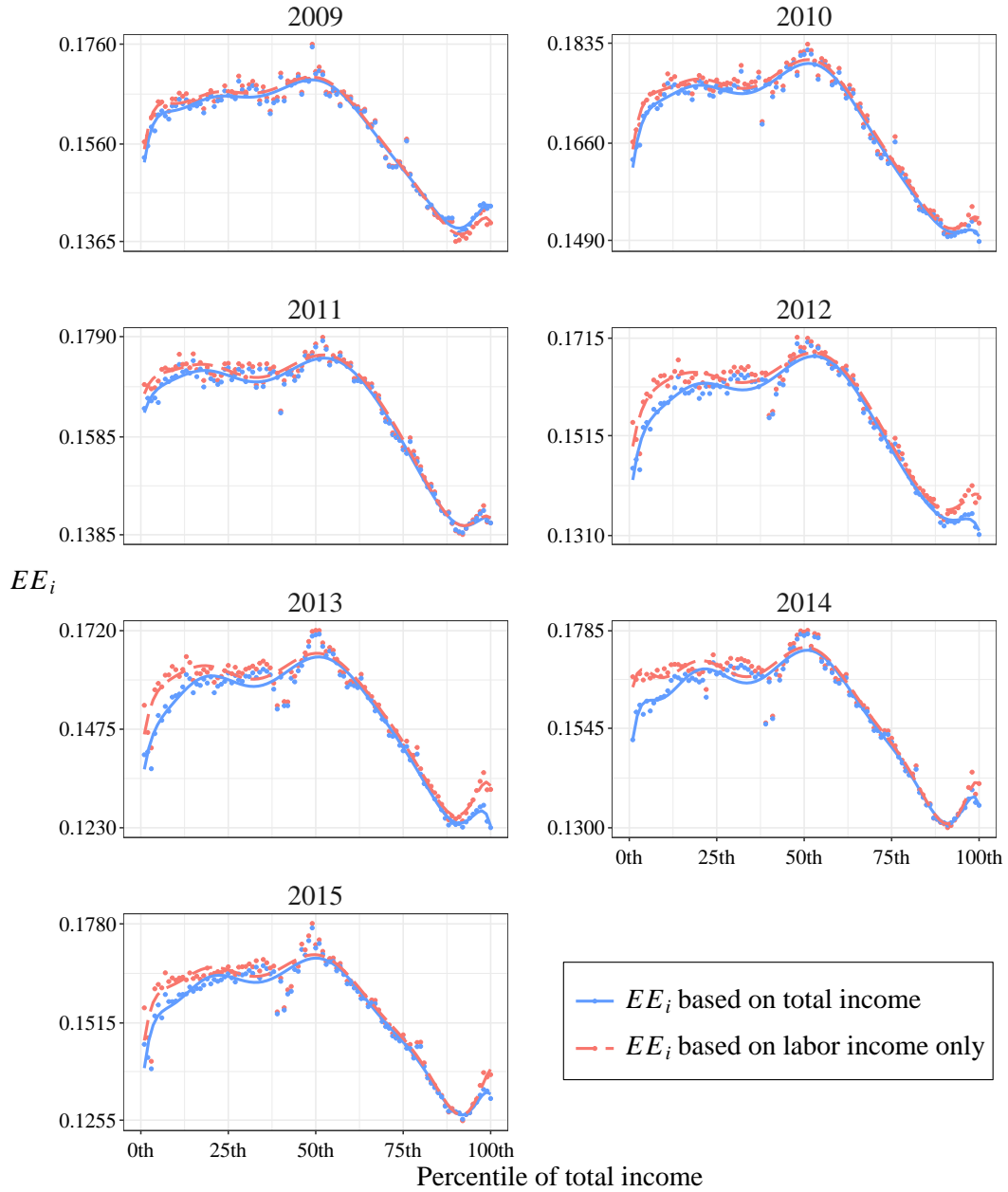
|      |                            | Mean  | Percentiles of distribution |                  |                  |                  |                    |
|------|----------------------------|-------|-----------------------------|------------------|------------------|------------------|--------------------|
|      |                            |       | 10 <sup>th</sup>            | 50 <sup>th</sup> | 90 <sup>th</sup> | 99 <sup>th</sup> | 99.9 <sup>th</sup> |
| 2009 | Capital income share       | 0.078 | 0.000                       | 0.000            | 0.003            | 1.000            | 1.000              |
|      | Export exposure ( $EE_i$ ) | 0.158 | 0.088                       | 0.138            | 0.281            | 0.455            | 0.455              |
|      | Import exposure ( $IE_i$ ) | 0.041 | 0.014                       | 0.031            | 0.097            | 0.111            | 0.122              |
| 2010 | Capital income share       | 0.082 | 0.000                       | 0.000            | 0.020            | 1.000            | 1.000              |
|      | Export exposure ( $EE_i$ ) | 0.169 | 0.088                       | 0.143            | 0.287            | 0.479            | 0.479              |
|      | Import exposure ( $IE_i$ ) | 0.045 | 0.011                       | 0.032            | 0.104            | 0.128            | 0.148              |
| 2011 | Capital income share       | 0.088 | 0.000                       | 0.000            | 0.121            | 1.000            | 1.000              |
|      | Export exposure ( $EE_i$ ) | 0.164 | 0.095                       | 0.139            | 0.292            | 0.445            | 0.445              |
|      | Import exposure ( $IE_i$ ) | 0.043 | 0.003                       | 0.028            | 0.105            | 0.127            | 0.139              |
| 2012 | Capital income share       | 0.110 | 0.000                       | 0.000            | 0.770            | 1.000            | 1.000              |
|      | Export exposure ( $EE_i$ ) | 0.155 | 0.084                       | 0.128            | 0.257            | 0.474            | 0.474              |
|      | Import exposure ( $IE_i$ ) | 0.038 | 0.011                       | 0.027            | 0.087            | 0.108            | 0.123              |
| 2013 | Capital income share       | 0.112 | 0.000                       | 0.000            | 0.799            | 1.000            | 1.000              |
|      | Export exposure ( $EE_i$ ) | 0.150 | 0.073                       | 0.133            | 0.274            | 0.586            | 0.586              |
|      | Import exposure ( $IE_i$ ) | 0.036 | 0.013                       | 0.028            | 0.082            | 0.101            | 0.112              |
| 2014 | Capital income share       | 0.116 | 0.000                       | 0.000            | 0.863            | 1.000            | 1.000              |
|      | Export exposure ( $EE_i$ ) | 0.158 | 0.076                       | 0.142            | 0.292            | 0.577            | 0.577              |
|      | Import exposure ( $IE_i$ ) | 0.030 | 0.006                       | 0.018            | 0.074            | 0.093            | 0.099              |
| 2015 | Capital income share       | 0.118 | 0.000                       | 0.000            | 0.897            | 1.000            | 1.000              |
|      | Export exposure ( $EE_i$ ) | 0.154 | 0.070                       | 0.144            | 0.280            | 0.590            | 0.590              |
|      | Import exposure ( $IE_i$ ) | 0.023 | -0.002                      | 0.012            | 0.070            | 0.086            | 0.095              |

Notes: Baseline sample of individuals in the administrative dataset who have strictly positive income and whose labor income can be mapped to an education-province pair. Capital income share refers to the ratio of capital earnings to total earnings.

## C.2 Export and Import Exposure Across Years

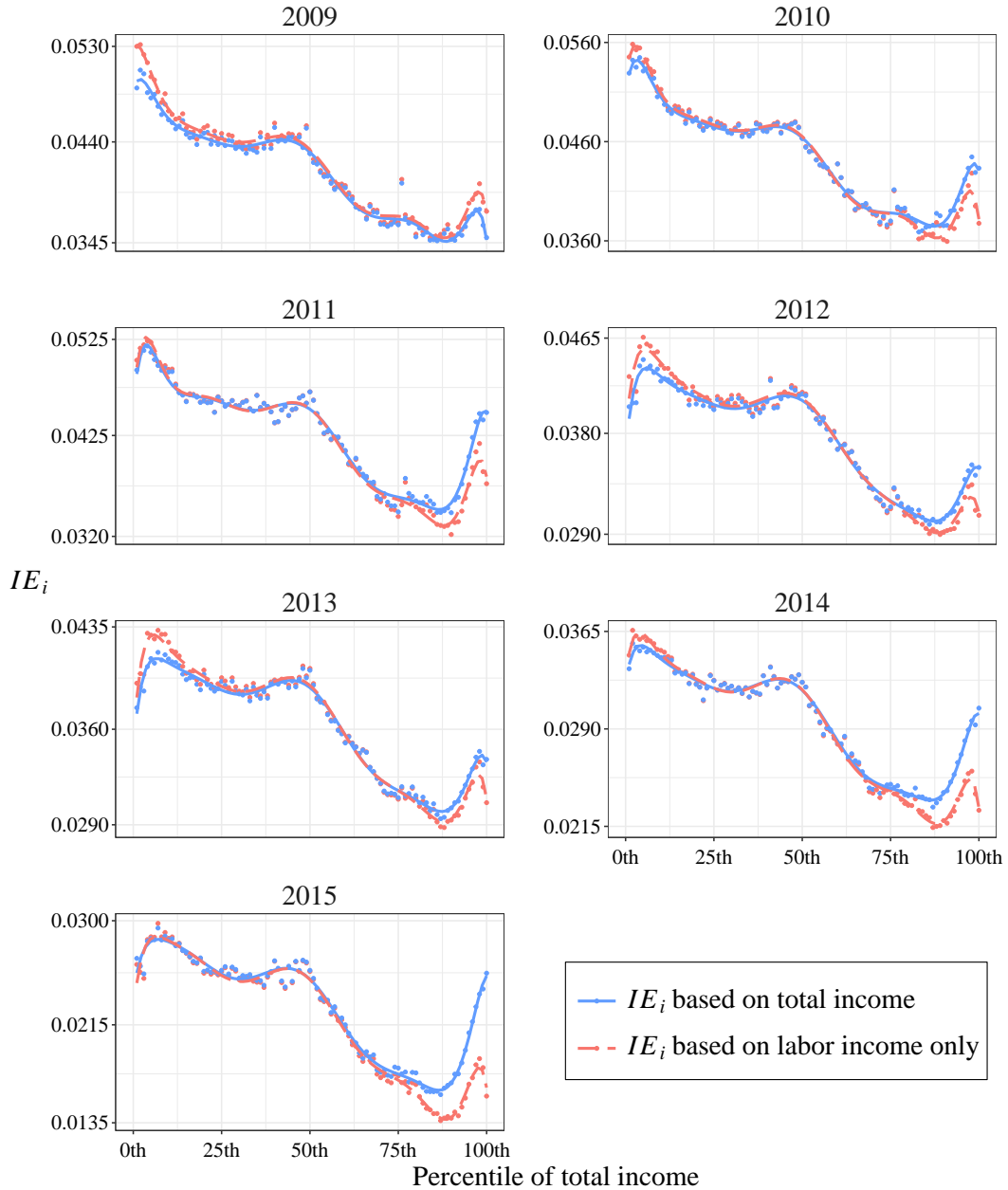
Figure C.3 illustrates the distribution of individual-level export exposure ( $EE_i$ ), as in Figure 2a, for all years, 2009-2015. Figure C.4 does the same for import exposure ( $IE_i$ ) as in Figure 2b.

**Figure C.3: Distribution of Export Exposure Across Individuals, 2009-2015**



*Notes:* The blue dots report, for each year indicated, the average value of export exposure  $EE_i$ , computed as in equation (21), across all individuals whose total income lies within each percentile of the total income distribution. The solid blue line indicates a fitted 10<sup>th</sup>-order polynomial. The red dots (and dashed red line) are analogous but report export exposure of labor income only, that is,  $EE_i$  computed giving no weight to capital in individuals' income and only including individuals with positive labor income.

**Figure C.4: Distribution of Import Exposure Across Individuals, 2009-2015**



*Notes:* The blue dots, for each year indicated, report the average value of  $IE_i$ , computed as in equation (23), across all individuals whose total income lies within each percentile of the total income distribution. The solid blue line indicates a fitted 10<sup>th</sup>-order polynomial. The red dots (and dashed red line) are analogous but use a measure of  $IE_i$  that is computed while giving no weight to capital in individuals' income and among individuals with positive labor income.

**Figure C.5: Distribution of Export Exposure Across Individuals, Firm-Based Factors, 2012**



*Notes:* The blue dots report the average value of export exposure  $EE_i$ , computed as in equation (21), across all individuals in 2012 whose total income lies within each percentile of the total income distribution. The solid blue line indicates a fitted 10<sup>th</sup>-order polynomial. The green dots (and dashed green line) are analogous but use a measure of  $EE_i$  that is computed by assuming firm-based factors.

### C.3 Alternative Export Exposure Measures

Figure C.5 reports a version of Figure 2a for the case where we define factors as being firm-specific. Figure C.6 reports instead an alternative version of Figure 2a for the case where we set the exports of oil-sector firms to zero.

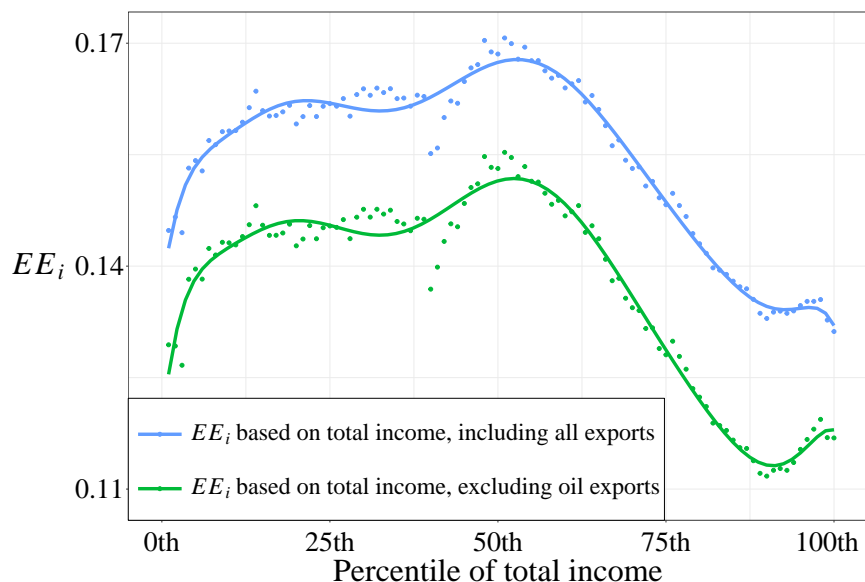
### C.4 Estimation of Micro-Level Elasticities: Zeroth-Stage Regression

The logic of the IVs in Section 5 relies on product-level export and import shocks in the rest of the world,  $(\text{Export Shock})_{v,t}$  and  $(\text{Import Shock})_{v,t}$ , having a positive effect on the log of Ecuador's total export value and import unit value,  $(\text{Export Ecuador})_{v,t}$ , and  $(\text{Import Ecuador})_{v,t}$ , respectively. We now evaluate whether this is the case through the following "zeroth-stage" regression:

$$Y_{v,t}^{\text{Ecuador}} = \beta Y_{v,t}^W + \zeta_v + \delta_t + \epsilon_{v,t},$$

with  $Y_{v,t}^{\text{Ecuador}} = (\text{Export Ecuador})_{v,t}, (\text{Import Ecuador})_{v,t}$ ,  $Y_{v,t}^W = (\text{Export Shock})_{v,t}, (\text{Import Shock})_{v,t}$ , and where  $\zeta_v$  and  $\delta_t$  are product and year fixed-effects. In this specification, the coefficient  $\beta$  captures the pass-through of foreign shocks to Ecuadorian variables. We estimate this pass-through using the sample of product-year pairs for which we observe positive exports and

**Figure C.6: Distribution of Export Exposure Across Individuals, All Exports vs. Non-Oil Exports, 2012**



*Notes:* The blue dots report the average value of export exposure  $EE_i$ , computed as in equation (21), across all individuals in 2012 whose total income lies within each percentile of the total income distribution. The solid blue line indicates a fitted 10<sup>th</sup>-order polynomial. The green dots (and dashed green line) are analogous but use a measure of  $EE_i$  that is computed by first setting to zero the exports of oil-sector firms.

imports for Ecuador between 2009 and 2015. Table C.2 reports the results of this exercise for the total export value in Panel A and the import unit value in Panel B. For both exports and imports, column (1) shows that a foreign shock of 1% causes an increase of roughly 0.2% in Ecuador's export total value and import unit value. Columns (2) and (3) indicate that the pass-through coefficient is positive for both manufacturing and non-manufacturing products.

**Table C.2: Impact of World Shocks on Ecuadorian Trade**

|  | (1)              | (2)              | (3)              |
|--|------------------|------------------|------------------|
| Panel A: Log of Ecuador's export total value |                  |                  |                  |
| Log of World's export total value            | 0.204<br>(0.026) | 0.224<br>(0.031) | 0.131<br>(0.048) |
| Product-year observations                    | 7,691            | 5,817            | 1,874            |
| Number of products                           | 1,593            | 1,265            | 328              |
| Panel B: Log of Ecuador's import unit value  |                  |                  |                  |
| World's avg. log import unit value           | 0.232<br>(0.020) | 0.243<br>(0.022) | 0.170<br>(0.045) |
| Product-year observations                    | 26,319           | 23,238           | 3,081            |
| Number of products                           | 4,058            | 3,555            | 503              |
| Sample of Products                           |                  |                  |                  |
| Manufacturing                                | Yes              | Yes              | No               |
| Non-manufacturing                            | Yes              | No               | Yes              |

*Notes:* Sample of HS6 products exported (Panel A) and imported (Panel B) by Ecuador in 2009-2015. Dependent variable is the log of Ecuador's total export value in Panel A and the log of Ecuador's import unit value in Panel B. In each specification, we report the coefficient of the corresponding variable computed for all countries in the world economy excluding Ecuador. All specifications include product and year fixed-effects. Standard errors in parentheses are clustered by product.

## C.5 Estimation of Ecuador's Factor Demand Model Under Alternative Specifications

This section reports alternative specifications for the estimation of the baseline parameters of our factor demand model,  $\eta$  and  $\sigma$ , beyond those reported in Table 1.

**Elasticity of Substitution Between Factors.** We begin with alternative specification choices for the elasticity of substitution between factors  $\eta$ . Column (1) of Table C.3 re-states the baseline value as reported in Table 1. As described in Section 5.1, this baseline specification uses a balanced panel of all firm-factor-year observations from 2009-2015, uses both the export-based and import-based IVs in equations (25) and (26), controls for firm-year and factor fixed effects, includes additional controls for year fixed effects interacted with the factor's exposure to exports and imports in the initial year, and clusters the standard errors at the factor level. The specifications in columns (2)-(9) retain each of these features of the baseline but alter one feature. Column (2) drops the additional controls for year fixed effects interacted with the factor's exposure to exports and imports in the initial year.

Column (3) uses a sample comprised of firms that hire more than five workers. Column (4) uses all firm-factor-year observations, not just those comprising a balanced panel. Column (5) includes only those observations after 2009 and column (6) does the same for the post-2010 era—these alternatives explore the extent to which our results are sensitive to the global trade collapse of 2008-2010. Column (7) uses wage observations that are constructed as the (exponential of the) residuals from a Mincer regression of log wages on gender, age and age squared. Column (8) reports standard errors that are clustered at the sector level. And column (9) uses, in addition to the import IV, an export shift-share IV where the summation in equation (25) only includes oil products (defined as those in chapter 27 of the HS07 classification).

**Table C.3: Additional Estimates of  $\eta$  (Alternative Specifications)**

|                         | Baseline       |                           | Alternative Specifications |                          |                        |                        |                           |                               |                                |
|-------------------------|----------------|---------------------------|----------------------------|--------------------------|------------------------|------------------------|---------------------------|-------------------------------|--------------------------------|
|                         | (1)            | (2)                       | (3)                        | (4)                      | (5)                    | (6)                    | (7)                       | (8)                           | (9)                            |
| Estimate of $\eta$      | 2.10<br>(0.34) | 2.15<br>(0.65)            | 2.07<br>(0.32)             | 2.11<br>(0.33)           | 2.11<br>(0.58)         | 3.31<br>(2.52)         | 2.11<br>(0.35)            | 2.10<br>(0.38)                | 1.80<br>(0.49)                 |
| First-stage F statistic | 10.0           | 5.0                       | 10.3                       | 8.7                      | 18.2                   | 5.2                    | 10.7                      | 29.4                          | 15.6                           |
| Factor-firm-year obs.   | 627,355        | 627,355                   | 515,228                    | 861,670                  | 538,794                | 447,843                | 627,355                   | 627,355                       | 627,355                        |
| Number of clusters      | 75             | 75                        | 75                         | 75                       | 75                     | 75                     | 75                        | 56                            | 75                             |
| Alternative:            | -              | Drop<br>extra<br>controls | Firms<br>w/ > 5<br>workers | Un-<br>balanced<br>panel | Years<br>2010-<br>2015 | Years<br>2011-<br>2015 | Mincer<br>resid.<br>wages | Cluster<br>at sector<br>level | Oil only<br>export<br>shifters |

*Notes:* Sample of incorporated firms with positive payments for more than one factor and more than one employee. Baseline specification (column 1) uses a balanced panel from 2009-2015, uses both export and import IVs, includes firm-year and factor fixed effects, includes the extra controls consisting of year fixed effects interacted with the factor's exposure at  $t_0$  to exports and imports, and reports standard errors (in parentheses) that are clustered by factor. Columns (2)-(9) report specifications that retain these features of the baseline but with the alternative described. Observations weighted by initial factor-firm payments (winsorized at the 95th percentile).

Table C.4 continues with the estimation of  $\eta$ , now using alternative instrumental variables. Column (1) re-states the baseline estimate, which uses two instruments, one based on export shocks and the other on import shocks. Columns (2) and (3) then report estimates obtained when using IVs based only on export or import shocks, respectively. Although these three point estimates are similar across all types of shock IVs, the first-stage strength differs, with export shocks being more important. Columns (4) and (5) go on to address concerns about the potential existence of global shocks that may simultaneously drive the variation in domestic shocks,  $\epsilon_{fn,t}$ , and foreign shocks,  $(\text{Export Shock})_{v,t}$  and  $(\text{Import Shock})_{v,t}$ . We build on the intuition of the “granular” IV proposed in Gabaix and Koijen (2020) by isolating the idiosyncratic component of shocks to the trade outcomes of large countries. Specifically, in column (4) we compute shifters using only the countries with export val-

ues above those of the median country; and in column (5) we further subtract from these shifters an estimate of the global common component of trade outcomes computed as the product-specific average of log exports and log import unit values, respectively, for countries with export values below those of the median country. In both case, we again obtain similar point estimates.

**Table C.4: Additional Estimates of  $\eta$  (Alternative Instruments)**

|                         | Baseline                                   | Alternative Specifications |                           |  |   |
|-------------------------|--|----------------------------|---------------------------|--|---|
|                         | (1)  | (2)                        | (3)                       | (4)  | (5)   |
| Estimate of $\eta$      | 2.10<br>(0.34)                             | 2.13<br>(0.47)             | 2.03<br>(0.73)            | 2.09<br>(0.35)   | 2.35<br>(0.50)  |
| First-stage F statistic | 10.0                                       | 19.2                       | 3.0                       | 10.4   | 12.6  |
| IV construction:        | Export<br>and import<br>IVs<br>(25) & (26) | Export<br>IV (25)<br>only  | Import<br>IV (26)<br>only | (Shock) $_{v,t}$<br>measured<br>using large<br>countries<br>only | (Shock) $_{v,t}$<br>further sub-<br>tracts small-<br>country avg. |

*Notes:* Sample of incorporated firms with positive payments for more than one factor and more than one employee. All specifications use a balanced panel of 627,355 factor-firm-year observations from 2009-2015, include factor and firm-year fixed effects, and include controls for year fixed effects interacted with factor exposure at  $t_0$  to exports and imports. Observations weighted by initial factor-firm payments (winsorized at the 95th percentile). Standard errors in parentheses are clustered by factor (of which there are 75).

**Elasticity of Substitution Between Goods.** We turn now to the estimation of the elasticity of substitution between goods  $\sigma$ . Column (1) of Table C.5 reports the baseline specification (as in Table 1), which uses a balanced panel of all firm-year observations from 2009-2015, uses the three IVs in equations (30)-(32), controls for firm and sector-year fixed effects, includes additional controls for year fixed effects interacted with the firm’s cost share spent on primary factors, and reports standard errors that are clustered at the firm level. Columns (2)-(9) then report alternative specifications in the same manner as Table C.3 as described above. In this case, the Mincer residualized wages used in column (7) enter due to the presence of factor prices in the construction of the regressor, as per equation (28).

Finally, Table C.6 reports the results of using variants of our IV procedure for the estimation of  $\sigma$ . The baseline estimate in column (1) uses three instruments: one based on export shocks and two based on import shocks. Column (2) uses only export shocks, while column (3) uses only import shocks. This comparison indicates that import shocks are more important for the estimation of  $\sigma$  due to their direct impact on the production cost of importing



**Table C.5: Additional Estimates of  $\sigma$  (Alternative Specifications)**

|                         | Baseline       |                           | Alternative Specifications |                          |                        |                        |                           |                               |                                |
|-------------------------|----------------|---------------------------|----------------------------|--------------------------|------------------------|------------------------|---------------------------|-------------------------------|--------------------------------|
|                         | (1)            | (2)                       | (3)                        | (4)                      | (5)                    | (6)                    | (7)                       | (8)                           | (9)                            |
| Estimate of $\sigma$    | 2.11<br>(0.55) | 2.04<br>(0.56)            | 1.97<br>(0.60)             | 2.90<br>(0.66)           | 1.59<br>(0.48)         | 1.58<br>(0.75)         | 1.46<br>(0.66)            | 2.11<br>(0.39)                | 2.57<br>(0.60)                 |
| First-stage F statistic | 16.4           | 14.3                      | 11.3                       | 18.5                     | 12.0                   | 4.1                    | 5.8                       | 8.7                           | 18.9                           |
| Firm-year obs.          | 181,671        | 181,671                   | 120,414                    | 279,790                  | 155,718                | 129,765                | 181,671                   | 181,671                       | 181,671                        |
| Number of clusters      | 25,953         | 25,953                    | 17,202                     | 47,480                   | 25,953                 | 25,953                 | 25,953                    | 53                            | 25,953                         |
| Alternative:            | -              | Drop<br>extra<br>controls | Firms<br>w/ >5<br>workers  | Un-<br>balanced<br>panel | Years<br>2010-<br>2015 | Years<br>2011-<br>2015 | Mincer<br>resid.<br>wages | Cluster<br>at sector<br>level | Oil only<br>export<br>shifters |

*Notes:* Sample of incorporated firms with positive final sales and more than one employee. Baseline specification (column 1) uses a balanced panel of observations from 2009-2015, uses both export and import IVs, includes firm and sector-year fixed effects, includes the extra controls comprising of year fixed effects interacted with the firm's cost share spent on primary factors, and reports standard errors (in parentheses) that are clustered by firm. Columns (2)-(9) report specifications that retain these features of the baseline but with the alternative described. Observations are weighted by initial firm final sales (weights winsorized at the 95 percentile).

firms. Turning to columns (4) and (5), as with Table C.4 above, these specifications explore how the main source of variation in the shifters are idiosyncratic shocks to large countries.

**Table C.6: Additional Estimates of  $\sigma$  (Alternative Instruments)**

|                         | Baseline                                     |                           | Alternative Specifications   |  |   |
|-------------------------|--|---------------------------|------------------------------|--|---|
|                         | (1)  | (2)                       | (3)                          | (4)  | (5)   |
| Estimate of $\sigma$    | 2.11<br>(0.55)                               | 2.81<br>(4.87)            | 2.08<br>(0.55)               | 2.01<br>(0.54)   | 2.38<br>(0.73)  |
| First-stage F statistic | 16.4   | 1.0                       | 24.4                         | 17.7   | 7.6   |
| IV construction:        | Export<br>and import<br>IVs<br>(30, 31 & 32) | Export<br>IV (30)<br>only | Import IVs<br>(31 & 32) only | (Shock) <sub>v,t</sub><br>measured<br>using large<br>countries<br>only | (Shock) <sub>v,t</sub><br>further sub-<br>tracts small-<br>country avg. |

*Notes:* Sample of incorporated firms with positive final sales and more than one employee. All specifications use a balanced panel of 181,671 firm-year observations from 2009-2015, include firm and sector-year fixed effects, and include controls for year fixed effects interacted with firm cost shares at  $t_0$  spent on primary factors. Observations weighted by initial firm final sales (winsorized at the 95 percentile). Standard errors in parentheses are clustered by firm (of which there are 25,953).

## C.6 Comparison to the Original Factor Content Approach

In order to compare our results to those of the original factor content approach, we replicate the strategy of [Katz and Murphy \(1992\)](#) to estimate the (aggregate) elasticity of substitution between educational groups. That is, we estimate

$$\ln\left(\frac{w_{H,t}}{w_{L,t}}\right) = -\frac{1}{\eta_{agg}} \ln\left(\frac{\bar{L}_{H,t}}{\bar{L}_{L,t}}\right) + \gamma \text{year}_t + \epsilon_t, \quad (\text{C.1})$$

where, in year  $t$ ,  $w_{H,t}/w_{L,t}$  is the wage of high-skill workers relative to the wage of low-skilled workers,  $\bar{L}_{H,t}/\bar{L}_{L,t}$  is the supply of high-skill workers relative to the supply of low-skilled workers, and  $\text{year}_t$  is a linear time trend. To measure the average wage and total employment for workers classified as high- and low-skilled, we use the ENEMDU survey described in [Appendix B.4.2](#).<sup>79</sup> We define high-skilled workers to be those with a college degree.

Column (1) of [Table C.7](#) reports the estimate of  $\eta_{agg}$  that we obtain using this procedure. This implies an estimate of  $\eta_{agg}$  equal to 1.42, a value that is very similar to estimates of this parameter for the U.S. ([Acemoglu and Autor, 2011](#)).

We also consider an alternative estimate of  $\eta_{agg}$  obtained from the following three-group extension of the [Katz and Murphy's \(1992\)](#) specification,

$$\ln(w_{f,t}) = -\frac{1}{\eta_{agg}} \ln(\bar{L}_{f,t}) + \gamma_f \text{year}_t + \zeta_f + \zeta_t + \epsilon_t, \quad (\text{C.2})$$

where  $f$  is one of the three education groups in our baseline analysis,  $\gamma_f$  is a factor-specific linear time trend, and  $\zeta_f$  and  $\zeta_t$  are factor and year fixed-effects, respectively. As reported in [column \(2\)](#), in this cases we obtain an estimate of  $\eta_{agg}$  equal to 2.53, similar to the firm-level elasticity of substitution between the labor and capital factors estimated from fluctuations in export and import shocks in [Section 5](#).

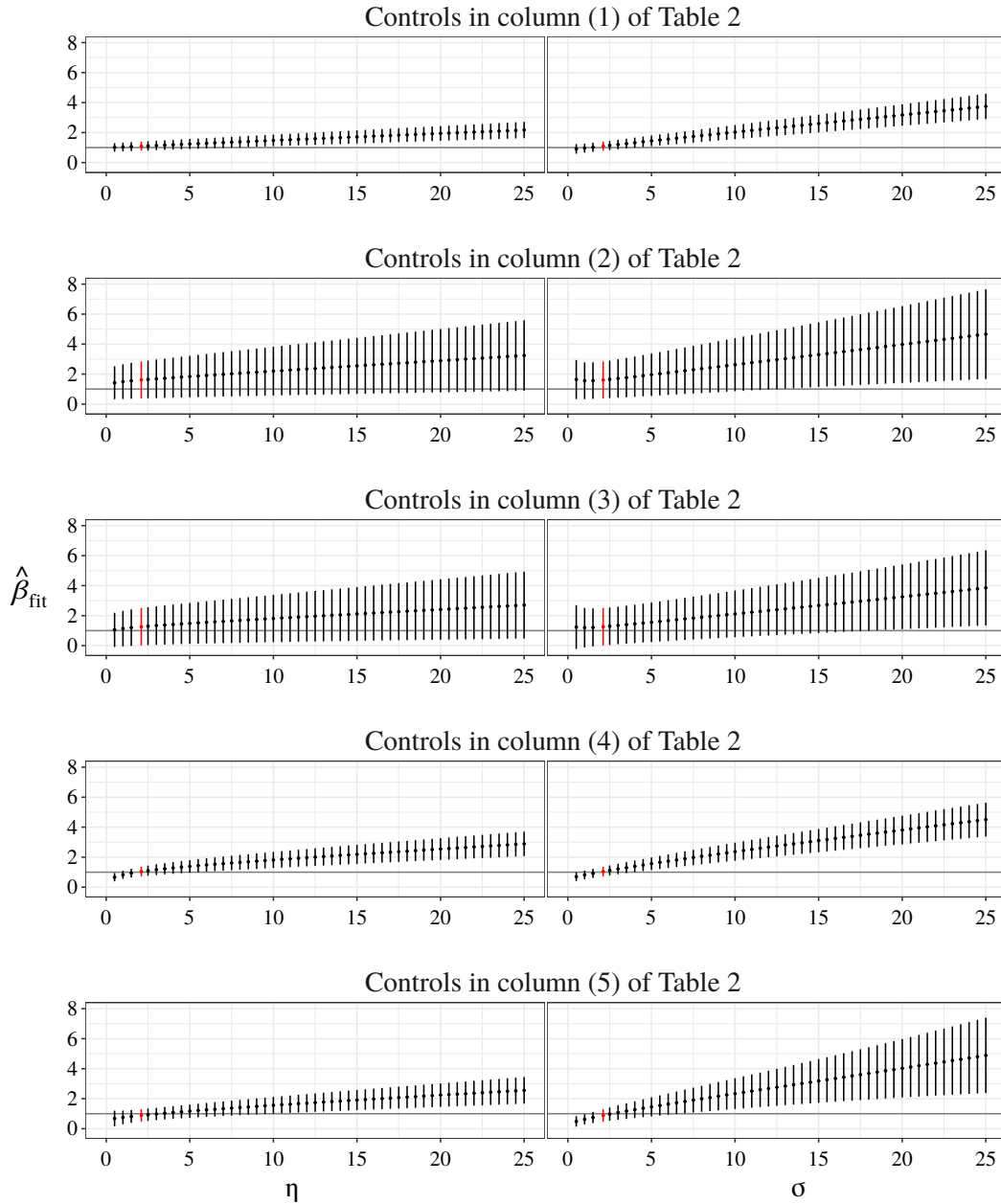
## C.7 Goodness of Fit Test Under Alternative Micro-Level Elasticities

[Figure C.7](#) describes how estimates of  $\hat{\beta}_{\text{fit}}$  from [Section 6](#) vary when alternative values of  $\sigma$  and  $\eta$  are used to construct  $\ln w_{f,t}^{\text{model}}$ .

---

<sup>79</sup>Given the availability of the ENEMDU survey, our sample is based on the fourth quarter information for the years between 2007 and 2019.

**Figure C.7: Goodness of Fit Test Under Alternative Values of Micro-Level Elasticities**



Notes: Each panel reports the fit coefficient  $\hat{\beta}_{fit}$  and the 95% confidence interval implied by the estimation of (34) with  $\ln \hat{w}_{f,t}^{model}$  computed under alternative values of the elasticity of substitution between factors in production,  $\eta$ , and the elasticity of substitution between firms in consumption,  $\sigma$ . The left-hand panels vary  $\eta$  at  $\sigma = 2.11$ , and the right-hand panels vary  $\sigma$  at  $\eta = 2.10$ , the baseline parameter values used in Table 2. Red points denote those same baseline values. Based on sample of 75 factors in 2009-2015. All specifications include year and factor fixed effects. Observations are weighted by initial factor payments (with weights winsorized at the 95 percentile). Standard errors clustered by factor.

**Table C.7: Estimates of the Katz-Murphy Factor Demand Elasticity**

|                            | (1)                     | (2)                  |
|----------------------------|-------------------------|----------------------|
| Estimate of $\eta_{agg}$   | 1.42<br>(0.37)          | 2.53<br>(0.19)       |
| Number of education groups | 2                       | 3                    |
| Education groups:          | college,<br>non-college | college,<br>HS, < HS |

*Notes:* Column (1) reports the estimate of  $\eta_{agg}$  obtained using two skill groups and equation (C.1), whereas column (2) reports that for equation (C.2) and three skill groups. Column (1) includes a linear time trend over the 13-year period. Column (2) includes skill group and year fixed effects, and a linear time trend interacted with group dummies. Robust standard errors in parentheses.

## C.8 Connecting Exposure Measures to Counterfactual Responses

The goal of this subsection is to assess how the export and import exposure measures from Section 4,  $EE_{i,t}$  and  $IE_{i,t}$ , relate to the counterfactual changes in earnings predicted for each individual,  $(\Delta Y_{i,t})_{trade}/Y_{i,t}$ . We do this by means of the linear regression

$$\frac{(\Delta Y_i)_{trade}}{Y_i} = \beta + \beta^E EE_i + \beta^I IE_i + v_i, \quad (C.3)$$

using the sample of all individuals  $i$  (in 2012). Table C.8 reports our estimates, beginning in column (1) with the regression coefficients corresponding to total income. Both exposure measures have signs that are in line with the local predictions of Proposition 1 and Proposition 3 (for  $\sigma > 1$ ) and the total contribution of the two exposure measures is high (with an  $R^2 = 0.90$ ). The same is true for labor income on its own, reported in column (3). In order to explore the relative explanatory contributions of  $EE_{i,t}$  and  $IE_{i,t}$  to this high overall fit, columns (2) and (4) report the Shapley decomposition of the  $R^2$  in columns (1) and (3), respectively. It is clear, in both cases, that significantly more fit can be accounted for in this sense by the import exposure measure.

## C.9 Parameter Estimation for Sensitivity Analysis

This section presents details of the parameter estimation of the more general nested CES models used in Section 7.3. A unified model that nests all of these extensions is presented in Section D.2 together with further details about the construction of the counterfactual autarky equilibria.

**Table C.8: Distribution of the Gains from Trade and Individual Exposure, 2012**

|                            | Proportional change<br>in total income |                           | Proportional change<br>in labor income |                           |
|----------------------------|--|---------------------------|--|---------------------------|
|                            | Coefficient<br>estimates<br>(1)        | Shapley<br>% $R^2$<br>(2) | Coefficient<br>estimates<br>(3)        | Shapley<br>% $R^2$<br>(4) |
| Export exposure ( $EE_i$ ) | 1.121<br>(0.001)                       | 7.4%                      | 1.205<br>(0.001)                       | 7.9%                      |
| Import exposure ( $IE_i$ ) | -7.533<br>(0.002)                      | 92.6%                     | -7.583<br>(0.001)                      | 92.1%                     |
| $R^2$                      | 89.5%                                  | 100.0%                    | 92.8%                                  | 100.0%                    |
| Obs.                       | 2,613,011                              |                           | 2,413,801                              |                           |

*Notes:* Columns (1) and (3) report the results of the estimation of (C.3) for the changes, between the trade and the counterfactual autarkic equilibrium, in total and labor income, respectively. Columns (2) and (4) report the Shapley decomposition of the  $R^2$  for each specification. Robust standard errors in parentheses.

### C.9.1 Additional Technology Parameters

**Elasticities of Substitution Between Factors.** This extension allows the elasticity of substitution between capital and labor—which we will continue to refer to as  $\eta$ , as described in equation (D.13)—to differ from the elasticity of substitution between different labor groups—which we denote  $\eta_L$ , as described in equation (D.14). Beginning with  $\eta_L$ , equation (D.16) implies the following demand for labor types  $f \in \mathcal{F}_L$  within any domestic firm  $n$  at time  $t$

$$\ln X_{fn,t} = (1 - \eta_L) \ln w_{f,t} + \zeta' \text{Controls}_{f,t} + \zeta_{n,t} + \zeta_f + \epsilon_{fn,t}. \quad (\text{C.4})$$

This is analogous to the specification in Section 5.1 apart for the fact that only labor factor types  $f \in \mathcal{F}_L$  enter the estimation sample. We therefore follow the same IV estimation procedure and controls as in Section 5.1. Table C.9 reports the resulting estimate of  $\eta_L$  in column (1).

Turning to  $\eta$  for this extended model, equation (D.16) implies the following relative demand for capital by any domestic firm  $n$  at time  $t$ ,

$$\frac{X_{Kn,t}}{X_{Ln,t}} = \frac{\Theta_{Kn,t}}{\Theta_{Ln,t}} \left( \frac{w_{n,t}^K}{w_{n,t}^L} \right)^{1-\eta}, \text{ for all } n \in \mathcal{N},$$

where  $X_{Kn,t}$  and  $X_{Ln,t} \equiv \sum_{f \in \mathcal{F}_L} X_{fn,t}$  are the capital and labor payments of firm  $n$ , and  $w_{n,t}^F$  is a revealed measure of the CES price index for the composite bundle of factor  $F = K, L$  used

by firm  $n$  at time  $t$  such that  $\ln w_{n,t}^F \equiv \sum_{f \in \mathcal{F}_F} x_{fn,t} \left( \ln w_{f,t} + \frac{1}{\eta_F - 1} \ln x_{fn,t} \right)$ . In the case of capital, since all firms in a sector only use one type of capital,  $w_{n,t}^K$  reduces to the price of capital in the sector in which firm  $n$  operates. In line with the analysis of Section (5.1), we assume that the relative capital demand shock,  $\Theta_{Kn,t} / \Theta_{Ln,t}$ , is a function of year term  $\zeta_t$ , a firm-specific term  $\zeta_n$ , and a residual demand shock,  $\epsilon_{n,t}$ . This leads to the following specification:

$$\ln \frac{X_{Kn,t}}{X_{Ln,t}} = (1 - \eta) \ln \frac{w_{n,t}^K}{w_{n,t}^L} + \zeta_t + \zeta_n + \epsilon_{n,t}. \quad (\text{C.5})$$

Following again Section 5.2, we define the firm-level IVs for the price index of each of its composite factor bundles:

$$\hat{E}_{n,t} = \hat{E}_{Kn,t} - \hat{E}_{Ln,t} \text{ such that} \quad \hat{E}_{Fn,t} = \sum_{f \in \mathcal{F}_F} \frac{X_{fn,t_0}}{X_{Fn,t_0}} \times \hat{E}_{f,t}, \quad (\text{C.6})$$

$$\hat{I}_{n,t} = \hat{I}_{Kn,t} - \hat{I}_{Ln,t} \text{ such that} \quad \hat{I}_{Fn,t} = \sum_{f \in \mathcal{F}_F} \frac{X_{fn,t_0}}{X_{Fn,t_0}} \times \hat{I}_{f,t}. \quad (\text{C.7})$$

The estimate that we obtain for  $\eta$  in this extended model is reported in column (2) of Table C.9.

**Elasticity of Substitution Between Domestic Intermediate Goods.** We now allow for a non-unitary elasticity of substitution  $\mu$  across domestic intermediates, as described in equation (D.11), while maintaining a unit elasticity of substitution between domestic and foreign inputs ( $\epsilon = 1$ ) as well as between foreign inputs ( $\mu^* = 1$ ). Under these assumptions, equation (D.17) implies that the demand of a domestic firm  $n$  at time  $t$  for the intermediates sourced from any domestic firm  $r$  is given by

$$\ln X_{rn,t} = (1 - \mu) \ln p_{r,t} + \zeta_{n,t} + \ln \theta_{rn,t}, \quad (\text{C.8})$$

with  $\zeta_{n,t} \equiv \ln(1 - \beta_{n,t}) \Theta_{n,t} R_{n,t} (P_{n,t}^D)^{\mu - 1}$ . Since  $\mu \neq 1$ , we can no longer use the measure of  $\ln p_{r,t}$  derived in Section 5.2. Instead, we build an alternative measure of prices by combining equations (D.17), (D.23) and (D.24) under the assumption that  $\epsilon = \mu^* = 1$ . These equations imply that

$$\begin{aligned} \ln p_{r,t} &= \ln \varphi_{r,t} + \beta_{r,t} \ln w_{r,t} + x_{r,t}^* \ln P_{r,t}^* + (1 - \beta_{r,t}) \Theta_{r,t} \ln P_{r,t}^D, \\ \ln P_{r,t}^D &= \sum_{m \in \mathcal{N}_{r,t}} \frac{x_{mr,t}}{\sum_{m' \in \mathcal{N}_{r,t}} x_{m'r,t}} \left( \ln p_{m,t} + \frac{1}{\mu - 1} \ln \frac{x_{mr,t}}{(1 - \beta_{r,t}) \Theta_{r,t}} + \frac{1}{1 - \mu} \ln \theta_{mr,t} \right), \end{aligned}$$

with  $x_{r,t}^* \equiv (1 - \beta_{r,t})(1 - \Theta_{n,t})$  and  $\mathcal{N}_{r,t} \equiv \{m \in \mathcal{N}_t : x_{mr,t} / (1 - \beta_{r,t})\Theta_{r,t} > 0.01\}$  defined as the set of suppliers accounting for at least 1% of domestic purchases of firm  $r$ .<sup>80</sup> Substituting the second expression above into the first, we obtain after some manipulation that

$$\ln p_{r,t} = \sum_{m \in \mathcal{N}_t} b_{mr,t}^D \left( \ln \varphi_{m,t} + \beta_{m,t} \ln w_{m,t} + x_{m,t}^* \ln P_{m,t}^* + \frac{1}{\mu - 1} \sum_{l \in \mathcal{N}_t} x_{lm,t}^D \left( \ln \frac{x_{lm,t}}{(1 - \beta_{m,t})\Theta_{m,t}} - \ln \theta_{lm,t} \right) \right)$$

where  $x_{lm,t}^D \equiv (1 - \beta_{m,t})\Theta_{m,t} \mathbb{I}_{l \in \mathcal{N}_{m,t}} x_{lm,t} / (\sum_{l' \in \mathcal{N}_{m,t}} x_{l'm,t})$  with  $x_t^D \equiv \{x_{rm,t}^D\}_{r,m \in \mathcal{N}_t}$ , and  $b_{mr}^D$  are the elements of  $B^D \equiv \sum_{j=0}^{\infty} (x_t^D)^j$ . Substituting this expression into (C.8), we then get

$$\ln X_{rn,t} + \sum_{m \in \mathcal{N}_t} b_{mr,t}^D \sum_{l \in \mathcal{N}_t} x_{lm,t}^D \ln \frac{x_{lm,t}}{(1 - \beta_{m,t})\Theta_{m,t}} = (1 - \mu) \sum_{m \in \mathcal{N}_t} b_{mr,t}^D (\beta_{m,t} \ln w_{m,t} + x_{m,t}^* \ln P_{m,t}^*) + \zeta_{n,t} + \ln \hat{\theta}_{rn,t},$$

where  $\ln \hat{\theta}_{rn,t} \equiv \ln \theta_{rn,t} + \sum_{m \in \mathcal{N}} b_{mr,t}^D ((1 - \mu) \ln \varphi_{m,t} + \sum_{l \in \mathcal{N}_t} x_{lm,t}^D \ln \theta_{lm,t})$ . Finally, by assuming that  $\ln \hat{\theta}_{rn,t} = \zeta' \text{Controls}_{r,t} + \zeta_r + \epsilon_{rn,t}$  and using the definition of  $\ln P_{m,t}^*$ , we obtain our empirical specification:

$$\ln \hat{X}_{rn,t} = (1 - \mu) \sum_{r \in \mathcal{N}_t} b_{rn,t}^D \left( \beta_{r,t} \ln w_{r,t} + \sum_{l \in \mathcal{N}_t^*} x_{lr,t}^* \ln p_{l,t}^* \right) + \zeta' \text{Controls}_{r,t} + \zeta_{n,t} + \zeta_r + \epsilon_{rn,t}, \quad (\text{C.9})$$

where  $\ln \hat{X}_{rn,t} \equiv \ln X_{rn,t} + \sum_{m \in \mathcal{N}_t} b_{mr,t}^D \sum_{l \in \mathcal{N}_t} x_{lm,t}^D \ln \frac{x_{lm,t}}{(1 - \beta_{m,t})\Theta_{m,t}}$  and  $\ln w_{r,t}$  and  $\ln p_{l,t}^*$  are measured in the same way as  $\ln w_{r,t}^D$  and  $\ln p_{l,t}^*$  in Section 5.2.

In order to estimate  $\mu$  from (C.9), we again use the firm-level IVs,  $\hat{E}_{r,t}$ ,  $\hat{I}_{r,t}$  and  $\hat{P}_{r,t}^*$  in equations (30)–(32), and the same set of controls as in Section 5.2. Column (3) of Table C.9 reports our estimate of  $\mu$ .

**Elasticity of Substitution Between Domestic and Foreign Intermediate Goods.** Here, we allow for a non-unitary elasticity of substitution  $\epsilon$  between each domestic firm's bundle of domestic intermediates and its bundle of foreign intermediates, as described in equation (D.10), while maintaining a unit elasticity of substitution between domestic inputs ( $\mu = 1$ ) as well as between foreign inputs ( $\mu^* = 1$ ). Equations (D.17) and (D.18) together imply that the demand by domestic firm  $n$  at time  $t$  for its bundle of domestic-sourced intermediates,

<sup>80</sup>By focusing on this set of suppliers, we avoid measurement error in  $\ln P_{r,t}^D$  introduced by outlier values of  $\ln(x_{mr,t} / (1 - \beta_{r,t})\Theta_{r,t})$  for small suppliers.

relative to its foreign-sourced intermediates, is given by

$$\ln\left(\frac{X_{n,t}^D}{X_{n,t}^*}\right) = (1-\epsilon)\ln\left(\frac{P_{n,t}^D}{P_{n,t}^*}\right) + \ln\frac{\Theta_{n,t}}{1-\Theta_{n,t}}, \quad (\text{C.10})$$

where  $X_{n,t}^D \equiv \sum_{r \in \mathcal{N}} X_{rn,t}$  and  $X_{n,t}^* \equiv \sum_{r \in \mathcal{N}^*} X_{rn,t}$ . Here again, since  $\epsilon \neq 1$ , we can no longer use the measure of  $\ln p_{r,t}$  derived in Section 5.2 to compute  $\ln P_{n,t}^D$ . Instead, we build an alternative measure of prices by combining (D.17), (D.23) and (D.24) under the assumption that  $\mu = \mu^* = 1$ . These equations imply that

$$\begin{aligned} \ln P_{n,t}^D &= \sum_{m \in \mathcal{N}_t} \theta_{mn,t} \left( \ln \varphi_{m,t} + \beta_{m,t} \ln w_{m,t} + (1-\beta_{m,t}) \ln P_{m,t}^M \right), \\ \ln P_{n,t}^M &= \ln P_{n,t}^D + \frac{1}{\epsilon-1} \ln \frac{X_{n,t}^D}{(1-\beta_{n,t})R_{n,t}} + \frac{1}{1-\epsilon} \ln \Theta_{n,t}. \end{aligned}$$

Substituting the second expression above into the first, we then get

$$\ln P_{n,t}^D = \sum_{r \in \mathcal{N}_t} \bar{b}_{rn,t} \left( \ln \varphi_{r,t} + \beta_{r,t} \ln w_{r,t} + \frac{1}{\epsilon-1} (1-\beta_{r,t}) \left( \ln \frac{X_{r,t}^D}{(1-\beta_{r,t})R_{r,t}} - \ln \Theta_{r,t} \right) \right),$$

where  $\bar{b}_{rn,t}$  are the elements of  $\bar{B}_t \equiv \theta_t \sum_{j=0}^{\infty} (\bar{x}_t)^j$  with  $\bar{x}_t = \{\theta_{mn,t}(1-\beta_{m,t})\}_{m,n \in \mathcal{N}_t}$  and  $\theta_t \equiv \{\theta_{mn,t}\}_{m,n \in \mathcal{N}_t}$ . Substituting this expression into (C.10), in turn, implies

$$\ln\left(\frac{X_{n,t}^D}{X_{n,t}^*}\right) + \sum_{r \in \mathcal{N}_t} \bar{b}_{rn,t} \left( (1-\beta_{r,t}) \ln \frac{X_{r,t}^D}{(1-\beta_{r,t})R_{r,t}} \right) = (1-\epsilon) \left[ \sum_{r \in \mathcal{N}_t} \bar{b}_{rn,t} \beta_{r,t} \ln w_{r,t} - \ln P_{n,t}^* \right] + \ln \hat{\Theta}_{n,t},$$

with  $\ln \hat{\Theta}_{n,t} \equiv \sum_{r \in \mathcal{N}_t} \bar{b}_{rn,t} ((1-\epsilon) \ln \varphi_{r,t} + (1-\beta_{r,t}) \ln \Theta_{r,t}) + \ln(\Theta_{n,t}/(1-\Theta_{n,t}))$ . Finally, by imposing that  $\ln \hat{\Theta}_{n,t} = \zeta' \text{Controls}_{n,t} + \zeta_n + \zeta_t + \epsilon_{n,t}$  and using the definition of  $\ln P_{n,t}^*$ , we obtain our empirical specification:

$$\ln \hat{X}_{n,t}^D = (1-\epsilon) \left[ \sum_{r \in \mathcal{N}_t} \bar{b}_{rn,t} \beta_{r,t} \ln w_{r,t} - \sum_{l \in \mathcal{N}_t^*} \frac{x_{ln,t}^*}{x_{n,t}^*} \ln p_{l,t}^* \right] + \zeta' \text{Controls}_{n,t} + \zeta_n + \zeta_t + \epsilon_{n,t}, \quad (\text{C.11})$$

where  $\ln \hat{X}_{n,t}^D \equiv \ln\left(\frac{X_{n,t}^D}{X_{n,t}^*}\right) + \sum_{r \in \mathcal{N}_t} \bar{b}_{rn,t} \left( (1-\beta_{r,t}) \ln \frac{X_{r,t}^D}{(1-\beta_{r,t})R_{r,t}} \right)$  and  $\ln w_{r,t}$  and  $\ln p_{l,t}^*$  are given by the same measures  $\ln w_{r,t}^D$  and  $\ln p_{l,t}^*$  used in Section 5.2. We estimate  $\epsilon$  from (C.11) with the same import price IV,  $\hat{P}_{n,t}^*$  in (32), and control set used in Section 5.2. The resulting estimate of  $\epsilon$  that we obtain is reported in column (4) of Table C.9



### C.9.2 Additional Preference Parameters

Next, we let the within-sector elasticity of substitution between firms,  $\sigma_k$ , vary across sectors, as described in equation (D.7). Equation (D.8) implies that domestic final demand for any firm  $n$  in sector  $k$  at time  $t$  is given by

$$\ln D_{n(k),t} = (1 - \sigma_k) \ln p_{n(k),t} + \zeta'_k \text{Controls}_{n(k),t} + \zeta_{k,t} + \zeta_{n(k)} + \epsilon_{n(k),t}, \quad (\text{C.12})$$

where the price  $p_{n(k),t}$  is measured using equation (28) as before. This is the same expression as in our baseline, equation (29), but with separate coefficients for each sector (and hence estimation is separable by sector). We do so while continuing to use the same instruments as in Section 5.2.

Compared to the single value of  $\sigma$  used in our baseline analysis, we now allow for 4 groups of sectors, each with its own value of  $\sigma_k$ : “Tradables”, which consists of Agriculture, Fishing, Mining & Quarrying, and Manufacturing; “Construction and Real Estate”, which consists of Construction and Real Estate, Renting & Business Activities; “Other Services”, which consists of Hotels & Restaurants, Transport, Storage & Communications, Education, Health and Social Work, and Other Community, Social and Personal Service Activities; and Retail and Wholesale, which remains its own group, given its size.<sup>81</sup> Given this new grouping, our estimation proceeds as in (C.12), but with observations pooled within each broad sector group. The resulting estimates of  $\sigma_k$  are reported in columns (5)-(8) of Table C.9.

### C.9.3 Alternative Factor Definitions

Finally, we consider alternative factor definitions. Our baseline analysis groups workers into three education levels (high school not completed, high school completed but no college diploma, and college diploma and higher) interacted with the individual’s province, and allows for two types of capital (that in the Oil and non-Oil sectors). Here we re-estimate the elasticity of substitution between factors  $\eta$  under three alternative factor group definitions. In each case, this proceeds as in our baseline estimation after first re-calculating factor expenditures and prices for the alternatively defined groups.

We begin by aggregating labor groups (within each province) such that there are only two education categories (college and no-college). Column (9) of Table C.9 reports our estimate of  $\eta$  in this case. As a second alternative to defining labor factors, we return to the case of three education groups but remove the province component. This estimate appears

---

<sup>81</sup>A small number of firms belong to other (minor) sectors, not listed here. In such cases we continue to use our baseline estimate of  $\sigma$ .

in column (10). Finally, column (11) reports the value of  $\eta$  that we obtain when all factors (labor types and capital) are specific to either the oil or the non-oil sector.

**Table C.9: Parameter Estimates for Sensitivity Analysis**

| Parameter                          | Technology  |                   |                 |                             | Preferences            |                                 |                             |                             | Factors                       |                     |                             |
|------------------------------------|-------------|-------------------|-----------------|-----------------------------|------------------------|---------------------------------|-----------------------------|-----------------------------|-------------------------------|---------------------|-----------------------------|
|                                    | (1)         | (2)               | (3)             | (4)                         | (5)                    | (6)                             | (7)                         | (8)                         | (9)                           | (10)                | (11)                        |
|                                    | $\eta_L$    | $\eta$            | $\mu$           | $\varepsilon$               | $\sigma_1$             | $\sigma_2$                      | $\sigma_3$                  | $\sigma_4$                  | $\eta$                        | $\eta$              | $\eta$                      |
| Elasticity of substitution between | Labor types | Labor vs. capital | Domestic inputs | Domestic vs. foreign inputs | Tradables sector firms | Retail & Wholesale sector firms | RE & Construc. sector firms | Other Services sector firms | College vs. non-college labor | Nation-wide factors | Oil sector-specific factors |
| Estimating equation                | (C.4)       | (C.5)             | (C.8)           | (C.10)                      | (C.12)                 | (C.12)                          | (C.12)                      | (C.12)                      | (24)                          | (24)                | (24)                        |
| Parameter estimate                 | 3.15        | 1.27              | 1.36            | 1.02                        | 2.08                   | 1.46                            | 2.21                        | 1.77                        | 1.96                          | 1.58                | 2.00                        |
| Standard error                     | (0.69)      | (0.95)            | (0.52)          | (0.27)                      | (0.97)                 | (0.54)                          | (2.17)                      | (0.68)                      | (0.39)                        | (0.66)              | (0.27)                      |
| First-stage F-statistic            | 4.7         | 128.8             | 11.8            | 103.4                       | 5.7                    | 16.8                            | 1.0                         | 3.3                         | 14.0                          | 12.1                | 5.1                         |
| No. of observations                | 462,486     | 44,695            | 1,527,590       | 17,878                      | 25,809                 | 83,335                          | 30,786                      | 39,312                      | 484,998                       | 617,155             | 627,913                     |
| No. of clusters                    | 73          | 6,385             | 33,648          | 2,554                       | 3,687                  | 11,905                          | 4,398                       | 5,616                       | 51                            | 42                  | 88                          |

*Notes:* Each column reports estimates from a separate 2SLS regression. Specification details concerning sample, weights, fixed effects, additional controls, instruments, and (with the exception of column 10) clustering, in columns (1) and (9)-(11) are as in columns (1)-(2) of Table 1 and those in columns (5)-(8) are as in columns (3)-(4) of Table 1. The following notes refer to other columns. Sample used is a balanced panel of incorporated firms with at least one employee and with: in column (2), capital and labor shares each above 10% of total factor spending; in column (3), transactions worth at least 1% of the buyer's purchases; and in column (4), omitting observations with  $X_{n,t}^D / X_{n,t}^*$  outside the top and bottom 1% of that variable. Regressions weighted by (winsorized at the 95th percentile in each case): in column (2), initial total factor payments; in column (3), initial buyer-seller transaction value; and in column (4), initial final sales. Fixed effects included are: in columns (2) and (4), firm and year; and in column (3), firm-year and supplier. Additional controls: in columns (3) and (4), year fixed effects interacted with firm cost shares at  $t_0$  spent on primary factors. Instruments used are: in column (2), equations (C.6) and (C.7); in column (3), equations (30), (31) and (32); and in column (4), equation (32). Standard errors are clustered: in columns (2) and (4), at the firm level; in column (3), at the supplier level; and in column (10), at the factor-year level.

## D Appendix: Counterfactuals

### D.1 Baseline Analysis

We begin by describing our procedure for calculating the counterfactual exercises reported in Section 7.1. This involves demonstrating identification of Ecuador's relative domestic factor demand system, and an algorithm that solves for the counterfactual equilibrium.

#### D.1.1 Identification of Relative Domestic Factor Demand

Since we lack data on good prices, it is convenient to define

$$\begin{aligned}\hat{\theta}_{nc,t} &\equiv \theta_{nc,t} p_{n,t}^{1-\sigma} / \sum_{r \in \mathcal{N}_k} \theta_{rc,t} p_{r,t}^{1-\sigma} \text{ for all } n \in \mathcal{N}_t, \\ \hat{\phi}_{n,t} &\equiv \phi_{n,t} [(\prod_{r \in \mathcal{N}_t} (p_{r,t})^{\theta_{rn,t}})^{\Theta_{n,t}}]^{1-\beta_{n,t}} / p_{n,t} \text{ for all } n \in \mathcal{N}_t, \\ \hat{p}_{n,t}(p^*, w) &\equiv \tilde{p}_{n,t}(p^*, w) / p_{n,t} \text{ for all } n \in \mathcal{N}_t, \\ \hat{P}_{k,t}(p^*, w) &\equiv (\sum_{n \in \mathcal{N}_k} \hat{\theta}_{nc,t} \hat{p}_{n,t}^{1-\sigma}(p^*, w))^{1/(1-\sigma)} \text{ for all } k \in \mathcal{K}.\end{aligned}$$

Starting from Proposition 2, we can then rearrange relative domestic factor demand as

$$RD_{f,t}(p^*, w) = \left(\frac{w_f}{w_0}\right)^{-\eta} \frac{\sum_{n \in \mathcal{N}_t} \theta_{fn,t} \tilde{w}_{n,t}^{\eta-1}(w) \beta_{n,t} [\sum_{k \in \mathcal{K}, r \in \mathcal{N}_{k,t}} b_{nr,t} \alpha_{k,t} \hat{\theta}_{rc,t} \hat{P}_{k,t}^{\sigma-1}(p^*, w) \hat{p}_{r,t}^{1-\sigma}(p^*, w)]}{\sum_{n \in \mathcal{N}_t} \theta_{0n,t} \tilde{w}_{n,t}^{\eta-1}(w) \beta_{n,t} [\sum_{k \in \mathcal{K}, r \in \mathcal{N}_{k,t}} b_{nr,t} \alpha_{k,t} \hat{\theta}_{rc,t} \hat{P}_{k,t}^{\sigma-1}(p^*, w) \hat{p}_{r,t}^{1-\sigma}(p^*, w)]} \quad (\text{D.1})$$

with the normalized domestic prices equal to

$$\hat{p}_{n,t}(p^*, w) = \exp\left\{ \sum_{r \in \mathcal{N}} b_{rn,t} [\ln \hat{\phi}_{r,t} + \beta_{r,t} \ln \tilde{w}_{r,t}(w) + \sum_{l \in \mathcal{N}^*} (1 - \beta_{r,t})(1 - \Theta_{r,t}) \theta_{lr,t}^* \ln p_l^*] \right\} \text{ for all } n \in \mathcal{N}_t. \quad (\text{D.2})$$

In Section 4.1, we have already discussed how to measure domestic consumer expenditure shares across sectors, in order to identify  $\alpha_{k,t} = \sum_{r \in \mathcal{N}_{k,t}} D_{r,t} / \sum_{r \in \mathcal{N}_t} D_{r,t}$ , as well as how to measure the share of each firm  $n$ 's costs attributable to primary factors, in order to identify  $\beta_{n,t} = \sum_{f \in \mathcal{F}} x_{fn,t}$ . We have also discussed how to measure the (exogenous) domestic input output matrix  $M_t \equiv \{x_{nr,t}\}$ , which identifies the coefficients  $b_{nr,t}$  of the Leontief inverse  $B_t = \sum_{j=0}^{\infty} M_t^j$ , as well as the (exogenous) import shares, which identifies  $(1 - \beta_{r,t})(1 - \Theta_{r,t}) \theta_{lr,t}^* = x_{lr,t}^*$ . In Section 5, we have also shown how to identify  $\eta$  and  $\sigma$  using instrumental variables. To show that  $RD_{f,t}(\cdot, \cdot)$  is identified for all  $f \in \mathcal{F}$ , it remains to show that: (i)  $\hat{\theta}_{nc,t}$  is identified for all  $n \in \mathcal{N}_t$ , so that  $\hat{P}_{k,t}(\cdot)$  is identified for all  $k \in \mathcal{K}$ ; (ii)

$\theta_{fn,t}$  is identified for all  $f \in \mathcal{F}$  and  $n \in \mathcal{N}_t$ , so that  $\tilde{w}_{n,t}(\cdot)$  is identified for all  $n \in \mathcal{N}_t$ ; and (iii)  $\hat{\phi}_{n,t}$  is identified for all  $n \in \mathcal{N}_t$ , so that  $\hat{p}_{n,t}(\cdot, \cdot)$  is identified for all  $n \in \mathcal{N}_t$

Equation (13) implies

$$\hat{\theta}_{nc,t} = \frac{D_{n,t}}{\sum_{r \in \mathcal{N}_{k,t}} D_{r,t}} \text{ for all } k \in \mathcal{K} \text{ and } n \in \mathcal{N}_{k,t}.$$

Equation (17) implies

$$\theta_{fn,t} = \frac{x_{fn,t}}{\sum_{g \in \mathcal{F}} x_{gn,t} (w_{g,t}/w_{f,t})^{1-\eta}} \text{ for all } f \in \mathcal{F} \text{ and } n \in \mathcal{N}_t.$$

Finally, since  $\hat{p}_{r,t}(p_t^*, w_t) = 1$ , equation (D.2) implies

$$\hat{\phi}_{n,t} = [\tilde{w}_{n,t}(w_t)]^{-\beta_{n,t}} \left[ \prod_{r \in \mathcal{N}_t^*} (p_{r,t}^*)^{\theta_{rn,t}} \right]^{(\beta_{n,t}-1)(1-\Theta_{n,t})} \text{ for all } n \in \mathcal{N}_t.$$

Thus, conditions (i)-(iii) hold and  $RD_{f,t}(\cdot, \cdot)$  is identified for all  $f \in \mathcal{F}$ .

### D.1.2 Construction of the Counterfactual Autarkic Equilibrium

We first characterize the set of domestic firms,  $\mathcal{N}_{k,t}^A$ , with strictly positive output and finite prices in sector  $k \in \mathcal{K}$  in the counterfactual autarkic equilibrium at date  $t$ . Since foreign good prices  $p^* \rightarrow \infty$  under autarky, equation (D.2) implies  $\mathcal{N}_{k,t}^A = \{n \in \mathcal{N}_{k,t}, \bar{x}_{n,t}^* = 0\}$ .<sup>82</sup> Likewise, we let  $\mathcal{N}_t^A \equiv \cup_{k \in \mathcal{K}} \mathcal{N}_{k,t}^A$  denote the set of all active firms under autarky.

Starting from equations (D.1) and (D.2) and taking a limit as  $p^* \rightarrow \infty$ , we can express relative domestic factor demand under autarky as

$$RD_{f,t}^A(w) = \left( \frac{w_f}{w_0} \right)^{-\eta} \frac{\sum_{n \in \mathcal{N}_t^A} \theta_{fn,t} \tilde{w}_{n,t}^{\eta-1}(w) \beta_{n,t} [\sum_{k \in \mathcal{K}, r \in \mathcal{N}_{k,t}^A} b_{nr,t} \alpha_{k,t} \hat{\theta}_{rc,t} (P_{k,t}^A(w))^{\sigma-1} (p_r^A(w))^{1-\sigma}]}{\sum_{n \in \mathcal{N}_t^A} \theta_{0n,t} \tilde{w}_{n,t}^{\eta-1}(w) \beta_{n,t} [\sum_{k \in \mathcal{K}, r \in \mathcal{N}_{k,t}^A} b_{nr,t} \alpha_{k,t} \hat{\theta}_{rc,t} (P_{k,t}^A(w))^{\sigma-1} (p_r^A(w))^{1-\sigma}]} \quad (\text{D.3})$$

<sup>82</sup>For computational reasons, we approximate the set of active firms in autarky by  $\mathcal{N}_{k,t}^A \equiv \{n \in \mathcal{N}_{k,t}, \bar{x}_{n,t}^* < tol^A\}$ , with  $tol^A = 0.001$ . We also assume that  $\mathcal{N}_t^A$  includes the consolidated financial and public firms as well as the residual firm (for which  $\bar{x}_{n,t}^*$  no longer reflects the import share of an individual firm).

where the equilibrium domestic prices under autarky are such that

$$P_{k,t}^A(w) = \left[ \sum_{n \in \mathcal{N}_{k,t}^A} \hat{\theta}_{nc,t} (p_r^A(w))^{1-\sigma} \right]^{\frac{1}{1-\sigma}} \quad (\text{D.4})$$

$$p_{n,t}^A(w) = \exp \sum_{r \in \mathcal{N}_t^A} b_{rn,t} [\ln \hat{\phi}_{r,t} + \beta_{r,t} \ln \tilde{w}_{r,t}(w)]. \quad (\text{D.5})$$

Next, for a given value of the vector of domestic factor prices,  $w$ , we define the excess demand function for each factor  $f \neq 0$  such that

$$H_f(w) \equiv 1 - RD_{f,t}^A(w) / RS_{f,t} \text{ for all } f \neq 0,$$

where  $RS_{f,t} \equiv \bar{L}_{f,t} / \bar{L}_{0,t}$  is relative factor supply at date  $t$ , which we measure as  $\sum_{n \in \mathcal{N}} X_{fn,t} / \sum_{n \in \mathcal{N}} X_{0n,t}$  for all  $f \neq 0$ .<sup>83</sup> By construction, the vector  $w_t^A$  is an equilibrium vector of factor prices under autarky if  $H_f(w_t^A) = 0$  for all  $f \neq 0$ .

Finally, to solve for  $w_t^A$ , we use the following algorithm:

- i. Consider an initial guess  $w^{(0)} = 1$ ;
- ii. For each step  $j$ , compute  $H^{(j)} = \{H_f(w^{(j)})\}_{f \neq 0}$ ;
  - (a) If  $|H^{(j)}| < tol$ , set  $w_t^A = w^{(j)}$ ;
  - (b) Otherwise, compute  $w_f^{(j+1)} = w_f^{(j)} (1 - \kappa H_f^{(j)})$  for all  $f \neq 0$  and proceed to step  $j+1$ .

### D.1.3 Individual Earnings

Consider an individual  $i$  with factor endowments  $\bar{l}_i \equiv \{\bar{l}_{fi}\}_{f \in \mathcal{F}}$ . In the initial equilibrium, individual  $i$ 's earnings are given by  $Y_{i,t} = \sum_{f \in \mathcal{F}} \bar{l}_{fi} w_{f,t}$ . In the counterfactual autarkic equilibrium, they are given by  $(Y_{i,t})_A = \sum_{f \in \mathcal{F}} \bar{l}_{fi} (w_{f,t})_A$ . We therefore have

$$\frac{(\Delta Y_{i,t})_{trade}}{Y_{i,t}} = 1 - \frac{(Y_{i,t})_A}{Y_{i,t}} = 1 - \sum_f \frac{Y_{fi,t}}{Y_{i,t}} \frac{(w_{f,t})_A}{w_{f,t}} = 1 - \sum_f \omega_{fi,t} \exp(-(\Delta \ln w_{f,t})_{trade}),$$

with  $\omega_{fi,t} \equiv Y_{fi,t} / Y_{i,t}$ .

<sup>83</sup>This is equivalent to setting units of account for each factor so that  $w_{f,t} = 1$  in the initial trade equilibrium. It should be clear that this particular choice of units of account, imposed both under trade and autarky, has no impact on the values of  $(\Delta \ln w_t)_{trade} = \{\ln w_{f,t} - \ln (w_{f,t})_A\}_{f \in \mathcal{F}}$ .

Let  $(\Delta Y_{i,t})_{exports} = Y_{i,t} - (Y_{i,t})_{NE}$  and  $(\Delta Y_{i,t})_{imports} = (Y_{i,t})_{NE} - (Y_{i,t})_A$  where  $(Y_{i,t})_{NE}$  are the counterfactual earnings associated with the counterfactual equilibrium without differences in relative export exposure, ( $w^* = w_t^*, REE = 1$ ). Similarly, we have

$$\frac{(\Delta Y_{i,t})_{exports}}{Y_{i,t}} = 1 - \frac{(Y_{i,t})_{NE}}{Y_{i,t}} = 1 - \sum_f \frac{Y_{fi,t}}{Y_{i,t}} \frac{(w_{f,t})_{NE}}{w_{f,t}} = 1 - \sum_f \omega_{fi,t} \exp(-(\Delta \ln w_{f,t})_{exports}),$$

$$\frac{(\Delta Y_{i,t})_{imports}}{Y_{i,t}} = \frac{(Y_{i,t})_{NE}}{Y_{i,t}} - \frac{(Y_{i,t})_A}{Y_{i,t}} = [1 - \sum_f \omega_{fi,t} \exp(-(\Delta \ln w_{f,t})_{imports})] \exp(-(\Delta \ln w_{f,t})_{exports}).$$

## D.2 Sensitivity Analysis

We now provide the details behind the counterfactual simulations reported in Section 7.3. We first outline a generalized model that nests all cases in Section 7.3, show that the relative domestic factor demand system remains identified in this more general setting, and describe a procedure for calculating the equilibrium in this model. We then describe how we remove retailers from and add informal firms to our analysis. We conclude by reporting our counterfactuals results for labor income only.

### D.2.1 General Model

**Preferences.** All consumers have the same nested CES utility functions as before,

$$u_i = \prod_{k \in \mathcal{K}} (u_{i,k})^{\alpha_k}, \quad (\text{D.6})$$

$$u_{i,k} = \left( \sum_{n \in \mathcal{N}_k} \theta_{nc}^{\frac{1}{\sigma_k}} q_{i,n}^{\frac{\sigma_k-1}{\sigma_k}} \right)^{\frac{\sigma_k}{\sigma_k-1}}, \quad (\text{D.7})$$

but where the elasticity of substitution  $\sigma_k$  may now vary across sectors. In turn, total domestic expenditure is equal to

$$D_n(p, w) = \frac{\alpha_k \theta_{nc} p_n^{1-\sigma_k} (w \cdot \bar{L})}{\sum_{r \in \mathcal{N}_k} \theta_{rc} p_r^{1-\sigma_k}}, \text{ for all } n \in \mathcal{N}_k \text{ and } k \in \mathcal{K}. \quad (\text{D.8})$$

**Technology.** All domestic firms have nested CES production functions,

$$y_n = \varphi_n (\bar{l}_n)^{\beta_n} (\bar{m}_n)^{1-\beta_n}, \quad (\text{D.9})$$

$$\bar{m}_n = [(\Theta_n)^{\frac{1}{\epsilon}} (m_n^d)^{\frac{\epsilon-1}{\epsilon}} + (1-\Theta_n)^{\frac{1}{\epsilon}} (m_n^*)^{\frac{\epsilon-1}{\epsilon}}]^{\frac{\epsilon}{\epsilon-1}}, \quad (\text{D.10})$$

$$m_n^D = \left[ \sum_{r \in \mathcal{N}} (\theta_{rn})^{\frac{1}{\mu}} (m_{rn})^{\frac{\mu-1}{\mu}} \right]^{\frac{\mu}{\mu-1}}, \quad (\text{D.11})$$

$$m_n^* = \left[ \sum_{r \in \mathcal{N}^*} (\theta_{rn}^*)^{\frac{1}{\mu^*}} (m_{rn}^*)^{\frac{\mu^*-1}{\mu^*}} \right]^{\frac{\mu^*}{\mu^*-1}}, \quad (\text{D.12})$$

$$\bar{l}_n = [(\Theta_{Ln})^{\frac{1}{\eta}} (l_{Ln})^{\frac{\eta-1}{\eta}} + (\Theta_{Kn})^{\frac{1}{\eta}} (l_{Kn})^{\frac{\eta-1}{\eta}}]^{\frac{\eta}{\eta-1}}, \quad (\text{D.13})$$

$$l_{Ln} = \left[ \sum_{f \in \mathcal{F}_L} (\theta_{fn})^{\frac{1}{\eta_L}} (l_{fn})^{\frac{\eta_L-1}{\eta_L}} \right]^{\frac{\eta_L}{\eta_L-1}}, \quad (\text{D.14})$$

$$l_{Kn} = \left[ \sum_{f \in \mathcal{F}_K} (\theta_{fn})^{\frac{1}{\eta_K}} (l_{fn})^{\frac{\eta_K-1}{\eta_K}} \right]^{\frac{\eta_K}{\eta_K-1}}, \quad (\text{D.15})$$

where  $\varphi_n, \beta_n, \Theta_n, \Theta_{Ln}, \Theta_{Kn}, \theta_{rn}, \theta_{rn}^*, \theta_{fn} \geq 0$  are exogenous technology parameters, with  $\beta_n \in [0, 1]$ ,  $\Theta_n \in [0, 1]$ ,  $\sum_{r \in \mathcal{N}} \theta_{rn} = \sum_{r \in \mathcal{N}^*} \theta_{rn}^* = 1$ ,  $\sum_{f \in \mathcal{F}_L} \theta_{fn} = \sum_{f \in \mathcal{F}_K} \theta_{fn} = 1$  and  $\sum_{F=L,K} \Theta_{Fn} = 1$ ;  $\epsilon > 0$  is the elasticity of substitution between domestic and foreign intermediates;  $\mu > 0$  is the elasticity of substitution among domestic intermediates;  $\mu^* > 0$  is the elasticity of substitution among foreign intermediates;  $\eta > 0$  is the elasticity of substitution between capital and labor;  $\eta_L > 0$  is the elasticity of substitution among labor groups; and  $\eta_K > 0$  is the elasticity of substitution between types of capital.<sup>84</sup> Thus, shares of costs spent on domestic factors, domestic intermediates, and foreign intermediates are equal to

$$x_{fn}(p, p^*, w) = \beta_n \Theta_{Fn} \theta_{fn} \left( \frac{w_f}{\tilde{w}_n^F(w)} \right)^{1-\eta_F} \left( \frac{\tilde{w}_n^F(w)}{\tilde{w}_n(w)} \right)^{1-\eta}, \quad \text{for } f \in \mathcal{F}_F, n \in \mathcal{N}, \quad (\text{D.16})$$

$$x_{rn}(p, p^*, w) = (1-\beta_n) \Theta_n \theta_{rn} \left( \frac{p_r}{\tilde{p}_n^D(p)} \right)^{1-\mu} \left( \frac{\tilde{p}_n^D(p)}{\tilde{p}_n^M(p, p^*)} \right)^{1-\epsilon}, \quad \text{for } r \in \mathcal{N}, n \in \mathcal{N}, \quad (\text{D.17})$$

$$x_{rn}^*(p, p^*, w) = (1-\beta_n)(1-\Theta_n) \theta_{rn}^* \left( \frac{p_r^*}{\tilde{p}_n^*(p^*)} \right)^{1-\mu^*} \left( \frac{\tilde{p}_n^*(p^*)}{\tilde{p}_n^M(p, p^*)} \right)^{1-\epsilon}, \quad \text{for } r \in \mathcal{N}^*, n \in \mathcal{N}, \quad (\text{D.18})$$

<sup>84</sup>In our empirical analysis, all firms only use one type of capital. So the value of elasticity of substitution  $\eta_K$  is irrelevant for any of our counterfactual results. We only introduce this parameter for notational convenience when describing factor cost shares and factor price indices below.

with the CES price indices given by

$$\tilde{w}_n^F(w) \equiv \left( \sum_{g \in \mathcal{F}_F} \theta_{gn} w_g^{1-\eta_F} \right)^{\frac{1}{1-\eta_F}}, \text{ for all } F = L, K \text{ and } n \in \mathcal{N}, \quad (\text{D.19})$$

$$\tilde{w}_n(w) \equiv [\Theta_{Ln}(\tilde{w}_n^L(w))^{1-\eta} + \Theta_{Kn}(\tilde{w}_n^K(w))^{1-\eta}]^{\frac{1}{1-\eta}}, \text{ for all } n \in \mathcal{N}, \quad (\text{D.20})$$

$$\tilde{P}_n^D(p) \equiv \left( \sum_{r \in \mathcal{N}} \theta_{rn} p_r^{1-\mu} \right)^{\frac{1}{1-\mu}}, \text{ for all } n \in \mathcal{N}, \quad (\text{D.21})$$

$$\tilde{P}_n^*(p^*) \equiv \left[ \sum_{r \in \mathcal{N}^*} \theta_{rn}^* (p_r^*)^{1-\mu^*} \right]^{\frac{1}{1-\mu^*}}, \text{ for all } n \in \mathcal{N}, \quad (\text{D.22})$$

$$\tilde{P}_n^M(p, p^*) \equiv [\Theta_n(\tilde{P}_n^D(p))^{1-\epsilon} + (1-\Theta_n)(\tilde{P}_n^*(p^*))^{1-\epsilon}]^{\frac{1}{1-\epsilon}}, \text{ for all } n \in \mathcal{N}. \quad (\text{D.23})$$

Finally, unit costs are equal to

$$c_n(p, p^*, w) = \phi_n [\tilde{w}_n(w)]^{\beta_n} [\tilde{P}_n^M(p, p^*)]^{1-\beta_n}, \text{ for all } n \in \mathcal{N}, \quad (\text{D.24})$$

with  $\phi_n \equiv \varphi_n^{-1} (\beta_n)^{-\beta_n} (1-\beta_n)^{-(1-\beta_n)}$ .

**Domestic relative factor demand.** As before, let  $\tilde{p}(p^*, w)$  denote the unique solution to the system of zero-profit conditions,

$$p_n = c_n(p, p^*, w) \text{ for all } n \in \mathcal{N}.$$

Combining the definition of domestic factor demand in equation (5) with the vector of domestic expenditure associated with (D.8), the matrix of factor shares,  $A(p, p^*, w)$ , associated with (D.16), and the Leontief inverse,  $B(p, p^*, w)$ , associated with (D.17), we obtain

$$RD_f(p^*, w) = \frac{w_f^{-\eta_{F(f)}} \sum_{n \in \mathcal{N}} \theta_{fn} \Theta_{F(f)n} (\tilde{w}_n^{F(f)}(w))^{\eta_{F(f)} - \eta} Z_n(p^*, w)}{w_0^{-\eta_{F(0)}} \sum_{n \in \mathcal{N}} \theta_{0n} \Theta_{F(0)n} (\tilde{w}_n^{F(0)}(w))^{\eta_{F(0)} - \eta} Z_n(p^*, w)}, \quad (\text{D.25})$$

where  $F(f)$  denotes the factor group that  $f$  belongs to, i.e.  $F(f) = L$  if  $f \in \mathcal{F}_L$  and  $F(f) = K$  if  $f \in \mathcal{F}_K$ , and  $Z_n(p^*, w)$  is given by

$$Z_n(p^*, w) \equiv \sum_{k \in \mathcal{K}, r \in \mathcal{N}_k} \alpha_k \theta_{rc} \beta_n \tilde{b}_{nr}(p^*, w) \tilde{w}_n^{\eta-1}(w) \tilde{P}_k^{\sigma_k-1}(p^*, w) \tilde{p}_r^{1-\sigma_k}(p^*, w),$$

with  $\tilde{b}_{nr}(p^*, w) \equiv b_{nr}(\tilde{p}(p^*, w), p^*, w)$  the coefficient of the Leontief inverse, expressed as a function of  $p^*$  and  $w$ .



## D.2.2 Identification of Relative Domestic Factor Demand

Like in Appendix D.1.1, given the lack of data on domestic good prices, it is convenient to define

$$\begin{aligned}
\hat{\theta}_{nc,t} &\equiv \theta_{nc,t} p_{n,t}^{1-\sigma_k} / \sum_{r \in \mathcal{N}_{k,t}} \theta_{rc,t} p_{r,t}^{1-\sigma_k} \text{ for all } n \in \mathcal{N}_{k,t} \text{ and } k \in \mathcal{K}, \\
\hat{\theta}_{rn,t} &\equiv \theta_{rn,t} p_{r,t}^{1-\mu} / \sum_{l \in \mathcal{N}} \theta_{ln,t} p_{l,t}^{1-\mu} \text{ for all } r \in \mathcal{N}_t \text{ and } n \in \mathcal{N}_t, \\
\hat{\Theta}_{n,t} &\equiv \Theta_n (P_{n,t}^D)^{1-\epsilon} / (P_{n,t}^M)^{1-\epsilon}, \text{ for all } n \in \mathcal{N}_t, \\
\hat{\phi}_{n,t} &\equiv \phi_{n,t} [P_{n,t}^M]^{1-\beta_{n,t}} / p_{n,t}, \text{ for all } n \in \mathcal{N}_t, \\
\hat{p}_{n,t}(p^*, w) &\equiv \tilde{p}_{n,t}(p^*, w) / p_{n,t}, \text{ for all } n \in \mathcal{N}_t, \\
\hat{P}_{k,t}(p^*, w) &\equiv \left( \sum_{n \in \mathcal{N}_k} \hat{\theta}_{nc,t} \hat{p}_{n,t}^{1-\sigma_k}(p^*, w) \right)^{\frac{1}{1-\sigma_k}} \text{ for all } k \in \mathcal{K}, \\
\hat{P}_{n,t}^D(p^*, w) &\equiv \left( \sum_{r \in \mathcal{N}} \hat{\theta}_{rn} \hat{p}_r^{1-\mu}(p^*, w) \right)^{\frac{1}{1-\mu}}, \text{ for all } n \in \mathcal{N}_t, \\
\hat{P}_{n,t}^M(p^*, w) &\equiv [\hat{\Theta}_{n,t} (\hat{P}_{n,t}^D(p^*, w))^{1-\epsilon} + (1 - \hat{\Theta}_{n,t}) (\tilde{P}_n^*(p^*) / P_{n,t}^*)^{1-\epsilon}]^{\frac{1}{1-\epsilon}}, \text{ for all } n \in \mathcal{N}_t,
\end{aligned}$$

where  $P_{n,t}^D \equiv \tilde{P}_{n,t}^D(p_t)$ ,  $P_{n,t}^* \equiv \tilde{P}_{n,t}^*(p_t^*)$ , and  $P_{n,t}^M \equiv \tilde{P}_{n,t}^M(p_t, p_t^*)$  are the values of the firm-level price indices at date  $t$ 's equilibrium.

Starting from equation (D.25), we can rearrange relative domestic factor demand as

$$RD_{f,t}(p^*, w) = \frac{\omega_f^{-\eta_{F(f),t}} \sum_{n \in \mathcal{N}_t} \theta_{fn,t} \Theta_{F(f)n,t} (\tilde{w}_{n,t}^{F(f)}(w))^{\eta_{F(f),t} - \eta_t} \hat{Z}_{n,t}(p^*, w)}{\omega_0^{-\eta_{F(0),t}} \sum_{n \in \mathcal{N}_t} \theta_{0n,t} \Theta_{F(0)n,t} (\tilde{w}_{n,t}^{F(0)}(w))^{\eta_{F(0),t} - \eta_t} \hat{Z}_{n,t}(p^*, w)}, \quad (\text{D.26})$$

with

$$\hat{Z}_n(p^*, w) \equiv \sum_{k \in \mathcal{K}, r \in \mathcal{N}_k} \alpha_k \hat{\theta}_{rc} \beta_n \hat{b}_{nr}(p^*, w) \tilde{w}_n^{\eta-1}(w) \hat{P}_k^{\sigma_k-1}(p^*, w) \hat{p}_r^{1-\sigma_k}(p^*, w). \quad (\text{D.27})$$

In this expression, the normalized domestic prices,  $\hat{p}_{n,t}(p^*, w)$ , are given by the solution to

$$p_n = \hat{\phi}_{n,t} [\tilde{w}_{n,t}(w)]^{\beta_{n,t}} [\hat{P}_{n,t}^M(p, \{p_r^* / p_{r,t}^*\})]^{1-\beta_{n,t}} \text{ for all } n \in \mathcal{N}_t, \quad (\text{D.28})$$

and the Leontief inverse  $\hat{B}(p^*, w) \equiv \{\hat{b}_{nr}(p^*, w)\}$  is equal to

$$\hat{B}(p^*, w) = \sum_{j=0}^{\infty} \hat{M}^j(p^*, w), \quad (\text{D.29})$$

with the domestic input-output matrix under autarky,  $\hat{M}(p^*, w) \equiv \{\hat{x}_{nr}(p^*, w)\}$ , such that

$$\hat{x}_{rn}(p^*, w) = (1 - \beta_n) \hat{\Theta}_n \hat{\theta}_{rn} \left( \frac{\hat{p}_r^{1-\sigma}(p^*, w)}{\hat{P}_n^D(p^*, w)} \right)^{1-\mu} \left( \frac{\hat{P}_n^D(p^*, w)}{\hat{P}_{n,t}^M(p^*, w)} \right)^{1-\epsilon}, \text{ for all } r \in \mathcal{N}_t \text{ and } n \in \mathcal{N}_t. \quad (\text{D.30})$$

The preference parameters  $\alpha_{k,t}$  and the technology parameters  $\beta_{n,t}$  are identified in the same way as in Appendix D.1.1. The elasticities  $\{\eta_F\}$ ,  $\eta$ ,  $\epsilon$ ,  $\mu$ ,  $\mu^*$ , and  $\{\sigma_k\}$  can be identified using the same general estimation strategy as in Section 5, as further discussed in Appendix C.9. To show that  $RD_{f,t}(\cdot, \cdot)$  is identified for all  $f \in \mathcal{F}$ , it remains to show that: (i)  $\hat{\theta}_{nc,t}$  is identified for all  $n \in \mathcal{N}_t$ , so that  $\hat{P}_{k,t}(\cdot)$  is identified for all  $k \in \mathcal{K}$ ; (ii)  $\theta_{fn,t}$  and  $\Theta_{F(f),t}$  are identified for all  $F = L, K$ ,  $f \in \mathcal{F}_F$  and  $n \in \mathcal{N}_t$ , so that  $\tilde{w}_n^F(\cdot)$  and  $\tilde{w}_{n,t}(\cdot)$  is identified for all  $F = L, K$  and  $n \in \mathcal{N}_t$ ; (iii)  $\hat{\theta}_{rn,t}$  and  $\hat{\Theta}_{n,t}$  are identified for all  $r \in \mathcal{N}_t$  and  $n \in \mathcal{N}_t$ , so that  $\hat{P}_{n,t}^D(\cdot, \cdot)$  and  $\hat{P}_{n,t}^M(\cdot, \cdot)$  are identified; (iv)  $\theta_{rn,t}^*$  is identified for all  $r \in \mathcal{N}_t^*$  and  $n \in \mathcal{N}_t$ , so that  $\tilde{P}_n^*(\cdot)$  is identified; (iv) ; and (v)  $\hat{\phi}_{n,t}$  is identified for all  $n \in \mathcal{N}_t$ , so that  $\hat{p}_{n,t}(\cdot, \cdot)$  and, in turn,  $\hat{x}_{nr}(\cdot, \cdot)$  and  $\hat{b}_{nr}(w)$  are identified for all  $n \in \mathcal{N}_t$  and  $r \in \mathcal{N}_t$ .

Equation (D.8) implies

$$\hat{\theta}_{nc,t} = \frac{D_{n,t}}{\sum_{r \in \mathcal{N}_{k,t}} D_{r,t}} \text{ for all } k \in \mathcal{K} \text{ and } n \in \mathcal{N}_{k,t}.$$

Equation (D.16) implies

$$\theta_{fn,t} = \frac{x_{fn,t} w_{f,t}^{\eta_F - 1}}{\sum_{g \in \mathcal{F}_F} x_{gn,t} w_{g,t}^{\eta_F - 1}} \text{ for all } F = L, K, f \in \mathcal{F}_F \text{ and } n \in \mathcal{N}_t,$$

$$\Theta_{Fn,t} = \frac{(\sum_{g \in \mathcal{F}_F} x_{gn,t}) (\sum_{f \in \mathcal{F}_F} x_{fn,t} w_{f,t}^{\eta_F - 1})^{\frac{\eta-1}{\eta_F - 1}}}{\sum_{G=L,K} (\sum_{g \in \mathcal{F}_G} x_{gn,t}) (\sum_{f \in \mathcal{F}_G} x_{fn,t} w_{f,t}^{\eta_F - 1})^{\frac{\eta-1}{\eta_F - 1}}} \text{ for } F = L, K \text{ and } n \in \mathcal{N}_t.$$

Equation (D.17) implies

$$\hat{\theta}_{rn,t} = \frac{x_{rn,t}}{\sum_{l \in \mathcal{N}_t} x_{ln,t}} \text{ for all } r \in \mathcal{N}_t \text{ and } n \in \mathcal{N}_t,$$

$$\hat{\Theta}_{n,t} = \frac{\sum_{r \in \mathcal{N}_t} x_{rn,t}}{1 - \beta_{n,t}} \text{ for all } n \in \mathcal{N}_t.$$

Equation (D.18) implies

$$\theta_{rn,t}^* = \frac{x_{rn,t}^* (p_{r,t}^*)^{\mu^* - 1}}{\sum_{l \in \mathcal{N}_t^*} x_{ln,t}^* (p_{l,t}^*)^{\mu^* - 1}} \text{ for all } r \in \mathcal{N}_t^* \text{ and } n \in \mathcal{N}_t;$$

Finally, since  $\hat{p}_{r,t}(p_t^*, w_t) = 1$ , equation (D.2) implies

$$\hat{\phi}_{n,t} = [\tilde{w}_{n,t}(w_t)]^{-\beta_{n,t}} \text{ for all } n \in \mathcal{N}_t.$$

Thus, conditions (i)-(v) hold and  $RD_{f,t}(\cdot, \cdot)$  is identified for all  $f \in \mathcal{F}$ .

### D.2.3 Construction of the Counterfactual Autarkic Equilibrium

We first describe the set of domestic firms,  $\mathcal{N}_{k,t}^A$ , with strictly positive output and finite prices in sector  $k \in \mathcal{K}$  in the counterfactual autarkic equilibrium at date  $t$ . There are three separate cases.

**Case 1:  $\epsilon > 1$  and  $\mu > 1$ .** In this case, we have the same set of active firms in the autarkic and trade equilibria,  $\mathcal{N}_{k,t}^A = \mathcal{N}_{k,t}$ .

**Case 2:  $\epsilon \leq 1$  and  $\mu > 1$ .** In this case, direct importers are no longer active in the autarkic equilibrium,  $\mathcal{N}_{k,t}^A = \{n \in \mathcal{N}_{k,t}, x_{n,t}^* = 0\}$ .

**Case 3:  $\epsilon \leq 1$  and  $\mu \leq 1$ .** In this case, both direct and indirect importers are no longer active in the autarkic equilibrium,  $\mathcal{N}_{k,t}^A \equiv \{n \in \mathcal{N}_{k,t}, \bar{x}_{n,t}^* = 0\}$ . As before, we let  $\mathcal{N}_t^A \equiv \cup_{k \in \mathcal{K}} \mathcal{N}_{k,t}^A$  denote the set of all active firms in the autarkic equilibrium.<sup>85</sup>

Starting from (D.31)-(D.30) and taking a limit as  $p^* \rightarrow \infty$ , we can then express relative domestic factor demand under autarky for the three previous cases as

$$RD_f^A(w) = \frac{w_f^{-\eta_{F(f)}} \sum_{n \in \mathcal{N}_t^A} \theta_{fn} \Theta_{F(f)n} (\tilde{w}_n^{F(f)}(w))^{\eta_{F(f)} - \eta} Z_n^A(w)}{w_0^{-\eta_{F(0)}} \sum_{n \in \mathcal{N}_t^A} \theta_{0n} \Theta_{F(0)n} (\tilde{w}_n^{F(0)}(w))^{\eta_{F(0)} - \eta} Z_n^A(w)}, \text{ for all } f \neq 0, \quad (\text{D.31})$$

with

$$Z_n^A(w) = \sum_{k \in \mathcal{K}, r \in \mathcal{N}_{k,t}^A} \alpha_k \theta_{rc} \beta_n b_{nr}^A(w) \tilde{w}_n^{\eta-1}(w) (P_k^A(w))^{\sigma-1} (p_r^A(w))^{1-\sigma}, \text{ for all } n \in \mathcal{N}_t^A,$$

---

<sup>85</sup>We implement the construction of this set in the same way described in footnote 82.

where the domestic autarky prices,  $\{p_{n,t}^A(w)\}$ , are equal to the unique solution to

$$\begin{aligned} p_n &= \lim_{p^* \rightarrow \infty} \hat{\phi}_{n,t} [\tilde{w}_{n,t}(w)]^{\beta_{n,t}} [\hat{P}_{n,t}^M(p, \{p_r^*/p_{r,t}^*\})]^{1-\beta_{n,t}} \\ &= \hat{\phi}_{n,t} \hat{\Theta}_{n,t}^{\frac{1-\beta_{n,t}}{1-\epsilon}} [\tilde{w}_n(w)]^{\beta_{n,t}} \left[ \sum_{r \in \mathcal{N}_t^A} \hat{\theta}_{rn,t} p_{r,t}^{1-\mu} \right]^{\frac{1-\beta_{n,t}}{1-\mu}} \text{ for all } n \in \mathcal{N}_t^A; \end{aligned}$$

the sector-level price index,  $P_k^A(w)$ , is equal to

$$P_k^A(w) = \left[ \sum_{n \in \mathcal{N}_{k,t}^A} \hat{\theta}_{nc,t} (p_{n,t}^A(w))^{1-\sigma_k} \right]^{\frac{1}{1-\sigma_k}} \text{ for all } k \in \mathcal{K};$$

and the Leontief inverse under autarky,  $B^A(w) \equiv \{b_{nr}^A(w)\}$ , is equal to

$$B^A(w) = \sum_{j=0}^{\infty} (M^A)^j(w),$$

with the domestic input-output matrix under autarky,  $M^A(w) \equiv \{x_{nr}^A(w)\}$ , such that

$$x_{nr}^A(w) = \lim_{p^* \rightarrow \infty} \hat{x}_{rn}(p^*, w) = \frac{(1-\beta_{r,t}) \hat{\theta}_{nr,t} (p_{n,t}^A(w))^{1-\mu}}{\sum_{m \in \mathcal{N}_t^A} \hat{\theta}_{mr,t} (p_{m,t}^A(w))^{1-\mu}}, \text{ for all } r \in \mathcal{N}_t^A \text{ and } n \in \mathcal{N}_t^A.$$

Given the previous characterization of  $RD_f^A(w)$ , we can solve for the vector of domestic factor prices under autarky  $w_t^A$  using the same algorithm as in Appendix D.1.2.

#### D.2.4 Counterfactual without Retailers

To replicate our counterfactual results without retailers, we construct an alternative dataset in which we reallocate the revenues and costs of retailers across non-retailing firms.

We start from a consolidated firm in the retail sector such that

$$\begin{aligned} D_{\text{retail}} &\equiv \sum_{n \in \mathcal{N}_{\text{retail}}} D_n, & E_{\text{retail}} &\equiv \sum_{n \in \mathcal{N}_{\text{retail}}} E_n, & X_{\text{retail}m} &\equiv \sum_{n \in \mathcal{N}_{\text{retail}}} X_{nm}, \\ X_{f\text{retail}} &\equiv \sum_{n \in \mathcal{N}_{\text{retail}}} X_{fn}, & X_{\text{retail}}^* &\equiv \sum_{n \in \mathcal{N}_{\text{retail}}} X_n^*, & X_{m\text{retail}} &\equiv \sum_{n \in \mathcal{N}_{\text{retail}}} X_{mn}. \end{aligned}$$

For any firm not in retail, we adjust final sales by the extent of their total sales to the retail sector,

$$(D_n)' = D_n + X_{n\text{retail}}.$$

We do not make any adjustment to the factor payments, exports, imports, and intermediate sales of firms not in retail and instead allocate those to the residual firm,

$$\begin{aligned}
(E_n)' &= E_n \text{ for all } n \notin \mathcal{N}_{\text{retail}}, \\
(X_n^*)' &= X_n^* \text{ for all } n \notin \mathcal{N}_{\text{retail}}, \\
(X_{fn})' &= X_{fn} \text{ for all } n \notin \mathcal{N}_{\text{retail}}, \\
(X_{nm})' &= X_{nm} \text{ for all } n \notin \mathcal{N}_{\text{retail}}, \\
(X_R^*)' &= X_R^* + X_{\text{retail}}^*, \\
(E_R^*)' &= E_R^* + E_{\text{retail}}^*, \\
(X_{fR})' &= X_{fR} + X_{f\text{retail}}, \\
(X_{Rm})' &= X_{Rm} + X_{\text{retail}m} \text{ for all } m \in \mathcal{N}.
\end{aligned}$$

Finally, we compute capital payments in this alternative dataset by subtracting costs from revenues,

$$(X_{Kn})' = \left[ (D_n)' + (E_n)' + \sum_{m \notin \mathcal{N}_{\text{retail}}} X_{nm} \right] - \left[ (X_n^*)' + \sum_{f \in \mathcal{F}_L} (X_{fn})' + \sum_{m \notin \mathcal{N}_{\text{retail}}} (X_{mn})' \right].$$

If negative, we perform the same adjustment as in our original dataset by raising final sales.

Given this alternative dataset without retailers, we construct the counterfactual autarkic equilibrium using the procedure described in Section [D.1.2](#).

### D.2.5 Counterfactual with Informal Sector

We extend the baseline model to include informal activities using the survey data described in Section [B.4](#). This survey allows us to infer the share of earnings associated with the informal sector for individuals at different percentiles of the earnings distribution, as well as the industry and factor group associated with the source of the informal income of each individual. Compared to formal workers, we do not observe the specific firms making these informal payments. To fill this gap, we introduce, for each sector  $k$ , a representative informal firm that combines domestic factors in the same CES fashion as formal firms in the model above, does not purchase either domestic or foreign inputs, and sells only to final consumers,

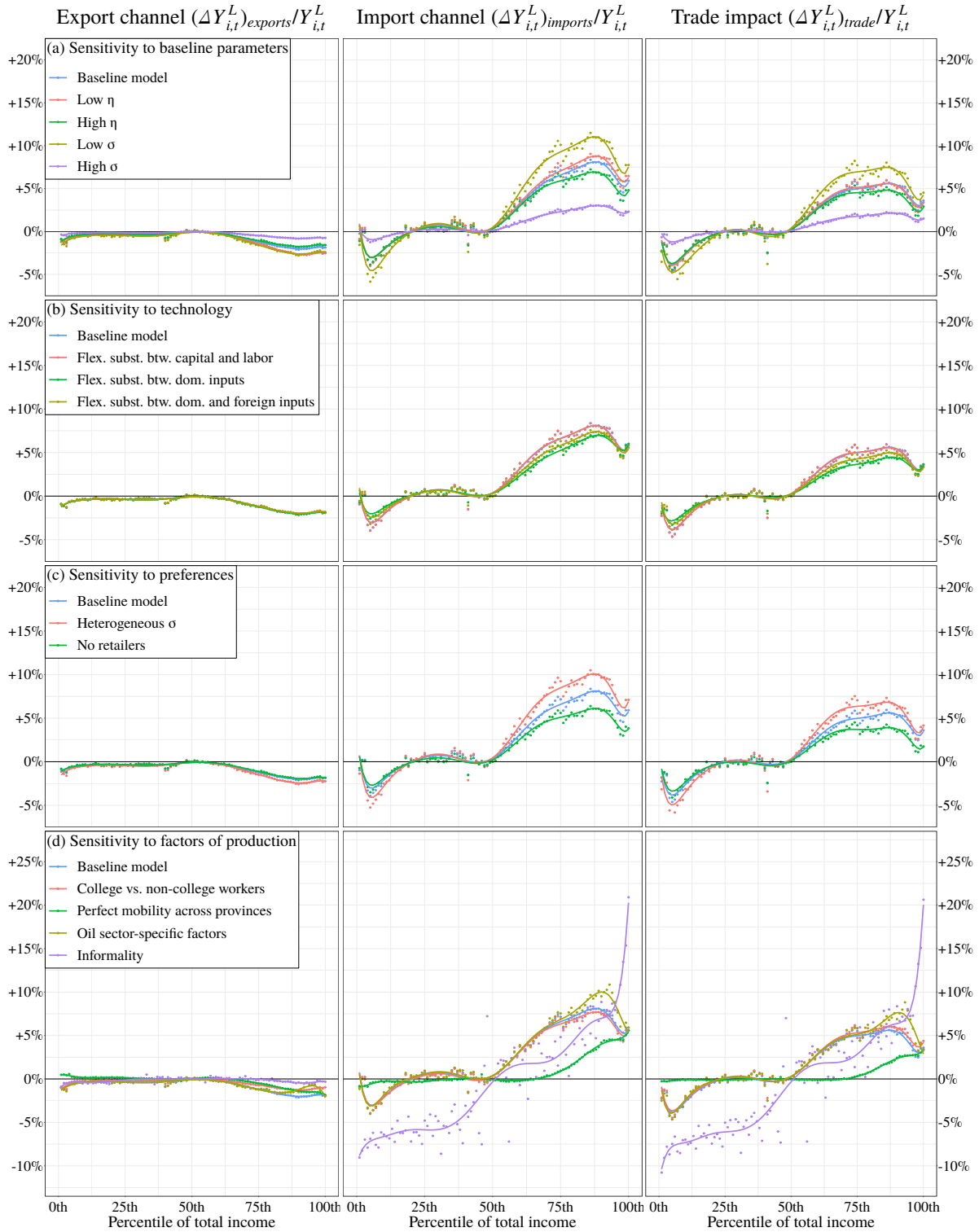
$$q_{\text{informal},k} = \varphi_{\text{informal},k} \left( \sum_{f \in \mathcal{F}} \theta_{f\text{informal},k}^{1/\eta} I_{f\text{informal},k}^{(\eta-1)/\eta} \right)^{\eta/(\eta-1)},$$

with  $\eta$  set to 2.10, the baseline value for formal firms, and the shifters  $\varphi_{\text{informal}}$  and  $\theta_{\text{informal}}$  identified in the exact same way as we did for formal firms in Appendix D.1.1.

## D.2.6 Counterfactual Results for Labor Income

Figure 6 reported the results from the sensitivity analysis of Section 7.3 for the case of impacts on trade on total earnings. Figure D.1 here reports the analogous results for labor income only.

**Figure D.1: Trade and Earnings Inequality, Sensitivity Analysis (Labor Income)**



*Notes:* Blue dots in all figures display the predicted impact of trade on the labor-only earnings of individuals at each income percentile (normalized to zero at the median and expressed as percentages) in our baseline model, as in Figure 4. Other colors report the analog for alternative parameter values (panel a), alternative specifications of technologies (panel b) and preferences (panel c), and alternative factor group definitions (panel d). See the text for details of these extensions. Lines indicate a fitted 10<sup>th</sup>-order polynomial.

### D.3 Trade and Observed Changes in Inequality

The counterfactual simulations reported in Section 7 focus on the difference between trade and autarky at a given point in time. A distinct, but related, question is whether the trends in earnings inequality observed in Ecuador over time would have been different if the Ecuadorian economy had been subject to the same domestic shocks, i.e. fluctuations in the preference and technological parameters  $\bar{\Theta}_t \equiv \{\theta_{nc,t}, \theta_{fn,t}, \theta_{rn,t}, \Theta_{n,t}, \alpha_{n,t}, \beta_{n,t}, \varphi_{n,t}\}$ , but closed to international trade. That is, what is the contribution of trade to observed changes in inequality?

#### D.3.1 Baseline Results

To revisit this question, it is sufficient to note that log-changes in factor prices between some initial period  $t_0$  and any given date  $t$  in the counterfactual autarkic equilibrium,  $\ln(w_{f,t})_A - \ln(w_{f,t_0})_A$ , can be expressed as

$$\ln(w_{f,t})_A - \ln(w_{f,t_0})_A = [\ln w_{f,t} - \ln w_{f,t_0}] - [(\Delta \ln w_t)_{trade} - (\Delta \ln w_{t_0})_{trade}].$$

We observe the first difference on the right-hand side directly in the data, whereas we can compute the second difference for each year (as we did for 2012 in Section 7). Once counterfactual changes in factor prices  $\ln(w_{f,t})_A - \ln(w_{f,t_0})_A$  have been obtained, changes in individual earnings can again be computed using information about the share of each factor  $f$  owned by a given individual. We do this using the augmented sample with both formal and informal workers described in Appendix B.4.2 so that changes in earnings inequality observed in the trade equilibrium are representative of the overall Ecuadorian economy, not just its formal sector.

Table D.1 reports the changes in different ratios of percentiles of the distribution of earnings between 2009 and 2015, both under the trade equilibrium in column (1), i.e. as observed in our dataset over that time period, as well as the counterfactual autarkic equilibrium of our baseline model in column (2) and the difference between the two measures, i.e. the contribution of trade, in column (4). Except at the very top, we see that the decrease in inequality experienced by Ecuador would have been *smaller* in the absence of trade. This reflects the fact that although trade tends to increase inequality at all dates, it does so less and less in later years of our sample. Equivalently, this means that over the study period, Ecuador's economy generated larger increases in gains from trade at the lower end of the income distribution.



**Table D.1: Change in Earnings Inequality, 2009-2015**

|                                    | Actual<br>change<br>in open<br>economy | Counterfactual change<br>in closed economy |                               | Contribution of trade |                               |
|------------------------------------|--|--|-------------------------------|-----------------------|-------------------------------|
|                                    |  | Baseline<br>model                          | Deardorff's<br>(2000) formula | Baseline<br>model     | Deardorff's<br>(2000) formula |
|                                    |  | (1)  | (2)                           | (3)                   | (4)                           |
| $\Delta$ Log of 50-10 income ratio | -0.134                                 | -0.074                                     | -0.118                        | -0.059                | -0.016                        |
| $\Delta$ Log of 90-50 income ratio | -0.185                                 | -0.107                                     | -0.176                        | -0.077                | -0.009                        |
| $\Delta$ Log of 99-90 income ratio | -0.046                                 | -0.079                                     | -0.052                        | 0.033                 | 0.005                         |

*Notes:* Calculations based on sample with informal earnings included. “50-10 income ratio” (etc.) calculated from the ratio of the income of the 50th-percentile earner to that of the 10th-percentile earner, separately in each year and scenario. Autarky factor prices in column (3) computed using equation (10) at  $\eta_{agg} = 2.53$ .

### D.3.2 Back to the Original Factor Content Approach

A large empirical literature has studied the role of international trade in exacerbating income inequality in the United States through the lens of the original factor content approach (Murphy and Welch, 1991; Borjas et al., 1992; Katz and Murphy, 1992; Wood, 1995; Borjas et al., 1997). Most of this work, with the notable exception of the non-standard calculations of Wood (1995), has concluded that trade played a small part. Although we lack the granular data to replicate our empirical exercise for the U.S., we can compare our conclusions to those that one would have drawn from applying the original factor content approach in the Ecuadorian context. Column (3) of Table D.1 reports the change in inequality under autarky from 2009-15 calculated using Deardorff’s (2000) original formula—that is, the change predicted by equation (10) for  $\eta_{agg} = 2.53$ , as in Section 7.2. The difference between columns (1) and (3) again measures the contribution of trade and is reported in column (5). Under the alternative assumptions, one would have (wrongly) concluded that the contribution of international trade to the changes in inequality observed in Ecuador was an order of magnitude smaller than those implied by the more general factor demand system that we have estimated. These findings re-open the possibility that the previous consensus about the U.S. case may be equally sensitive to the assumptions implicitly embedded in the original factor content approach.

## References (Online Appendix)

Acemoglu, Daron and David Autor, *Skills, Tasks, and Technologies: Implications for Employment and Earnings*, Vol. 4 of *Handbook of Labor Economics*, Elsevier, 2011.

— and **Pablo D. Azar**, “Endogenous Production Networks,” *Econometrica*, 2020, 88 (1), 33–82.

**Borjas, George J., Richard B. Freeman, and Lawrence F. Katz**, “On the labor market effects of immigration and trade,” in G.J. Borjas and R.B. Freeman, eds., *Immigration and the work force*, NBER, 1992.

—, —, and —, “How much do immigration and trade affect labor market outcomes?,” *Brookings Papers on Economic Activity*, 1997, 1, 1–90.

**Deardorff, Alan**, “Factor Prices and the Factor Content of Trade Revisited: What’s the Use?,” *Journal of International Economics*, 2000, 50 (1), 73–90.

**Gabaix, Xavier and Ralph SJ Koijen**, “Granular instrumental variables,” Technical Report, National Bureau of Economic Research 2020.

**Gale, David**, *The Theory of Linear Economic Models*, The Rand Corporation, 1960.

**Katz, Lawrence and Kevin Murphy**, “Changes in Relative Wages, 1963-1987: Supply and Demand Factors,” *Quarterly Journal of Economics*, 1992, 107 (1), 35–78.

**Murphy, Kevin M. and Finis Welch**, “The Role of International Trade in Wage Differentials,” in M. Koster, ed., *Workers and their Wages*, American Enterprise Institute, Washington DC, 1991.

**The Growth Lab at Harvard University**, “Growth Projections and Complexity Rankings,” 2019.

**Wood, Adrian**, *North-South trade, employment, and inequality: Changing fortunes in a skill-driven world*, Oxford University Press, 1995.