IMPORTS, EXPORTS, AND EARNINGS INEQUALITY: MEASURES OF EXPOSURE AND ESTIMATES OF INCIDENCE*

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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 data set 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, import exposure is pro-rich, and 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. *JEL Codes:* F10, F14, F16.

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I. 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 effect 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 article, we propose to revisit these classical questions using an intuitive supply and demand framework. The basic idea on 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 data set 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, and so on. Likewise, on the import side, this data set 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 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 people 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 II 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—and 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, $L^* \to 0$ (the export channel) and $p^* \to \infty$ (the import channel).[1]

Section III 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

1. The critical assumption behind our approach is perfect competition in factor markets, not good markets. We come back to this point in Section II.D.

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, and the incidence of such exposure can be inferred in an intuitive way from the extent to which consumers and firms reallocate expenditure in response to changes in good and factor prices.

Section IV uses administrative tax data to measure these differences in trade exposure across Ecuador's income distribution. Starting from the structural relationship, we say that individuals' earnings are more exposed to exports if their factor services are disproportionately demanded abroad (i.e., if $\frac{L_f^*}{\bar{L}_f}$ 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 exposed to imports if changes in import prices lead to larger shifts in the domestic demand for their factor services (i.e., if $\left|\frac{d \ln L_f(w,p^*)}{d \ln p^*}\right|$ 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, people 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 V 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, in each firm, and the elasticity of substitution between final goods, in 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 data set, the values of these two parameters identify Ecuador's domestic factor demand.

Before proceeding to our counterfactual analysis, Section VI offers 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. Because we have estimated Ecuador's domestic factor demand system indirectly by estimating two micro-level elasticities governing firm- and consumer-level responses, there is a priori no reason 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 VII 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 midpoint 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 for 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.[2]

2. Although 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.

I.A. Related Literature

The literature on trade and inequality is rich and varied, from applied theory work (Stolper and Samuelson 1941; Grossman and Rossi-Hansberg 2008; Helpman, Itskhoki, and Redding 2010) to reduced-form evidence (e.g., Hanson and Harrison 1999; Attanasio, Goldberg, and Pavcnik 2004; Autor, Dorn, and Hanson 2013) to structural empirical approaches (e.g., Artuc, Chaudhuri, and McLaren 2010; Burstein and Vogel 2017; Galle, Rodríguez-Clare, and Yi 2017). A nonexhaustive list of recent surveys includes Goldberg and Pavcnik (2007), Feenstra (2010), Harrison, McLaren, and McMillan (2011), Muendler (2017), Pavcnik (2017), Helpman (2018), and Hummels, Munch, and Xiang (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, Freeman, and Katz 1992, 1997; Katz and Murphy 1992; Wood 1995) 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.[3] Deardorff (2000) generalizes this result to the case of constant elasticity of substitution (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.[4] More generally, changes in relative

3. In addition to providing the theoretical foundations of the original factor content approach, Deardorff and Staiger (1988) offer more general correlation results that relax the Cobb-Douglas assumption.

4. 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

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 the 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 noncollege graduates, and measures the factor content of exports and imports using coarse input-output matrices.[5] It is well known that such data may mask tremendous heterogeneity, in terms of factor price changes in groups and in terms of factor intensity in sectors, in particular between firms that are globally engaged and those that are not (Bernard and Jensen 1999; Bernard et al. 2007). In contrast, by combining data on firm-to-firm transactions and firm-level international transactions (as in Huneeus 2018; Spray and Wolf 2018; Bernard et al. 2019; Demir et al. 2021; Dhyne et al. 2021; Alfaro-Ureña, Manelici, and Vasquez 2022) 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 effect of trade on top income inequality (Piketty and Saez 2003; Piketty, Saez, and Zucman 2018; Smith et al. 2019).

On the estimation side, our structural relationship is valid 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 domestic factors in a hypothetical autarkic economy, not the elasticity of substitution in

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 and a method for indirectly estimating the previous quantities from foreign production data.

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

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, qualitatively and quantitatively, for our conclusions.

In emphasizing the economics of factor supply and factor demand, our analysis also relates to Adão, Costinot, and Donaldson (2017), who made the case for estimating global factor demand to study the effect 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 effect of trade on (factoral) terms-of-trade between individuals in 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 effect 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 to strengthen the credibility of our empirical conclusions.

Finally, we note that throughout this article, we focus on relative rather than real factor prices and we use the terms "inequality" and "earnings inequality" interchangeably. A number of papers have studied how international trade may affect the distribution of real income across individuals by differentially affecting the costs of living faced by people with heterogeneous or nonhomothetic 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 effect of trade on inequality through such cost-of-living considerations.[6]

6. 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 contexts of Argentina and the United States, respectively). We expand on the earnings channel side of these studies by de-

II. 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 II.A–II.C and delay the discussion of increasing returns and imperfect competition to Section II.D.

II.A. 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.

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

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

where $p \equiv \{p_n\} > 0$ is the vector of domestic good prices; $w \equiv \{w_f\} > 0$ is the vector of factor prices; $\bar{l}_i \equiv \{\bar{l}_{fi}\} \geqslant 0$ 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.[7] We let $d_i(p, w)$ denote the unique solution to problem (1) and $D(p, w) \equiv$

veloping 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).

7. Economies with elastic labor supply are nested by treating leisure as an additional nontraded good. Roy models, as in Ohnsorge and Trefler (2007), Costinot and Vogel (2010), and Grossman, Helpman, and Kircher (2017), are also nested by treating workers with different productivity levels across sectors or occupations as distinct factors of production. Finally, because we 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 data set are accounted for by firms with at least some domestic value added.

$\{\sum_{i \in \mathcal{I}} p_n d_{i,n}(p, w)\}$ denote the associated vector of total domestic expenditure.

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

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

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.[8] We further assume that some domestic factor or foreign intermediate is essential in production, that is, $f_n(0, m_n, 0) = 0$ for all $n \in \mathcal{N}$, and that all goods can be produced, that is, 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

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

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, $x_{fn}(p, p^*, w) \equiv \frac{w_f l_{fn}(p, p^*, w)}{c_n(p, p^*, w)}$; and $M(p, p^*, w) \equiv \{x_{nr}(p, p^*, w)\}$ denote the domestic input-output matrix, with $x_{nr}(p, p^*, w) \equiv \frac{p_n m_{nr}(p, p^*, w)}{c_r(p, p^*, w)}$.[9]

8. 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 effect of trade on inequality, as we discuss in Sections II.D and VII.B.

9. 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. Although 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 the buying side.

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

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

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

where $e \equiv \{e_n\}_{n \in \mathcal{N}} \geqslant 0$ 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.

4. *Competitive Equilibrium.* We are now ready to define a competitive equilibrium.

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 problem* (1) *for all* $i \in \mathcal{I}$*;* $(y_{n,T}, l_{n,T}, m_{n,T}, m^*_{n,T})$ *solves problem* (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 parameters. For 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 estimating the overall effect of trade on inequality, however, one can remain agnostic about such conditions, as we demonstrate next.

II.B. 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 effect 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 $n \in \mathcal{N}$.[10] That is, we view good prices as determined by

10. For characterizing equilibrium factor prices, our focus on equilibria where the zero-profit condition is binding for all domestic firms, including those with

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 II.D.

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.[11] 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*

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

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 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 intermediates required to produce those intermediates, and so on.

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

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 Online Appendix A.1.

11. Acemoglu and Azar (2020) (their theorems 1 and 2) offer a recent proof in an environment with one primary factor of production, labor, where all goods can be produced using labor only. Online Appendix A.1 demonstrates how to adapt their proof to the environment of Section II.A. We thank John Sturm for help with the formal argument and refer the interested reader to Flynn, Patterson, and Sturm (2020) for further results.

exports, $L^* \equiv \{L^*_f\}$, such that

$$\{w_f L^*_f\} \equiv A_T B_T E, \tag{6}$$

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, that is, total factor supply, $\bar{L}_f$, minus the factor content of exports, L^*_f.

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

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

The proof of Lemma 1 can be found in Online 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 effect of trade on inequality.

II.C. 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 $RD_f(p^*, w) \equiv \frac{L_f(p^*, w)}{L_0(p^*, w)}$ denote the domestic relative factor demand for *f* relative to factor "0", which we use as our numeraire $w_0 = 1$;[12] and let $RS_f \equiv \frac{\bar{L}_f}{\bar{L}_0}$ denote the total relative supply of factor *f*. In the original equilibrium with observed factor prices, w_T, import

12. Because 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).

prices, p^*, and factor content of exports, L^*, Lemma 1 implies the equality of domestic relative factor demand and domestic relative factor supply

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

where $REE_f \equiv \frac{1-\frac{L_0^*}{\bar{L}_0}}{1-\frac{L_f^*}{\bar{L}_f}}$ 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 0, $L_A^* = 0$, leading to

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

When moving from the trade equilibrium described in equation (8) to the autarkic equilibrium in equation (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 solid black relative supply curve (to the domestic market) to the dashed red one in Figure I as $REE_f \to 1$. Second, domestic demand for foreign goods must go to zero. We refer to this as an import channel captured by the shift from the solid black relative demand curve to the dashed red one in Figure I as $p^* \to \infty$.[13]

Formally, let $(\Delta \ln w)_{trade} \equiv \left\{ \ln\left(\frac{w_{f,T}}{w_{f,A}}\right) \right\}_{f \neq 0}$ denote the vector of log-differences in domestic factor prices between the

13. 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 effect 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, a distinct question is whether one can engineer shocks to foreign preferences, technology, or factor supply that would independently shift REE_f and p^* 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 take advantage of in the empirical analysis of Sections V and VI.

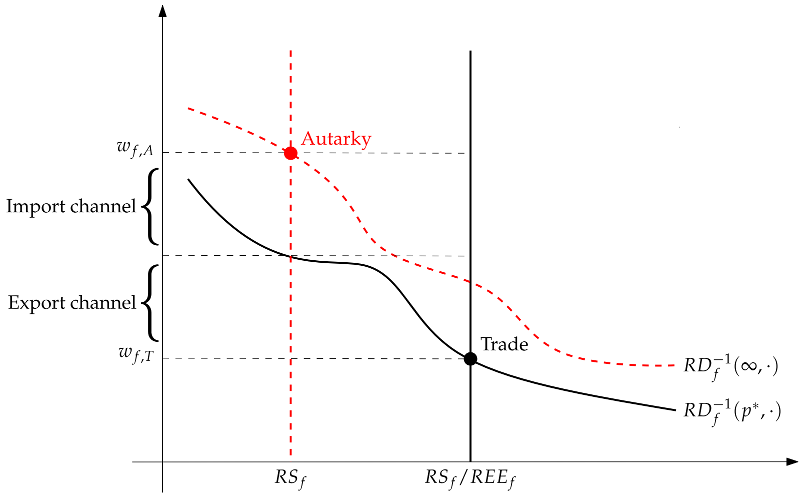

FIGURE I

The Overall Incidence of Trade on Earnings Inequality

At the original equilibrium, domestic factor prices (w_T) equate domestic relative factor demand, $RD_f(p_T^*, w_T)$, and its supply, $\frac{RS_f}{REE_f}$. 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 $REE_f = 1$).

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 equation (8) exists for all (p^*, REE), that $\ln RD$ is continuously differentiable, and that the matrix of domestic price elasticities $\frac{\partial \ln RD}{\partial \ln w} \equiv \left\{\frac{\partial \ln RD_f}{\partial \ln w_g}\right\}$ 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 II.A hold, that a solution to equation (8) exists for all (p^*, REE), that $\ln RD$ is continuously differentiable with respect to (p^*, w), and that $\frac{\partial \ln RD}{\partial \ln w} \equiv \left\{\frac{\partial \ln RD_f}{\partial \ln w_g}\right\}$ is invertible for all (p^*, w). Then differences in domestic factor prices between the trade and* *autarky equilibria are given by*

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

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

The proof can be found in Online 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 $\frac{\partial \ln RD_f}{\partial \ln p_n^*}$. We use both observations to construct measures of export and import exposures across individuals in Section IV.[14] Having specified a domestic factor demand system in Section III and estimated it in Section V, we use Proposition 1 to compute the full incidence of trade on earnings inequality in Section VII.

II.D. 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.

14. In contrast to the original factor content approach, which we discuss in detail later, 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 foreign import prices and foreign import volumes, one could further change variables to eliminate foreign prices, as in Arkolakis, Costinot, and Rodríguez-Clare (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 III and, in turn, our import exposure measures in Section IV.

1. *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.[15] 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 II.[16] 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 effect of trade on inequality is therefore

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

with $RNEE \equiv \left\{\frac{1-NEE_0}{1-NEE_f}\right\}_{f \neq 0}$.[17] This is the limit of the general formula for $(\Delta \ln w)_{trade}$ in Proposition 1 in an environment with

15. 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 II.A. 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.

16. 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.

17. 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. Because 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

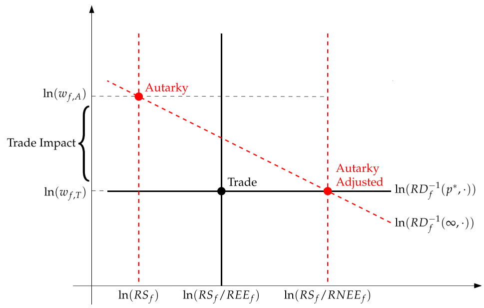

FIGURE II

Original Factor Content Approach

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 effect of trade on factor prices is equal to the effect in autarky, that is 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.

nested CES preferences, as the elasticity of substitution between goods from different countries is taken to infinity.[18]

2. *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, is also a sufficient statistic 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 II). 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),

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 with Burstein and Vogel (2017), who emphasize that the previous residual is nonzero in their structural model, one can view Proposition 1 as providing a general structural interpretation of that residual.

18. For empirical purposes, a challenge in applying this formula is that η_{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, η_{agg} is the slope of $RD(w, \infty)$, the dashed red demand curve in Figure II, an issue already emphasized in Leamer (2000).

and Feenstra and Hanson (1999), that, like the aforementioned factor content approach, aimed to shed light on the effect 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. However, this is not 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). Although we do not know what domestic good prices would be under autarky, we know that the factor content of exports would be zero.[19]

3. *Global Value Chains.* The factor content calculations carried out in Section II.B 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.[20]

19. We have nothing to add to the relative merits of these alternative counterfactual questions and refer interested readers to the discussions of this point in Deardorff (2000), Krugman (2000), and Leamer (2000).

20. 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 Adão, Costinot, and Donaldson (2017) followed to study the effect of arbitrary changes in trade costs.

4. *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, Adão et al. (2020), only the last of these assumptions 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, Redding, and Schott (2007), Sampson (2014), Harrigan and Reshef (2016), Antràs, de Gotari, and Itskhoki (2017), and Fieler, Eslava, and Xu (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.[21]

III. 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 II 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 between and within sectors.

For the purposes of the present article, 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.

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

III.A. Parametric Restrictions

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

1. *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 $k \in \mathcal{K}$,

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

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

where $\alpha_k, \theta_{nc} \geqslant 0$ 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

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

2. *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 $n \in \mathcal{N}^*$,

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

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

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

where $\varphi_n, \beta_n, \Theta_n, \theta_{fn}, \theta_{rn}, \theta_{rn}^* \geqslant 0$ 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; $\eta > 0$ is the elasticity of substitution between domestic factors. Thus, shares of costs spent on domestic factors, domestic intermediates, and foreign intermediates are equal to

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

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

$$x^*_{rn}(p, p^*, w) = (1 - \beta_n)(1 - \Theta_n)\theta^*_{rn}, \text{ for all } r \in \mathcal{N}^* \text{ and } n \in \mathcal{N}, \tag{19}$$

whereas unit costs are equal to

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

with $\phi_n \equiv \varphi_n^{-1}(\beta_n)^{-\beta_n}[(\Pi_{r\in\mathcal{N}}(\theta_{rn})^{\theta_{rn}}\Theta_n)^{\Theta_n}(\Pi_{r\in\mathcal{N}^*}(\theta^*_{rn})^{\theta^*_{rn}}(1-\Theta_n))^{(1-\Theta_n)}(1-\beta_n)]^{-(1-\beta_n)}$ an adjusted measure of firm n's productivity. We note that because of the previous Cobb-Douglas assumptions, both the domestic input-output matrix, $M(p, p^*, w) = \{(1 - \beta_r)\Theta_r\theta_{nr}\}$ and its Leontief inverse, $B(p, p^*, w) = \{b_{nr}\}$, are independent of all prices.[22]

3. *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

22. 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 Antràs, Fort, and Tintelnot (2017), for example. Here, firms are indifferent between exporting or selling domestically and spend an exogenous share of their costs on imports.

expenditure, factor cost shares, and domestic prices, we obtain the following characterization of relative domestic factor demand.

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

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

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

$$\tilde{w}_n(w) \equiv \left(\sum_{f\in\mathcal{F}} \theta_{fn} w_f^{1-\eta}\right)^{\frac{1}{1-\eta}},$$

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

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

The formal proof can be found in Online Appendix A.4. Although factor demand in 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.[23] Rather, nested CES preferences and technology aggregate up to a nested CES factor demand system, with two elasticities, σ and η, that are unrestricted and will form the basis of the estimation in Section V.

23. 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 in each sector—in our notation, this corresponds to $\sigma = \infty$.

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 turn to the economic considerations that will shape the strength of this import channel.

III.B. Elasticities with Respect to Foreign Import Prices

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

PROPOSITION 3. *Suppose that equations (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

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

where $s_{fm} \equiv \frac{\sum_{v \in \mathcal{N}} x_{fv} b_{vm} D_m}{w_f L_f}$ 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 $d_{rk} \equiv \frac{D_r}{\sum_{m \in \mathcal{N}_k} D_m}$ is the share of sector k's final expenditure devoted to firm r.

Derivations can be found in Online 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 σ.[24] 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, 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, that is, 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 import price shock, that is, 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.[25]

In the absence of intermediate goods, IE_{fn} takes a particularly simple form. Because all imports are accounted for 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.

III.C. *Elasticities with Respect to Domestic Factor Prices*

Let us now turn to the matrix of domestic price elasticities, $\frac{\partial \ln RD}{\partial \ln w}$. According to Proposition 1, this matrix determines the incidence of shifts in relative export exposure REE_f and foreign

24. The fact that foreign intermediate goods and domestic factors appear in distinct CES nests in equations (14)–(16) explains why η plays no role in Proposition 3.

25. 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 tend to reduce the demand for the factors employed by those firms.

import prices p^* on domestic factor prices. As shown in Online Appendix A.6, $\frac{\partial \ln RD}{\partial \ln w}$ takes the following form.

PROPOSITION 4. *Suppose that equations (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

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

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

where $r_{fm} \equiv \frac{\sum_{v \in \mathcal{N}} x_{fm} b_{mv} D_v}{w_f L_f}$ is the share of factor f's domestic demand employed by firm m; $x^D_{gm} \equiv \frac{x_{gm}}{\sum_{f \in \mathcal{F}} x_{fm}}$ 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 η now also plays a central role. It controls the magnitude of expenditure switching across factors in 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 in 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 toward all other factors in each firm m, proportional to the share of factor cost, x^D_{gm}. However, if the domestic demand for factor f is used in firms that are on average more intensive in factor g, that is, if $\sum_{k\in\mathcal{K}}\sum_{m\in\mathcal{N}_k} r_{fm}\times x^D_{gm}$ 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 affect 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 $\frac{\partial \ln RD}{\partial \ln w}$ is nondiagonal implies that trade may not only affect factor prices because different factors have different export and import exposures, which we 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 VI and VII.

IV. Export Exposure, Import Exposure, and Earnings

We build on the theoretical results of Sections II and III to estimate the effect 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.

IV.A. Data Sources

Our primary data set covers Ecuador's formal economy from 2009 to 2015. It tracks the universe of tax IDs—be they from incorporated or nonincorporated 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.[26] By its nature, this administrative data provide a comprehensive picture of the formal segment of Ecuador's private-sector activity—that which is reported to the tax authorities—but Section VII.C 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 Online Appendix B. Although all these measures are annual, we suppress time subscripts until they are necessary.

1. *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 II and III, 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 $x_n^* = \frac{X_n^*}{R_n}$ for all domestic firms.

2. *Value-Added Tax Data.* We use tax records related to Ecuador's value-added tax (VAT) system to measure spending X_{rn} by a domestic firm n on intermediate goods from any other domestic firm r.[27] Given the nature of the VAT transaction data, such spending includes purchases of nondurable materials and durable goods like machinery and equipment. This allows us to compute the domestic firm-to-firm input-output matrix M with elements $x_{rn} = \frac{X_{rn}}{R_n}$, as well as the share of any firm r in the total purchases of domestic inputs by firm n, $\theta_{rn} = \frac{X_{rn}}{\sum_{m \in \mathcal{N}} X_{mn}}$. By subtracting total sales of intermediate goods and exports from total revenues, we measure sales to domestic consumers as $D_n = R_n - \sum_{m \in \mathcal{N}} X_{nm} - E_n$.[28] This allows us to compute domestic consumer expenditure shares across sectors, $\alpha_k = \frac{\sum_{r \in \mathcal{N}_k} D_r}{\sum_{r \in \mathcal{N}} D_r}$, and across firms within sectors, $d_{nk} =$

26. While all such firms enter our analysis, the vast majority are nonincorporated 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.

27. This merge of corporate income tax and VAT records builds on earlier work by Carrillo, Pomeranz, and Singhal (2017).

28. 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 $D_n = 0$.

$\frac{D_n}{\sum_{r\in\mathcal{N}_k} D_r}$, 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 two-digit ISIC revision 3.1 classification.[29]

3. *Social Security Data.* We use social security records that link individuals to the firms in our sample via labor payments to measure spending X_{fn} by a domestic firm $n \in \mathcal{N}$ on different labor groups $f \in \mathcal{F}_{\mathrm{L,SS}}$. 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 their primary income.[30] This results in 72 labor groups in the social security database. We create an additional labor group that covers all employed individuals with missing information or those not appearing in social security records, $\mathcal{F}_{\mathrm{L,NSS}}$.

From the corporate tax forms, we know the total wage payments $W_n = \sum_{f\in\mathcal{F}_{\mathrm{L}}} X_{fn}$ of each firm n, with $\mathcal{F}_{\mathrm{L}} = \mathcal{F}_{\mathrm{L,SS}} \cup \mathcal{F}_{\mathrm{L,NSS}}$. For each individual i in the social security data set, 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 $f \in \mathcal{F}_{\mathrm{L,SS}}$ as $\frac{\sum_{i\in\mathcal{I}_f} W_{in}}{\sum_{i\in\mathcal{I}} W_{in}}$ and, in turn, $X_{fn} = \left(\frac{\sum_{i\in\mathcal{I}_f} W_{in}}{\sum_{i\in\mathcal{I}} W_{in}}\right) W_n$. Payments to the residual group of workers not in the social security system are $X_{Rn} = W_n - \sum_{f\in\mathcal{F}_{\mathrm{L,SS}}} X_{fn}$.

For each individual i, we let Y_{fi} denote the labor payments associated with any factor $f \in \mathcal{F}_{\mathrm{L}}$. 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, $Y_{fi} = \sum_{n\in\mathcal{N}} \left(\frac{W_{in}}{\sum_{j\in\mathcal{I}} W_{jn}}\right) W_n$, if $i \in \mathcal{I}_f$.

4. *Firm Ownership Data.* We refer to any factor of production not in $\mathcal{F}_{\mathrm{L}}$ as capital and let $\mathcal{F}_{\mathrm{K}}$ denote the set of such factors.

29. As described in Online Appendix B, we further aggregate all firms in the finance sector into a single consolidated firm, 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 create a residual firm (placed into a 63rd sector) whose sales and costs are used to balance all accounting identities in the model.

30. 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.

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" ($K_{\text{not oil}}$), 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 are 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, that is, 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 $K_{\text{not oil}}$ depending on the firm's sector.[31]

By dividing factor spending by total revenue, we obtain the domestic matrix of factor cost shares A with elements $x_{fn} = \frac{X_{fn}}{R_n}$ for all domestic factors $f \in \mathcal{F} = \mathcal{F}_{\text{L}} \cup \mathcal{F}_{\text{K}}$. 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 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.[32] Using those reported shares, we compute the share of each individual i in the capital payments of firm n, ϑ_{ni}. The capital payments of individual i associated with the oil sector are $Y_{K_{\text{oil}} i} = \sum_{n \in \mathcal{N}_{\text{oil}}} \vartheta_{ni} X_{K_{\text{oil}} n}$, whereas her capital payments associated with the rest of the economy are $Y_{K_{\text{not oil}} i} = \sum_{n \notin \mathcal{N}_{Oil}} \vartheta_{ni} X_{K_{\text{not oil}} n}$.

The total income of individual i is then given by $Y_i = \sum_{f \in \mathcal{F}} Y_{fi}$, with $\omega_{fi} = \frac{Y_{fi}}{Y_i}$ denoting the share of their earnings associated with factor f.[33]

31. Whenever profits are negative, we raise firm n's revenues to C_n to bring $R_n - C_n$ to zero. Those additional sales are imputed to the residual consolidated firm, as described in Online 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.

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

33. Because each individual is in only one labor group, they have at most three positive values of ω_{fi}: that associated with the 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.

5. *Customs Data.* We use international trade data from two sources: (i) Ecuadorian firm-level customs transaction records, available from 2009 to 2011; and (ii) country-level trade from CEPII's BACI data set, available from 2009 to 2015. Both data sets report trade flows at the HS6 digit level ($\mathcal{HS}$). These data sets allow us to construct instrumental variables in Section V as well as 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 measure $\theta^*_{rn} = \frac{X^*_{rn}}{\sum_{m \in \mathcal{N}^*} X^*_{mn}}$ and $x^*_{rn} = \theta^*_{rn} x^*_n$ for all $r \in \mathcal{N}^*$ and $n \in \mathcal{N}$.

IV.B. Summary Statistics

Before using the 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.

1. *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 toward 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 Online Appendix Figure C.1. This broad pattern of trade—exports of primary products in exchange for imports of manufacturing goods—is by no means unique to Ecuador but is a common feature in many low- and middle-income countries around the world, as Online Appendix Figure C.2 illustrates.

2. *Income Distribution.* Online Appendix B.2.2 presents additional statistics regarding the distribution of earnings among sample individuals in 2012, the midpoint of our data set, as well as how their sources of earnings vary.[34] 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

34. 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.

individuals in the 90th and 99th percentiles of the income distribution.[35] 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.

IV.C. Export Exposure across the Distribution of Earnings

1. *From Factor to Individual Export Exposure.* In Section II, we defined the relative export exposure of a factor f as $REE_f \equiv \frac{1-\frac{L_0^*}{\bar{L}_0}}{1-\frac{L_f^*}{\bar{L}_f}}$, 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 start from the export exposure of each factor appearing in REE_f, that is, the ratio of the value of factor f's services that are exported, directly and indirectly, to the total value of its services,

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

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

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

where $\omega_{fi} = \frac{Y_{fi}}{Y_i}$ 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, directly or indirectly, from

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

36. 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 $J > 10$.

exports rather than domestic consumption. It does not rely on any of the parametric assumptions introduced in Section III—as discussed in Section II, 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 receive relatively higher earnings under trade.[37]

2. *Results.* Figure III, Panel A plots (in the solid blue line) the relationship between EE_i and (total) income in our sample in 2012.[38] 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% highest earnings in our sample.[39]

Figure III, Panel A 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 dashed red line is consistently above the solid 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 people earn relatively larger

37. 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 $\frac{\partial \ln RD}{\partial \ln w}$ being nondiagonal or to the diagonal elements of $\frac{\partial \ln RD}{\partial \ln w}$ being heterogeneous.

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

39. 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, direct and indirect, of the firm employing individual i. Online Appendix Figure C.5 describes how export exposure would look across the income distribution under this alternative scenario. For interested readers, Online Appendix Figure C.6 also documents the role played by the oil sector in our measures of export exposure by replicating Figure III, Panel A with oil exports set to zero.

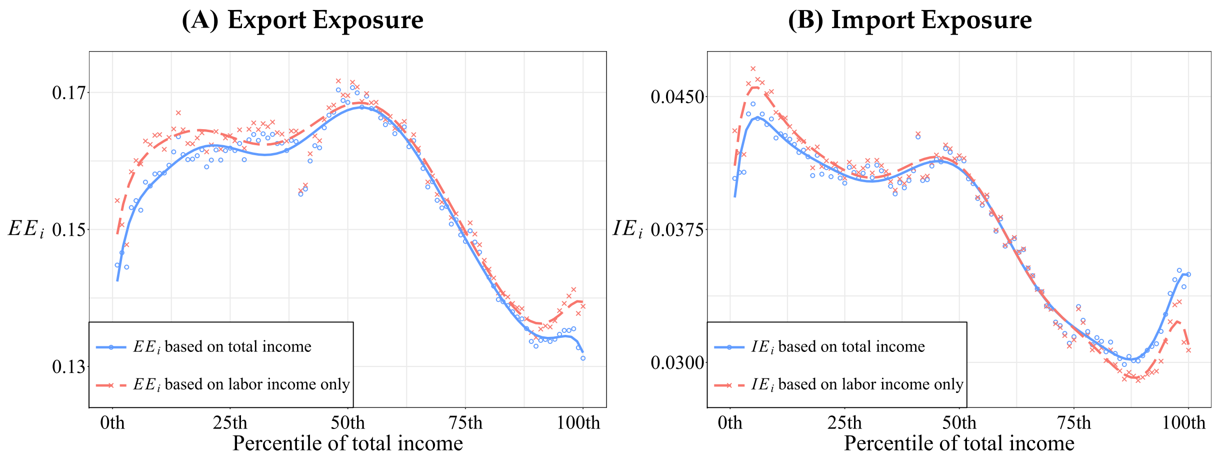

FIGURE III

Distribution of Trade Exposure across Individuals, 2012

In Panel A, the blue circles 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 10th-order polynomial. The red crosses (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).

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 people 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.

IV.D. Import Exposure across the Distribution of Earnings

1. *From Factor to Individual Import Exposure.* Changes in import prices are the second source of factor demand shifts emphasized by Proposition 1. In Section III, we 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 effect 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

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

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

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

with $\bar{x}_m^* \equiv \sum_{r\in\mathcal{N}} x_r^* b_{rm}$ the share of firm m's costs spent, 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,

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

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 ($p^* \to \infty$). Everything else being equal, this should lead to lower relative factor prices and relative earnings for these individuals.

2. *Results.* Figure III, Panel B reports the average import exposure for individuals in different percentiles of the income distribution.[40] 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.[41] 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, that is, those for which $\bar{x}^*_m - \sum_{r \in \mathcal{N}_k} d_{rk} \bar{x}^*_r \leqslant 0$. For an elasticity of substitution σ around 2, as we estimate in Section V, 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.

40. Again, Online 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 to a weighted sum of import shares across sectors, with weights given by the employment shares of the factor that she owns.

41. Burstein, Cravino, and Vogel (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 III.B.

Note that the red dashed curve is steeper than the blue solid curve. This reflects the 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 again indicates small differences between the import exposures of workers and capital owners.

Overall, Figure III, Panels A and B 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 antipoor in the sense that cheaper imports tend to reduce the relative domestic demand for the factor services of poor people. 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.

V. Estimation of Ecuador's Factor Demand System

The model in Section III 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 (η) and that between firms' products in domestic consumption (σ). In this section, we use firm-level microdata to estimate these two parameters.

V.A. Elasticity of Substitution between Factors

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

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

where $\zeta_{n,t} \equiv \ln\left(\frac{\beta_{n,t}\theta_{fn,t}R_{n,t}}{\sum_{f\in\mathcal{F}}\theta_{fn,t}w_{f,t}^{1-\eta}}\right)$ collects firm-year specific terms and η is the elasticity of substitution between factors to be estimated. For the purposes of estimating η, we let the demand shock $\theta_{fn,t}$ be a function of a factor-specific term, ζ_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,

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

where firm-level factor expenditures $X_{fn,t}$ are given by the procedure from Section IV.A; 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, $w_{f,t} = \frac{\sum_{n \in \mathcal{N}} X_{fn,t}}{\bar{L}_{f,t}}$; and the price of each type of capital $f \in \mathcal{F}_{\text{K}}$ is measured as the total factor payments $w_{f,t} = \sum_{n \in \mathcal{N}} X_{fn,t}$, since we have no physical measure available for the supply of capital.

2. *IV Strategy.* OLS estimates of η based on equation (24) suffer from simultaneity bias because factor prices $w_{f,t}$ themselves depend on the domestic productivity shocks $\{\epsilon_{fn,t}\}$. 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:

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

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

where $\mathcal{HS}$ denotes the set of all six-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 IV, computed in an initial period t_0.[42] 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 $(\text{ExportShock})_{v,t}$ 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 $(\text{ImportShock})_{v,t}$ 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 variable across all products at that date.[43]

We include in the vector $\text{Controls}_{f,t}$ 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 η is that shocks to domestic factor demand in Ecuador—formally, the structural residuals $\epsilon_{fn,t}$ of equation (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

42. That is, $EE_{fv,t_0} = \frac{\sum_{n \in \mathcal{N}} x_{fn,t_0} \sum_{r \in \mathcal{N}} b_{nr,t_0} E_{rv,t_0}}{\sum_{n \in \mathcal{N}} X_{fn,t_0}}$ 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 on product v at time t_0, directly and indirectly.

43. By demeaning both export and import shocks, we aim to isolate variation in shock realization across products, as discussed in Adão, Kolesár, and Morales (2019) and Borusyak, Hull, and Jaravel (2022). 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 Huneeus (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, Itskhoki, and Konings (2016) and Huneeus (2018).

TABLE I
Elasticity Estimates

	Elasticity of substitution between factors (η)		Elasticity of substitution between goods (σ)	
	OLS (1)	2SLS (2)	OLS (3)	2SLS (4)
Parameter estimate	1.34	2.10	1.04	2.11
	(0.19)	(0.34)	(0.04)	(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 columns (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 for which the factor accounts for more than 1% of the firm's factor payments and (in columns (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 columns (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 columns (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 columns (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 columns (3) and (4)) by firm (25,953).

the world (which is reasonable given that, as we show in Online 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 $(\text{ExportShock})_{v,\,t}$ and $(\text{ImportShock})_{v,\,t}$ 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 Online Appendix C.4.

3. *Results.* Table I reports OLS and IV estimates (using $\hat{E}_{f,t}$ and $\hat{I}_{f,t}$ as IVs) of η. 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.[44] This estimate is about twice as large as the

44. Standard errors are clustered by factor. This reflects the variation in our IVs while accounting for autocorrelation in residuals. Adão, Kolesár, and Morales (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

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 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 η is robust to various alternative specifications, as shown in Online Appendix C.5. Online Appendix Table C.3 evaluates alternative sets of controls, samples of firms, and sample periods, whereas Online Appendix 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.

V.B. Elasticity of Substitution between Goods

1. *Empirical Specification.* To estimate σ, we turn to the final demand equation (13), which describes substitution between goods produced by different domestic firms n in 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 $\zeta_{k,t} \equiv \ln\left(\frac{\alpha_{k,t}(w_t \cdot \bar{L}_t)}{\sum_{r\in\mathcal{N}_k}\theta_{rc,t}\,p_{r,t}^{1-\sigma}}\right)$ 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, ζ_n, a vector of observables, $\text{Controls}_{n,t}$, to be described below, and a residual preference shock, $\epsilon_{nc,t}$. This leads to

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

The only conceptual difference between the estimation of η and σ 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

effects and the impossibility of separately computing product exposure shares, due to the high dimension of the input-output matrix M.

Online Appendix A.7, we obtain

$$\ln p_{n,t} = \sum_{r \in \mathcal{N}} b_{rn,t} \left[\beta_{r,t} \ln w^D_{r,t} + \sum_{l \in \mathcal{N}^*} x^*_{lr,t} \ln p^*_{l,t} \right] + \rho_{n,t}, \tag{28}$$

where $w^D_{r,t}$ is a revealed measure of the CES price index for domestic factors in firm r such that $\ln w^D_{r,t} \equiv \sum_{f \in \mathcal{F}} x^D_{fr,t} \left(\ln w_{f,t} + \frac{1}{\eta-1} \ln x^D_{fr,t}\right)$;[45] $p^*_{l,t}$ 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 $\theta^*_{lr,t_0} x^*_{r,t}$;[46] and $\rho_{n,t} \equiv \sum_{r \in \mathcal{N}} b_{rn,t}$ $[\frac{1}{1-\eta} \sum_{f \in \mathcal{F}} x^D_{fr,t} \ln \theta_{fr,t} + \ln \phi_{r,t}]$ is a cost shifter determined by firm n's technology parameters and those of its suppliers.

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

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

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

2. *IV Strategy.* Like in Section V.A, OLS estimates of σ suffer from simultaneity bias because factor price indices $\{w^D_{r,t}\}$ 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 equation (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:

45. When calculating $w^D_{r,t}$ we omit any factor f with minuscule spending shares ($x^D_{fr,t} < 0.001$).

46. Our Ecuadorian firm- and product-level customs transaction records are only available from 2009 to 2011, hence our choice to use θ^*_{lr,t_0} rather than $\theta^*_{lr,t}$. Note that this restriction is irrelevant for the measures of import exposures presented in Section IV.D because they focus on uniform changes in import prices whose effect only depends on firms' total import shares, $x^*_{r,t}$, which are available in all years.

price shifters for the domestic factors used by different firms in each sector and analogous price shifters for their imports.

To construct domestic price shifters, we propose to use firm-level averages of the two factor-specific instruments described in equations (25) and (26):

$$\hat{E}_{n,t} = \sum_{f \in \mathcal{F}} x^{D}_{fn,t_0} \times \hat{E}_{f,t}, \tag{30}$$

$$\hat{I}_{n,t} = \sum_{f \in \mathcal{F}} x^{D}_{fn,t_0} \times \hat{I}_{f,t}, \tag{31}$$

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,

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

Finally, we include in $\text{Controls}_{n,t}$ the shares of firm n's costs at t_0 spent on primary factors, β_{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 for the estimation of η.

3. *Results.* Table I, columns (3) and (4) report the OLS and IV (using $\hat{E}_{n,t}$, $\hat{I}_{n,t}$, and $\hat{P}^{*}_{n,t}$ as IVs) estimates of σ. Again we take t_0 to be 2009–2011 as in Table I, so that initial shares in our IVs and controls are averaged over that period.[47]

47. Our estimate of σ depends (via the construction of $p_{n,\,t}$) on our estimate of η, for which we use the baseline value of $\eta = 2.10$. As a result, the standard error for σ 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 σ is not very sensitive to the value of η. For example, when considering 100 equally spaced values of η on its 95% confidence interval, the smallest and largest values of σ we obtain are 2.08 and 2.11. Section VII.C considers the robustness of our counterfactual simulations to the values of σ used across a considerably wider range.

Again, the OLS estimate of σ 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, Redding, and Weinstein (2016) who report a median elasticity of substitution between U.S. firms, within AC Nielsen product group categories, of 3.9. This is expected because such product groups are more narrowly defined than the two-digit industries used in our specification.[48] Our estimate of σ is also lower than those indirectly inferred from average markups under the assumption of monopolistic competition, as in Oberfield and Raval (2021) and Blaum, Lelarge, and Peters (2018). As with the elasticity of substitution between factors η, Online Appendix C.5 documents the robustness of our results across alternative samples, specification details, IV sets, and IV constructions (Online Appendix Tables C.5 and C.6).

VI. Fit of the Factor Demand Model: A Test

In Section II, 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 III, we have imposed specific parametric assumptions on preferences and technology that allow us to identify (as proved in Online Appendix D.1.1) the aggregate relative factor demand $RD(p^*, w)$ by combining the rich micro-data presented in Section IV with the two elasticities of substitution, η and σ, estimated in Section V. Going from micro to macro in this way, however, prompts 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?

48. Recall also that our sample covers final sales of domestic firms in all sectors, including retail (54.3% of final sales) and firms in construction (10.7%) and other services (18.2%). In Section VII.C, we explore the sensitivity of our conclusions to more flexible specifications that allow different degrees of substitutability in different broad sectors as well as a distinct treatment of retail activity.

VI.A. 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 in our sample. Starting from any equilibrium at date τ and differentiating the factor market clearing condition in equation (8) implies that up to a first-order approximation, changes in factor prices between date τ 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 Δ refers to changes between two consecutive periods, for example, $\Delta \ln w_\tau = \ln w_{\tau+1} - \ln w_\tau$, and the vector of structural demand shocks, $\varepsilon_{\tau+1}$, comprises relative supply and relative domestic demand shocks.[49] Summing across all years between $\tau = t_0$ and $t - 1$, we obtain the level of domestic factor prices, $\ln w^{model}_{f,t}$, predicted by our model in response to a sequence of foreign shocks, $\{\Delta \ln REE_\tau, \Delta \ln p^*_\tau\}_{\tau=t_0}^{t-1}$,

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

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

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

$$\ln w_{f,t} = \beta_{\text{fit}} \ln w^{model}_{f,t} + \epsilon_{f,t}, \tag{34}$$

with the structural error term $\epsilon_{f,t} \equiv \sum_{\tau=t_0}^{t-1} \varepsilon_{f,\tau+1}$. The fit coefficient β_{fit} should be equal to one under the null that our model

49. Specifically, we have $\varepsilon_{\tau+1} \equiv \left\{\Delta \ln\left(\frac{\bar{L}_{f,\tau}}{\bar{L}_{0,\tau}}\right)\right\} - \left(\frac{\partial \ln RD}{\partial \ln w}\right)_\tau^{-1} \left(\frac{\partial \ln RD}{\partial \ln \bar{\Theta}}\right)_\tau \Delta \ln \bar{\Theta}_\tau$, 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.

is correctly specified.[50] Because the changes in relative export exposures $\Delta \ln REE_t$ and foreign import prices $\Delta \ln p^*_t$ that enter $\ln w^{model}_{f,t}$ may be correlated with domestic demand shocks $\epsilon_{f,t}$ in Ecuador, we build the following IV for $\ln w^{model}_{f,t}$,

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

where $\widehat{REE}_\tau \equiv \left\{\frac{1-\frac{\hat{E}_{0,\tau}}{Y_{0,\tau}}}{1-\frac{\hat{E}_{f,\tau}}{Y_{f,\tau}}}\right\}$ 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 III 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 although one can always recover domestic residuals $\hat{\epsilon}_{f,t}$ such that equation (34) holds for $\beta_{\text{fit}} = 1$, such recovered residuals do not have to be orthogonal to our IV, $\ln \hat{w}^{model}_{f,t}$.[51] The flip side of this observation is that when imposing the orthogonality between $\ln \hat{w}^{model}_{f,t}$ and $\epsilon_{f,t}$, the estimated β_{fit} does not have to equal one. So our test has power against the null.

50. As noted in Table II, we always include factor and time fixed effects when estimating equation (34), so that estimates of β_{fit} are not sensitive to choices of the units of account for each factor (due to the factor fixed effect) or 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 Adão, Arkolakis, and Esposito (2020) do so to test the ability of different spatial models to replicate observed responses of regional outcomes to trade shocks.

51. Even though we relied on the same exogenous source of variation to estimate our two micro-level elasticities, $\ln w^{model}_{f,t}$ is a nonlinear 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 V to estimate η and σ within each CES nest.

TABLE II
GOODNESS OF FIT TESTS

	Δ Log of observed factor price				
	(1)	(2)	(3)	(4)	(5)
Δ Log of predicted factor price	1.10	1.61	1.26	1.04	0.89
	(0.15)	(0.62)	(0.62)	(0.16)	(0.20)
p-value (H_0: $\beta_{\text{fit}} = 1$)	[.53]	[.33]	[.68]	[.79]	[.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: column (2) EE_{f,t_0} and IE_{f,t_0}; column (3) capital factor indicators; column (4) province indicators; and column (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).

VI.B. Test Results

Table II reports our estimates of β_{fit}. Once again we take t_0 to be 2009–2011 as when estimating η and σ, so that initial shares in our IVs and controls are averaged over that period.

Remarkably, as seen in column (1), despite the strong parametric restrictions imposed in Section III, 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 = .53), 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 η and σ might also be successful. Figure C.7 in Online Appendix C.7 shows that this is not so. This analysis conducts the same macro tests as in Table II but for alternative values of η and σ. These results clearly indicate that $\hat{\beta}_{\text{fit}}$ departs from one as we move away from our baseline estimates of η and σ. 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 $\sigma \to \infty$.

VII. 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 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.

VII.A. Baseline Results

For our baseline results, we focus on the Ecuadorian economy at date $t = 2012$, the midpoint of our sample. To quantify the overall impact of trade on inequality at that date, we apply Proposition 1 and compute $(\Delta \ln w_t)_{trade} = \{\ln w_{f,t} - \ln(w_{f,t})_A\}$, 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 VI.A, 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.[52] Given changes in factor prices, the proportional changes in earnings of individual i between trade and autarky, $\frac{(\Delta Y_{i,t})_{trade}}{Y_{i,t}} = \frac{Y_{i,t} - (Y_{i,t})_A}{Y_{i,t}}$, as well as the changes in earnings associated with the export and import channels, $\frac{(\Delta Y_{i,t})_{exports}}{Y_{i,t}}$ and $\frac{(\Delta Y_{i,t})_{imports}}{Y_{i,t}}$, can be computed using the share of different factors f in individual i's earnings in the initial equilibrium, $\omega_{fi,t} \equiv \frac{Y_{fi,t}}{Y_{i,t}}$.[53]

52. 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. Because 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.

53. Online Appendix D.1.2 contains further details about the algorithm for calculating counterfactual factor price changes, and Online Appendix D.1.3 does the same for changes in individual earnings.

Figure IV 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 (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-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 Figure III, Panels A and B.[54] The existence of these opposing forces means that, in the case of Ecuador, an empirical analysis that might focus on only one of these channels would miss an important part of the distributional consequences of international trade.

The right panel of Figure IV combines the offsetting export and import channels. Evidently, the individuals in the top of Ecuador's income distribution 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 IV 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. By contrast, the return to highest-income labor is not particularly helped by trade.

54. To systematically explore the connection between the exposure measures presented in Section IV and the full effect of trade computed in this section, we regress $\frac{(\Delta Y_{i,t})_{trade}}{Y_{i,t}}$ on the exposure measures $EE_{i,t}$ and $IE_{i,t}$ defined in equations (21) and (23). The results are reported in Online Appendix Table 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.

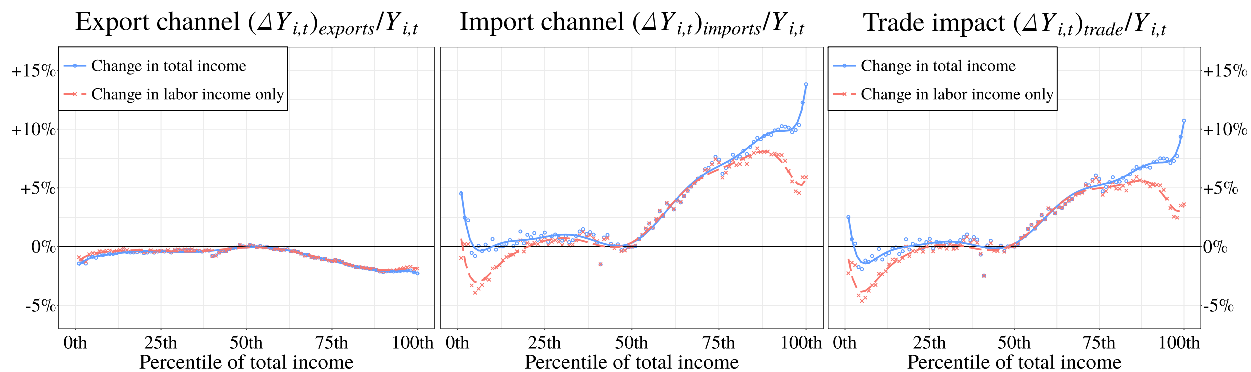

FIGURE IV

Trade and Earnings Inequality, Baseline

Blue circles 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 crosses do the same but for labor income only. Lines indicate fitted 10th-order polynomials. Trade impact is the sum of the export and import channels. All changes are expressed as percentages.

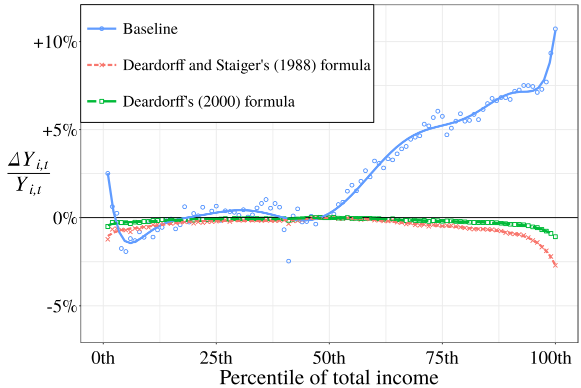

FIGURE V

Comparison with Original Factor Content Approach

Blue circles 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 IV. Red crosses and the dotted red line report the analog for the model in Deardorff and Staiger (1988), computed with the formula in equation (10) and $\eta_{agg} = 1$. Green squares and the dashed green line do the same for the model in Deardorff (2000), computed with the formula in equation (10) and $\eta_{agg} = 2.53$ (estimated using the strategy in Katz and Murphy 1992). Lines indicate a fitted 10th-order polynomial. All changes are expressed as percentages.

VII.B. *Comparison to Predictions from the Original Factor Content Approach*

As described in Section II.D, 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 ($\eta = 1$), perfect substitution between goods in each sector ($\sigma \to \infty$), and that all imported goods are produced at Home.

Figure V explores the consequences of imposing the previous assumptions—rather than estimating η and σ—by plotting the changes in earnings predicted by the formula displayed in equation (10) for $\eta_{agg} = 1$.[55] Figure V also plots the more flexible

55. 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 and the counterparts of the matrix of domestic factor shares, A, and the domestic input-output matrix, M, by adding up spending across all firms in each two-digit sector.

CES version of this formula with $\eta_{agg} \neq 1$, as derived in Deardorff (2000). In this second case, we estimate η_{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, Freeman, and Katz (1992), as described in Online Appendix C.6. Doing 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 I, but slightly higher than the aggregate elasticity of substitution estimated by Katz and Murphy (1992) for the United States.[56]

As is clear from Figure V, 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 Ecuador.

VII.C. Sensitivity Analysis

The goal of this section is to explore the sensitivity of the results in Figure IV 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 Online Appendices C.9 and D.2. All results focus on the effect of trade on total income, with the corresponding results for labor (and thus capital) income reported in Online Appendix D.2.6.

To go from changes in factor prices to changes in individual earnings, we follow the procedure described in Online Appendix D.1.3.

56. Compared to Katz and Murphy (1992), we estimate the elasticity of substitution between three education groups rather than only two, college and noncollege 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).

1. *Baseline Parameters.* The factor demand system of Section III.A contains two key micro-level elasticities: the within-firm elasticity of substitution between factors in production (η) and the within-industry elasticity of substitution between goods in consumption (σ). Figure VI, Panel A reproduces the counterfactual results in Figure IV 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 with a baseline value of $\eta = 2.10$, as well as high and low values of $\sigma = 1.5$ and 6, compared with a baseline value of $\sigma = 2.11$.[57] Lower values of either η or σ increase the estimated effects of trade on inequality, largely because they strengthen the import channel, but the qualitative features of relative effects are similar throughout the income distribution. Notably, changing σ has a larger effect than does η, a finding that echoes our analysis of the original factor content approach in Section VII.B.

2. *Technology.* For our second set of robustness checks, we generalize the nested CES production functions of Section III.A. 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 allow for a nonunitary elasticity of substitution between domestic intermediates, with an estimated value of 1.36, as well as a nonunitary elasticity of substitution between domestic and foreign intermediates, estimated to be 1.02. Figure VI, Panel B illustrates how these three departures affect our counterfactual results. Again, the qualitative effect 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.

57. The high values we use here correspond to the largest parameter values under which the goodness of fit tests in Section VI would fail to reject (see Online Appendix C.7). They encompass larger values than the maxima of the 95% confidence intervals reported in Table I.

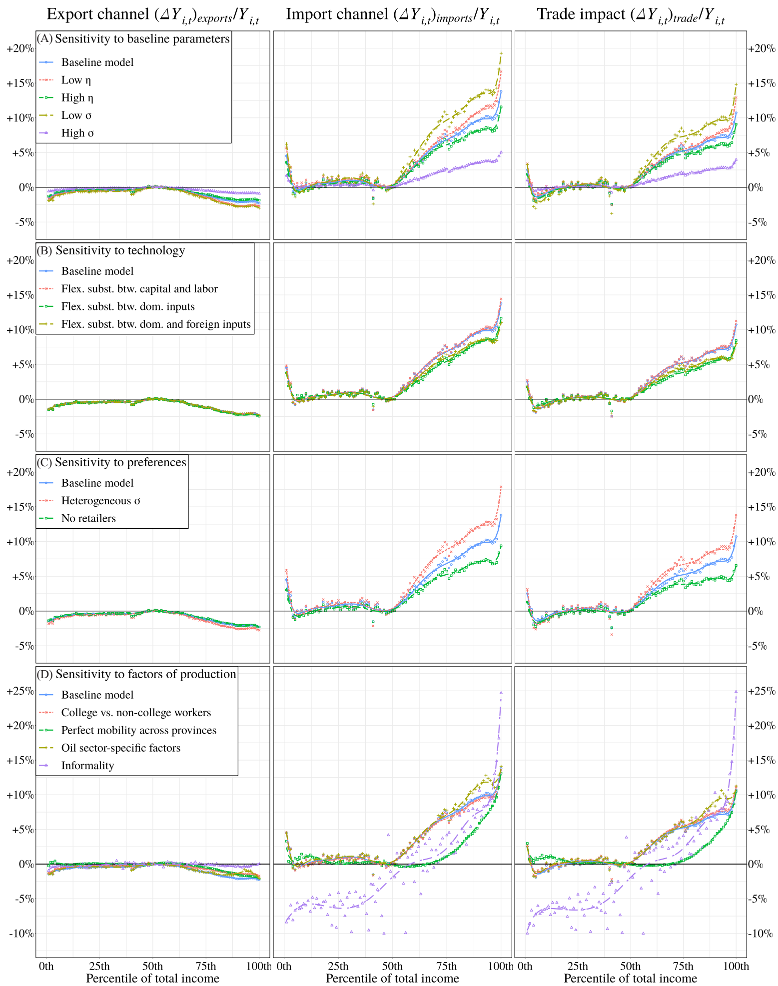

FIGURE VI

Trade and Earnings Inequality, Sensitivity Analysis

Point markers display the effect on total income at each income percentile (normalized to zero at the median and expressed as percentages). Blue circles denote predicted values for the baseline model (with $\sigma = 2.11$ and $\eta = 2.10$), as in Figure IV. Panel A uses alternative parameter values (η of 0.1 and 8, σ of 1.5 and 6). Panels B–D use alternative specifications of technology, preferences, and factors as described in Online Appendices D.2.1 (technology), D.2.1 (preferences), D.2.4 (retailers), and D.2.5 (informality), with the parameter estimates reported in Online Appendix Table C.9. Lines indicate a fitted 10th-order polynomial.

3. *Preferences.* Our next exercises focus on the specification of preferences. First, we allow for heterogeneity in the elasticity of substitution between goods (σ_k) in 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 Figure VI, Panel C, 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.

4. *Factors of Production.* We conclude by considering alternative treatments of primary factors of production. We group workers into two education groups (per province) based on college and noncollege attainment, which yields an estimated η of 1.96. We 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 η 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 in each factor group, as in Meghir, Narita, and Robin (2015) and Ulyssea (2018), and used by a representative informal firm in each sector that only sells to domestic consumers. To measure spending on informal factors, we draw on a representative survey of formal and informal sector earnings described in Online Appendix B.4. The results of these five alternative treatments of Ecuador's factors of production are shown in Figure VI, Panel D. 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.

5. *Summary.* Overall, we draw the following conclusions from Figure VI. First, the total effect 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 effect than does the import channel. Last, 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.[58]

VII.D. Trade and Observed Changes in Inequality

Our analysis focuses on the difference between autarky and trade at a given point in time, 2012. In Online Appendix D.3 we repeat such autarky-trade differences throughout the remainder of our sample period (2009–2015) to evaluate the contribution of trade to the large reduction in inequality observed in Ecuador over that time period.[59] We find that while trade is a force toward 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 muted 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 data set. As discussed further in Online 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.

58. The previous conclusions focus on the effect of trade on relative earnings. From an empirical standpoint, one of the main limitations of our data set 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 effect of trade on the cost of living of a representative Ecuadorian consumer. In the baseline model of Section VII.A, this effect 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 VII.C, 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.

59. These calculations incorporate informal factors as in Section VII.C.

VIII. Concluding remarks

What is the overall effect of international trade on earnings inequality? Without the ability to observe a given economy 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 proposed to tackle this classical question as one of factor supply and factor demand. We 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 estimated the overall incidence of international trade on earnings inequality, through both 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 reached the following empirical conclusions. In terms of exposure, we 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 which 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 data sets such as ours, combining VAT data with matched employer-employee records in countries like Belgium, Brazil, Chile, Costa Rica, the 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 can replicate the observed effect 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 conclude 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.

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Supplementary Material

An Online Appendix for this article can be found at *The Quarterly Journal of Economics* online.

Data Availability

Code replicating the tables and figures in this article can be found in Adão et al. (2022) in the Harvard Dataverse, https://doi.org/10.7910/DVN/DJE8I1.

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