Productivity, (Mis)allocation and Trade*

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Abstract

We examine the impact of international trade on aggregate productivity. Theoretically, we show that bilateral and unilateral export liberalization increase aggregate welfare and productivity, while unilateral import liberalization can either raise or reduce it. However, all three trade reforms have ambiguous effects in the presence of resource misallocation. Using unique new data on 14 European countries and 20 manufacturing industries during 1998-2011, we establish empirically that exogenous shocks to both export demand and import competition generate large gains in aggregate productivity. Although both trade activities increase average firm productivity, export expansion enhances allocative efficiency across firms, while import penetration leaves it unchanged or diminished. These effects operate through a combination of improved firm selection, within-firm productivity upgrading, and reallocation across firms. Finally, efficient institutions, factor and product markets amplify the productivity gains from import competition, but dampen those from export expansion.

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1 Introduction

World trade has steadily grown faster than world GDP since the early 1970s, and it expanded twice as quickly between 1985 and 2007.[1] This development was driven by sharp declines in trade policy barriers, continued reductions in transportation costs, and significant improvements in information and communication technologies. Of great policy interest is how globalization affects aggregate productivity and welfare, and how its impact differs across countries at different levels of economic development. In advanced economies, increased competition from low-wage countries has exacerbated public debates about the gains from trade, in the face of rising concerns about domestic employment and inequality and China's dramatic trade expansion after joining the WTO in 2001. In developing countries, trade reforms have not always yielded all or only the desired benefits, leading policy makers to question the merits of trade openness in light of weak macroeconomic fundamentals or structural transformation.

Economics theory provides a clear rationale for trade liberalization: it enables a more efficient organization of production across countries, sectors, and firms, which generates aggregate productivity growth and welfare gains. In particular, heterogenous-firm trade models emphasize the importance of firm selection, the reallocation of activity across firms, and within-firm productivity ugprading as key channels mediating these gains (e.g. Melitz 2003, Lileeva and Trefler 2010). At the same time, recent macroeconomics and growth research highlights how institutional and market frictions distort the allocation of productive resources across firms and thereby reduce aggregate productivity (e.g. Hsieh and Klenow 2009). How such frictions modify the gains from trade remains, however, poorly understood.

This paper investigates the impact of international trade on aggregate productivity. Theoretically, we show that bilateral and unilateral export liberalization increase aggregate productivity, while unilateral import liberalization can either raise or reduce it. However, all three trade reforms have ambiguous effects in the presence of resource misallocation. Using unique new data on 14 European countries and 20 manufacturing industries during 1998-2011, we establish empirically that exogenous shocks to both export demand and import competition generate large gains in aggregate productivity. Although both trade activities increase average firm productivity, export expansion enhances allocative efficiency across firms, while import penetration leaves it unchanged or diminished. We demonstrate that these effects operate through a combination of improved firm selection, within-firm productivity upgrading, and reallocation across firms. We further document that efficient institutions, factor and product markets amplify the productivity gains from import competition, but dampen those from export expansion.

We begin by theoretically examining the impact of trade liberalization in a heterogeneous-firm trade model. We emphasize three main results. First, reductions both in bilateral trade costs and in unilateral export costs unambiguously raise aggregate productivity and welfare, as in Melitz (2003). On the extensive margin, such reforms raise the threshold productivity level above which domestic firms can operate. On the intensive margin, they trigger reallocations of productive activity from less towards more productive firms. By constrast, unilateral import reforms have ambiguous implications because

[1] See Chapter 2 of the World Economic Outlook published by the International Monetary Fund in October 2016.

in general equilibrium they increase market competitiveness both in the liberalizing country and in its trade partner, with opposite effects on the productivity cut-off at home. This results in welfare and productivity gains when wages are flexible, but leads to Metzler-paradox losses when wages are set in an outside sector or sticky in the short run, as discussed in Demidova and Rodriguez-Clare (2013) and Bagwell and Lee (2016). With economies of scale in innovation and adoption, all three types of trade reforms can – but are not guaranteed to – induce within-firm productivity upgrading as in Bustos (2011), an additional source of aggregate gains.

Second, we formally establish that resource misallocation across firms can either amplify or dampen the gains from globalization, such that the impact of both bilateral and unilateral trade reforms on aggregate productivity and welfare becomes ambiguous in general. In our model, firms receive two exogenous draws, productivity φ and distortion η. Distortions η create a wedge between the social and the private marginal cost of production, and result in an inefficient allocation of production resources and market shares across firms. We think of misallocation as arising from institutional imperfections that generate frictions in factor markets for capital and labor and in product markets for firm outputs; we purposefully adopt CES preferences to abstract away from misallocation due to variable mark-ups as in Dhingra and Morrow (2014). We use two model parameters to characterize a higher degree of resource misallocation: a bigger dispersion σ_η of η and a lower correlation $\rho(\varphi, \eta)$ between φ and η. We numerically simulate the model using calibrated parameters from Burstein and Cravino (2015), and conclude that the gains from trade increase smoothly with $\rho(\varphi, \eta)$, are more likely to be positive when $\rho(\varphi, \eta) > 0$, and are a non-monotonic function of σ_η.

Third, we use our model to show how key theoretical concepts map to empirically observable variables and how theoretical mechanisms can be assessed with available data. In particular, we decompose aggregate productivity into average firm productivity and the covariance of firms' productivity and share of total employment, as in Olley and Pakes (1998) and Melitz and Polanec (2015). We demonstrate that the former component captures firm selection and within-firm productivity upgrading, while the latter signals allocative efficiency and is a function of both parameters governing misallocation, σ_η and $\rho(\varphi, \eta)$. This implies that one can study the channels through which trade affects aggregate productivity by evaluating its impact on these two productivity components. Moreover, as do Bartelsman, Haltiwanger and Scarpetta (2013) and Foster, Haltiwanger and Scarpetta (2015, 2016), we too find that misallocation cannot be gauged from the observed cross-firm dispersion in revenue-based total factor productivity or in marginal revenue products of input factors (capital, labor). While these dispersion measures have been proven to indicate misallocation under certain assumptions about the economic environment, they do not in the presence of production and export economies of scale as in our framework.

Guided by this theoretical framework, we empirically examine the effect of international trade on aggregate productivity and the mechanisms through which this effect acts. We use rich new data assembled by the Competitive Research Network at the ECB that allows us to operationalize the Olley-Pakes decomposition of aggregate labor productivity for 14 European countries and 20 manufacturing industries during 1998-2011. These data are unique in capturing not only aggregate outcomes at the country-sector-year level, but also multiple moments of the underlying distribution across firms. We exploit the World Input-Output Database on global trade flows to measure export and import activity at the country-sector-year level. In order to identify the causal impacts of export expansion and import competition, we use import tariffs and Bartik-style measures for foreign import demand and foreign export supply as instruments in a 2SLS IV strategy. We provide consistent results when we alternatively consider import competition specifically from China, and construct corresponding instruments for this China shock. We also confirm the stability of our findings to a series of specification checks and robustness exercises.

We establish three sets of empirical results. These results are consistent with the mechanisms illustrated in the model, and provide a quantification of the theoretically ambiguous effects of trade. First, export expansion and import penetration both significantly increase aggregate productivity. Based on the observed variation in our panel, a one-standard-deviation change in export demand would boost overall productivity by 57%-74% depending on the specification, while a comparable rise in import competition would generates estimates in the 9.8%-58% range.

Second, we find that the productivity gains from export and import activity are mediated through different channels. Export growth induces both sizeable improvements in average firm productivity and a reallocation of economic activity towards more productive firms. Enhanced allocative efficiency contributes 1/4 to 1/3 of the total effect. By contrast, all of the productivity benefits from import competition result from higher average firm productivity. Across alternative specifications, import penetration has either a negligible effect on allocative efficiency or negates up to 1/3 of average productivity growth by shifting economic activity towards less productive firms. By conditioning on the measure of firms and the minimum productivity level across firms in a given economy, we conclude that both dimensions of international trade improve firm selection by triggering exit from the left tail of the productivity distribution. Similar exercises based on R&D expenditure data indicate an important role for within-firm productivity upgrading as well.

Finally, we document that efficient institutions, factor and product markets amplify the productivity gains from import competition, but dampen those from export expansion. We consider rule of law as an overall indicator of the strength of institutions required to sustain economic transactions and activity. We also rely on indices for labor market flexibility, financial market development and product market regulation to proxy the structural causes of frictions that firms face in input and output markets. These findings reveal the complex interaction between trade openness and resource misallocation that determine aggregate welfare outcomes. In particular, they point to asymmetries in the ability of distorted economies to respond to and gain from positive shocks to domestic firms such as rising export demand vs. negative shocks such as tighter import competition.

Our primary contribution is to characterize and quantify the productivity gains from trade while distinguishing between export and import exposure and unpacking the adjustments to average firm productivity and resource allocation across firms. We thus speak to a vibrant theoretical trade literature on the role of firm heterogeneity for the welfare gains from globalization and inform the empirical validity of the mechanisms it highlights (e.g. Arkolakis, Costinot and Ridriguez-Clare 2012, Melitz and Redding 2014). Prior empirical work on this question has typically examined one-sided trade liberalization episodes in specific countries, often exploiting micro-level data. By contrast, we provide systematic cross-country evidence which nevertheless allows us to examine the firm dimension, establish causality, and directly compare the impact of export and import expansion.

We find evidence consistent with several mechanisms identified in previous studies. For example, Pavcnik (2002) explores the aggregate productivity gains from trade reforms in Chile in the late 1970s. Using a decomposition similar to ours, she concludes that about 2/3 of the gains resulted from improvements in the Olley-Pakes covariance term. On the other hand, Harrison et al. (2013) find that most of the productivity benefits from trade liberalization in India during 1990-2010 resulted from changes in the average productivity of surviving firms. In the case of the US, Bernard, Jensen and Schott (2006) show that following a decline in trade barriers, liberalized sectors experienced faster productivity growth both because the least productive firms exited and because more productive firms expanded operations. Several other adjustments within surviving firms have been documented in response to trade reforms, namely production technology upgrading (Lileeva and Trefler 2010, Bustos 2011, Bloom et al. 2016), product quality upgrading (Amiti and Koenings 2007, Amiti and Khandelwal 2013, Martin and Mejean 2014), reallocations across multiple products (Bernard, Redding and Schott 2011, Mayer, Melitz and Ottaviano 2014, Manova and Yu 2016), and product scope expansion (Goldberg et al. 2010, Khandelwal and Topalova 2013).

Our second contribution is to analyze the implications of resource misallocation for the adjustment to and welfare gains from trade. A burgeoning literature in macroeconomics shows that market frictions can distort the allocation of resources across firms and lower aggregate productivity (Hsieh and Klenow 2009, Epifani and Gancia 2011, Bartelsman, Haltiwanger and Sacrpetta 2013, Gopinath et al. 2015, Edmond, Midrigan and Xu 2015, Foster et al. 2008, Foster et al. 2015, 2016). At the same time, a growing body of work documents the detrimental impact of financial and labor market frictions on international trade activity (Chor and Manova 2012, Manova 2013, Foley and Manova 2015, Helpman, Itskhoki and Redding 2010, Cuñat and Melitz 2012). We draw on insights from these two strands of research to inform the fundamental question of welfare gains from trade in the presence of imperfect resource allocation. Our findings relate to several concurrent studies in this vein. Ben, Yahmed and Dougherty (2017) find that the impact of import competition on firm productivity depends on the degree of product market regulation, while Alfaro and Chen (2017) conclude that greater competition from multinational firms fosters productivity-enhancing reallocations of activity among domestic firms. Ding, Jiang and Sun (2016) document that import competition reduces productivity dispersion in China due to the exit of less productive firms.

The rest of the paper is organized as follows. Section 2 examines the impact of globalization on aggregate productivity through theoretical and numerical analyses. Section 3 introduces the data we use to study these questions empirically. Section 4 presents our baseline OLS estimates, while Section

4 develops our IV estimation strategy and reports our main IV results. Section 5 explores underlying transmission mechanisms through additional exercises within the IV estimation framework. The last section concludes.

2 Theoretical Framework (preliminary and incomplete)

We begin by theoretically examining the impact of international trade on aggregate welfare and productivity in different economic environments. Our goal is threefold. First, we highlight that in the absence of resource misallocation, bilateral and unilateral export liberalizations always raise welfare, while unilateral import liberalization can have ambiguous effects. Second, we show that all three types of globalization have ambiguous welfare consequences in the presense of misallocation. Third, we characterize the relationship between model concepts and observed measures of productivity at the firm and aggregate levels to provide a bridge between theory and empirics.

Our framework incorporates firm heterogeneity in productivity as in Melitz (2003) and resource misallocation as in Bartelsman, Haltiwanger and Scarpetta (2013). We provide economic intuition for the economic mechanisms and key results of interest, and relegate all former proofs and derivations to the Appendix.

2.1 Economic Environment

Consider a world in general equilibrium with two countries $i = 1, 2$. In each country, a measure L_i of consumers inelastically supplies a unit of labor, such that aggregate expenditure is $R_i = w_i L_i$. The utility of the representative consumer U_i is a Cobb-Douglas function of consumption of a homogenous good H_i and a CES aggregate over consumption of available differentiated varieties $z \in \Omega_i$ with elasticity of substitution $\sigma \equiv 1/(1-\alpha)$:

$$U_i = H_i^{1-\beta} Q_i^{\beta}, \quad Q_i = \left[\int_{z \in \Omega_i} q_i(z)^{\alpha} \, dz \right]^{1/\alpha}. \tag{2.1}$$

The homogeneous good is freely tradeable and produced under CRS technology that converts one unit of labor into one unit of output. It proves important to distinguish between two cases. When β is sufficiently low, both countries produce the homogeneous good, such that it serves as a numeraire that fixes worldwide wages to unity, $w_i = 1$. When $\beta = 1$ by contrast, only differentiated goods are consumed and wages are endogenously determined in equilibrium.

Demand $q_i(z)$ for a differentiated variety z with price $p_i(z)$ in country i is given by:

$$q_i(z) = \beta R_i P_i^{\sigma-1} p_i(z)^{-\sigma}, \quad P_i = \left[\int_{z \in \Omega_i} p_i(z)^{1-\sigma} \, dz \right]^{\frac{1}{1-\sigma}}, \tag{2.2}$$

where βR_i is total expenditure on differentiated goods, and P_i is an ideal price index.

In each country, a continuum of firms produce horizontally differentiated goods that they can sell at home and potentially export abroad. Upon paying a sunk entry cost $w_i f_i^E$, firms draw a productivity level φ from a known distribution $G_i(\varphi)$, which determines their variable production cost per unit of output, w_i/φ. Manufacturing in country i entails fixed operation costs $w_i f_{ii}$, while exporting from i to j requires both fixed overhead costs $w_i f_{ij}$ and iceberg trade costs such that τ_{ij} units of a product need to be shipped for 1 unit to arrive. We assume $\tau_{ii} = 1$ and $\tau_{ij} > 1$ if $i \neq j$. We will think of τ_{ij} as comprising both transportation and tariff duties, and consider reductions in τ_{ij} to analyze the impact of trade liberalization.

Firms choose their sales price and quantity to maximize profits separately in each market they service. The problem of a firm with productivity φ and its optimal revenues and profits are thus respectively:

$$\begin{aligned} \max_{p,q} \pi_{ij}(\varphi) &= p_{ij}(\varphi)q_{ij}(\varphi) - \tau_{ij} w_i q_{ij}(\varphi)/\varphi - w_i f_{ij} \quad \text{s.t.} \quad q_{ij}(\varphi) = \beta R_j P_j^{\sigma-1} p_{ij}(\varphi)^{-\sigma} \\ \implies r_{ij}(\varphi) &= \beta R_j \left(\frac{\alpha P_j \varphi}{\tau_{ij} w_i}\right)^{\sigma-1}, \quad \pi_{ij}(\varphi) = \frac{r_{ij}(\varphi)}{\sigma} - w_i f_{ij}. \end{aligned} \tag{2.3}$$

Since profits are monotonically increasing in productivity, firms in country i export to country j only if their productivity exceeds a threshold φ_{ij}^*. In turn, consumer love of variety and the fixed operation costs imply that no firm exports without also serving its home market. Upon entry, firms in country i therefore commence production only if their productivity draw is above a minimum level φ_{ii}^*, and exit otherwise. These two domestic and export cut-offs are implicitly defined by:

$$r_{ii}(\varphi_{ii}^*) = \sigma w_i f_{ii}, \quad r_{ij}(\varphi_{ij}^*) = \sigma w_i f_{ij}. \tag{2.4}$$

We assume as standard that the parameter space guarantees firm selection into exporting, i.e. $\varphi_{ij}^* > \varphi_{ii}^*$ for any $\tau_{ij} > 1$. The cut-off expressions imply a precise relationship between the productivity thresholds for local and foreign firms wishing to serve the same market j:

$$\varphi_{ij}^* = \left(\frac{f_{ij}}{f_{jj}}\right)^{\frac{1}{\sigma-1}} \left(\frac{w_i}{w_j}\right)^{\frac{\sigma}{\sigma-1}} \tau_{ij} \varphi_{jj}^*. \tag{2.5}$$

With free entry, ex-ante expected profits must be zero in equilibrium. Since the ratio of two firms' sales in a given market, $r_{ij}(\varphi')/r_{ij}(\varphi)$, depends only on the ratio of their productivity levels, φ'/φ, the free entry condition can be expressed as follows:

$$f_{ii} \int_{\varphi_{ii}^*}^{\infty} \left[\left(\frac{\varphi}{\varphi_{ii}^*}\right)^{\sigma-1} - 1\right] dG_i(\varphi) + f_{ij} \int_{\varphi_{ij}^*}^{\infty} \left[\left(\frac{\varphi}{\varphi_{ij}^*}\right)^{\sigma-1} - 1\right] dG_i(\varphi) = f_i^E. \tag{2.6}$$

In this environment, two different indicators of aggregate productivity are economically relevant. From the perspective of consumers who demand both domestically produced and imported varieties, $\widetilde{\varphi}_{iT}$ is the total weighted average productivity across all i and j firms selling in country i, using their sales in i as weights. From the perspective of domestic producers, aggregate productivity $\widetilde{\varphi}_i$ is the weighted average across all firms producing in country i, using their global sales as weights. Since a firm's market share at home and abroad is pinned down by its productivity draw, $\widetilde{\varphi}_{iT}$ and $\widetilde{\varphi}_i$ are given by:

$$\widetilde{\varphi}_{iT}^{\sigma-1} = \frac{M_i}{M_i + M_{ji}} \int_{\varphi_{ii}^*}^{\infty} \varphi^{\sigma-1} \frac{dG_i(\varphi)}{1 - G_i(\varphi_{ii}^*)} + \frac{M_{ji}}{M_i + M_{ji}} \tau_{ji}^{1-\sigma} \int_{\varphi_{ji}^*}^{\infty} \varphi^{\sigma-1} \frac{dG_j(\varphi)}{1 - G_j(\varphi_{ji}^*)}, \tag{2.7}$$

$$\widetilde{\varphi}_i^{\sigma-1} = \frac{M_i}{M_i + M_{ij}} \int_{\varphi_{ii}^*}^{\infty} \varphi^{\sigma-1} \frac{dG_i(\varphi)}{1 - G_i(\varphi_{ii}^*)} + \frac{M_{ij}}{M_i + M_{ij}} \tau_{ij}^{1-\sigma} \int_{\varphi_{ij}^*}^{\infty} \varphi^{\sigma-1} \frac{dG_i(\varphi)}{1 - G_i(\varphi_{ij}^*)}, \tag{2.8}$$

where M_i is the measure of domestic firms active in i and $M_{ij} = \frac{1-G_i(\varphi_{ij}^*)}{1-G_i(\varphi_{ii}^*)} M_i$ is the measure of i firms exporting to j. Note that $\widetilde{\varphi}_{iT} = \widetilde{\varphi}_i$ with symmetric countries and bilateral trade costs, but this need not hold more generally.

Finally, consumer welfare is given by the real wage w_i/P_i, and is a function solely of the productivity cut-off for domestic production φ_{ii}^* and model parameters.

$$\frac{w_i}{P_i} = \left(\frac{\beta L_i}{\sigma f_{ii}} \right)^{\frac{1}{\sigma-1}} \alpha \varphi_{ii}^*. \tag{2.9}$$

It is useful to point out four features of the open economy equilibrium that inform the mechanisms through which trade liberalization affects welfare.[2] For convenience, we state them as lemmas here and refer to them in the discussion below.

Lemma 1: Trade liberalization moves the productivity cut-offs in country i for domestic production and for exporting in opposite directions, i.e. either (i) $d\varphi_{ii}^*/d\tau > 0 > d\varphi_{ij}^*/d\tau$ or (ii) $d\varphi_{ii}^*/d\tau < 0 < d\varphi_{ij}^*/d\tau$.

This result follows directly from equation (2.6). Intuitively, any force that lowers the productivity cut-off for exporting tends to increase expected export profits conditional on production. For free entry to continue to hold, the probability of survival conditional on entry must therefore fall, such that overall expected profits from entry can remain unchanged. This logic applies to any change in the economic environment, including trade reforms that affect τ_{ij}, τ_{ji}, or both.

Lemma 2: Trade liberalization brings the productivity cut-offs for domestic and foreign firm entry in country j closer if wages are exogenously fixed, i.e. $d\left(\varphi_{ij}^*/\varphi_{jj}^*\right)/d\tau_{ij} > 0$ if $\beta < 1$. This effect is ambiguous with endogenous wages, i.e. $d\left(\varphi_{ij}^*/\varphi_{jj}^*\right)/d\tau_{ij} \gtrless 0$ if $\beta = 1$.

This conclusion is based on equation (2.5). Intuitively, a firm from country i has to pay both fixed and variable trade costs to penetrate market j, while a local firm headquartered in country j does not. When $w_i = w_j = 1$, country i firms thus have to clear a higher productivity cut-off than country j firms in order to be sufficiently competitive to generate non-negative profits in j, such that $\varphi_{ij}^* > \varphi_{jj}^*$. Reductions in bilateral export costs τ_{ij} narrow this gap. Cross-country differences in wages modify these comparisons as a foreign firm that incurs lower labor costs might be more competitive than a local producer despite the presence of trade costs. If trade reforms trigger endogenous adjustments in relative wages w_i/w_j, the impact on the cut-off ratio $\varphi_{ij}^*/\varphi_{jj}^*$ becomes ambiguous.

Lemma 3: Aggregate welfare in country i increases monotonically with the productivity cut-off for

[2] When $\beta < 1$ and the homogeneous-good sector is active, the model is closed with an additional condition that relates the mass of firm entrants to the mass of active firms and an exogenous probability of firm death. When $\beta = 1$ instead, the complete characterization of the general equilibrium further requires balanced trade in the differentiated goods sector that implicitly links productivity thresholds and relative wages across countries.

domestic production in i, i.e. $d\left(w_i/P_i\right)/d\varphi_{ii}^* > 0$.

This comparative static can be derived from equation (2.9). Intuitively, when the productivity cut-off for domestic production rises, there is a reallocation of economic activity towards more productive firms both along the extensive margin of firm survival and along the intensive margin of firm sales and employment. This reallocation tends to reduce the aggregate price index and improve consumers' real purchasing power. These forces dominate any potential welfare loss associated with a possible decline in the measure of domestic firms and hence of available domestic product varieties. Conversely, any potential expansion in the measure of domestic firms and/or in the measure of imported foreign varieties would instead amplify the welfare gains. A direct implication of Lemma 3 is that the productivity threshold φ_{ii}^* is a sufficient statistic, such that the welfare impact of trade liberalization can be assessed with its effect on φ_{ii}^*.

Lemma 4: Aggregate welfare in country i increases monotonically with the total productivity across all firms selling in i, but not with the aggregate productivity across all firms producing in i, i.e. $d\left(w_i/P_i\right)/d\widetilde{\varphi}_{iT} > 0$ and $d\left(w_i/P_i\right)/d\widetilde{\varphi}_i \gtrless 0$.

This implication follows from equations (2.9), (2.7) and (2.8). Intuitively, the consumer price index depends on the prices and market shares of all varieties sold in a given market, and therefore implicitly on the productivity of all firms supplying that market captured by $\widetilde{\varphi}_{iT}$. By contrast, the aggregate productivity of all domestic firms $\widetilde{\varphi}_i$ is relevant for the producer price index in a country and its aggregate economic growth, but is not directly linked to consumer welfare. Thus although these two objects are jointly determined with the endogenous productivity cut-offs in general equilibrium, they need not be monotonically related to each other and generally depend on the shape of the underlying productivity distributions. In the case of symmetric countries, however, the measure, productivity, prices and market shares of firms exporting from i to j is identical to that of firms exporting from j to i, such that $\widetilde{\varphi}_{iT} = \widetilde{\varphi}_i$ and welfare in i rises smoothly with aggregate productivity $\widetilde{\varphi}_i$.

2.2 From Theory to Empirics

A key challenge in empirically evaluating the gains from trade is that one does not directly observe welfare, nor the theoretical concepts of firm-level and aggregate productivity. It is thus important to establish how these theoretical objects relate to their measured counterparts, in order to correctly design and interpret empirical analysis. In this section, we provide precisely such a mapping. In subsequent sections, we characterize the predicted impact of globalization on aggregate welfare and productivity as defined in the model, as well as on aggregate productivity as measured in the data.

In our empirical exercise, we will measure firm productivity φ with the log real value added per worker $\Phi_i(\varphi)$. Observed value added corresponds to the theoretical notion of total firm revenues $r_i(\varphi)$ from domestic sales and any exports abroad, where $r_i(\varphi) \equiv \sum_j r_{ij}(\varphi)\mathbf{I}(\varphi \geq \varphi_{ij}^*)$ and $\mathbf{I}$ is the indicator function. Total firm employment $l_i(\varphi)$ represents the overall number of labor units that the firm hires for its fixed and variable costs of domestic production and any export activity. In particular, $l_i(\varphi) = \sum_j [\tau_{ij} q_{ij}(\varphi)/\varphi + f_{ij}] \mathbf{I}(\varphi \geq \varphi^*_{ij})$. It is convenient to denote labor used specifically towards fixed costs as $f_i(\varphi) = \sum_j f_{ij}\mathbf{I}(\varphi \geq \varphi^*_{ij})$. Deflating by the country-specific price index P_i, measured firm productivity becomes:

$$\Phi_i(\varphi) = \frac{r_i(\varphi)}{P_i l_i(\varphi)} = \frac{w_i}{\alpha P_i}\left[1 - \frac{f_i(\varphi)}{l_i(\varphi)}\right]. \tag{2.10}$$

It can be shown that the ranking of theoretical and measured productivity for two firms with the same export status is always preserved. Note that given CES preferences and monopolistic competition, firms set a constant mark-up above marginal cost, and the ratio of firm sales to variable labor employment, $r_i(\varphi)/[l_i(\varphi) - f_i(\varphi)]$, is invariant across firms. However, economies of scale in production and exporting ensure that real value added per total employment, $\Phi_i(\varphi)$, is a strictly increasing function of the theoretical notion of quantity-based productivity φ in the subsample of non-exporters and in the subsample of exporters.

One can also show that the measured productivity of a given firm based on domestic sales should it not export exceeds its measured productivity based on global sales should it export, even though the actual productivity of the firm φ is unchanged.[3] This is due to a downward shift in the function $\Phi_i(\varphi)$ at the export productivity cut-off φ^*_{ij}, because firms incur discontinuously higher fixed costs upon export entry, while export revenues rise smoothly with productivity. In addition, changes in the domestic and export productivity cut-offs change the measured productivity of a given firm as indicated in Lemma 5:

Lemma 5: Conditional on export status, measured firm productivity increases monotonically with theoretical firm productivity, i.e. $\Phi'(\varphi) > 0$. For non-exporters, measured productivity decreases with the domestic productivity cut-off φ^*_{ii} and increases with the real wage w_i/P_i. For exporters, measured productivity increases with the domestic productivity cut-off φ^*_{ii}, the domestic-to-export cut-off ratio $\varphi^*_{ii}/\varphi^*_{ij}$, and the real wage w_i/P_i.

In the data, we will measure aggregate productivity $\widetilde{\varphi}_i$ with a size-weighted average of firm productivity, $\tilde{\Phi}_i$. As weights, we will use a model-consistent indicator of firms' contribution to economic activity, namely firms' share of total employment in production, $\theta_i(\varphi) = l_i(\varphi)/\int_{\varphi^*_{ii}}^{\infty} l_i(\varphi)\,\frac{dG_i(\varphi)}{1-G_i(\varphi^*_{ii})}$:[4]

$$\tilde{\Phi}_i \equiv \int_{\varphi^*_{ii}}^{\infty} \theta_i(\varphi)\Phi_i(\varphi)\,\frac{dG_i(\varphi)}{1 - G_i(\varphi^*_{ii})}. \tag{2.11}$$

One can show that this empirical proxy for aggregate productivity can be rewritten in terms of the theoretical concept of welfare, w_i/P_i, and a multiplicative factor that depends on total labor embodied

[3] For the case of two non-exporting firms, it is easy to show that $\Phi_i(\varphi) = w_i \frac{\varphi^{\sigma-1}}{\alpha\varphi^{\sigma-1} + (1-\alpha)\left(\varphi^*_{ii}\right)^{\sigma-1}}$ such that $\Phi_i(\varphi') > \Phi_i(\varphi)$ if and only if $\varphi' > \varphi$. For the case of two exporting firms, the expression for $\Phi_i(\varphi)$ does not simplify as neatly when there is asymmetry in countries' market size, aggregate expenditure and aggregate price index, but one can nevertheless show that $\Phi_i(\varphi') > \Phi_i(\varphi)$ if and only if $\varphi' > \varphi$.

[4] Our empirical results are unchanged if we instead construct aggregate productivity using firm sales as weights. We work with employment weights because they produce model-consistent measures for aggregate productivity and are immune to potential variation in the price deflator across firms.

in the fixed costs of entry, production and exporting incurred across all firms in the economy, $\tilde{f}_i$:

$$\tilde{\Phi}_i = \frac{w_i}{P_i} \frac{\sigma \tilde{f}_i}{\sigma \tilde{f}_i - f_i^E}, \quad \text{where} \quad \tilde{f}_i \equiv f_i^E + \sum_j \left[1 - G_i(\varphi_{ij}^*)\right] f_{ij}. \tag{2.12}$$

In general, $\tilde{f}_i$ is an endogenous function of the productivity cut-offs for domestic production and exporting. Our numerical simulations in Section 2.6, however, indicate that welfare increases monotonically with measured aggregate productivity under reasonable assumptions about model parameters taken from the existing literature, as well as under parameter values calibrated to our data. Moreover, one can establish this result analytically in the empirically relevant case of firm productivity distributed Pareto with shape parameters φ_m and $\gamma > \sigma - 1$. In this case, $\tilde{f}_i = f_i^E \gamma / (\sigma - 1)$ is a constant determined solely by model parameters, such that measured aggregate productivity constitutes a summary statistic for welfare:

$$\tilde{\Phi}_i = \frac{w_i}{P_i} \left(1 - \frac{\alpha}{\gamma}\right) \quad \text{if} \quad G_i(\varphi) = 1 - (\varphi_m/\varphi)^\gamma. \tag{2.13}$$

We summarize these results with the following lemma:

Lemma 6: Welfare increases monotonically with measured aggregate productivity, i.e. $d\,(w_i/P_i)\,/d\tilde{\Phi}_i > 0$.

As an accounting identity a la Olley and Pakes (1996), aggregate measured productivity $\tilde{\Phi}_i$ can be decomposed into an unweighted average productivity across firms, $\overline{\Phi}_i$, and the covariance between firms' productivity and share of economic activity, Cov_i:

$$\tilde{\Phi}_i = \overline{\Phi}_i + Cov_i = \int_{\varphi_{ii}^*}^{\infty} \Phi_i(\varphi) \frac{dG_i(\varphi)}{1 - G_i(\varphi_{ii}^*)} + \int_{\varphi_{ii}^*}^{\infty} \left[\Phi_i(\varphi) - \overline{\Phi}_i\right] \left[\theta_i(\varphi) - \overline{\theta}_i\right] \frac{dG_i(\varphi)}{1 - G_i(\varphi_{ii}^*)}. \tag{2.14}$$

In this OP decomposition, changes in $\overline{\Phi}_i$ reflect two extensive-margin effects of firm selection on measured aggregate productivity: exit and entry into production which modifies the set of active firms, and exit and entry into exporting which preserves the set of active firms but impacts measured productivity at the firm level. On the other hand, changes in Cov_i identify intensive-margin reallocations of economic activity across firms with different productivity levels through changes in their share of total employment and, implicitly, output and sales. Notice that both $\Phi_i(\varphi)$ and $\theta_i(\varphi)$ are increasing in φ, such that the covariance term must be positive.

The covariance term Cov_i is often referred to as the OP gap. It is a summary statistic for the extent to which more productive firms capture a bigger share of production resources and consumer markets, and thus serves as an indicator of allocative efficiency in an economy. It is important to note that the optimal allocation of resources across firms generally depends on the economic environment (i.e. demand structure, nature of firm competition, etc.), and no specific value for Cov_i signals perfect allocative efficiency in an absolute sense. Within the context of a given economic environment, however, increases and reductions in Cov_i can be interpreted respectively as improvements and deteriorations in the efficiency of resource allocation. As we elaborate in Section 6.4, this interpretation is moreover not sensitive to specific assumptions about the market structure or the production technology that alternative measures of allocative efficiency require.

2.3 Trade Liberalization With Flexible Wages

We are now in a position to examine the impact of trade liberalization on five outcomes of interest: the theoretically defined welfare w_i/P_i and aggregate productivity $\widetilde{\varphi}_i$, and the empirically measured aggregate productivity $\tilde{\Phi}_i$, unweighted average productivity $\overline{\Phi}_i$, and OP gap Cov_i. We consider three forms of trade liberalization: a bilateral, symmetric reduction in variable trade costs τ_{ij} and τ_{ji}, a unilateral reduction in export costs τ_{ij}, and a unilateral reduction in import costs τ_{ji}. We examine the adjustment mechanisms that such reforms trigger, and analyze which effects can be unambiguously signed and which are theoretically ambiguous. We evaluate all of these effects through numerical simulations in Section 2.6.

It proves important to distinguish economic environments with and without flexible wages. In this subsection, we study the case when $\beta = 1$. In this case, countries produce differentited goods only, and equilibrium wages w_i are determined by labor market clearing and balanced international trade. Wages thus adjust endogenously in response to changes in market conditions, including trade reforms.[5]

Consider first a symmetric bilateral liberalization. On the export side, a fall in τ_{ij} creates more attractive export opportunities for firms in i, as lower delivery costs allow them to charge consumers in j lower prices and to thereby benefit from increased export demand for their products. This decreases the productivity cut-off for exporting φ^*_{ij}, such that continuing exporters expand foreign sales and new firms commence exporting. This tends to bid up labor demand and hence wages in i, making it more difficult for less productive firms in i that sell only at home to survive. With free entry, these forces act to raise the productivity threshold for survival φ^*_{ii}. On the import side, a decline in τ_{ji} enables foreign firms to sell more cheaply to i. This intensifies import competition in i, reducing the aggregate price index and demand for locally produced varieties. This depresses domestic sales for all firms, and reinforces the exit of relatively less productive firms in i and the corresponding rise in φ^*_{ii}.

Bilateral trade liberalization increases welfare w_i/P_i and measured aggregate productivity $\tilde{\Phi}_i$, but its impact on theoretical aggregate productivity $\widetilde{\varphi}_i$ is generally ambiguous. This stems from the reallocation of economic activity across firms via the exit of low-productivity firms on the extensive margin, as well as from the shift in market share towards high-productivity firms on the intensive margin. In particular, the shape of the productivity distribution influences the expansion in the sales share of new export entrants and low-productivity exporters in the middle of the distribution, relative to that of high-productivity exporters at its upper tail.[6] These results build directly on Lemmas 1, 3 and 5, and have been shown by

[5] The same argument applies when the homogeneous good is produced by all countries but is not tradeable for technological reasons (e.g. haircuts), or when $\beta < 1$ is sufficiently high such that the homogeneous good is tradeable but is not produced by all countries.

[6] With endogenous within-firm productivity growth, trade reforms can generate further aggregate productivity and welfare gains. Improved export opportunities can incentivize firms to improve their production efficiency if there are economies of scale in innovation and technology adoption. Increased import competition can also encourage such activities in surviving firms if it becomes profit-maximizing given increased competitive pressures, even if it previously wasn't; economies of scale

Melitz (2003) and Demidova and Rodriguez-Clare (2013) for w_i/P_i and $\widetilde{\varphi}_i$.

In the case of flexible wages, unilateral export and import liberalizations spur the same adjustment processes and exert the same effects on aggregate welfare, theoretical and measured productivity as bilateral reforms. These comparative statics for w_i/P_i and $\widetilde{\varphi}_i$ have been established by Demidova and Rodriguez-Clare (2013).

Turning to the OP decomposition of measured aggregate productivity $\tilde{\Phi}_i$, it is clear that if $\tilde{\Phi}_i$ rises in response to globalization, then either unweighted average firm productivity $\overline{\Phi}_i$ or the covariance of firms' productivity and share of economic activity Cov_i or both must rise as well.

Trade liberalization stimulates measured unweighted average productivity, $\overline{\Phi}_i$, through three channels that relate to Lemma 5. First, the least productive firms in the economy exit as the cut-off for domestic production φ^*_{ii} rises. Second, the measured productivity $\Phi_i(\varphi)$ of surviving firms that do not change their export status increases because real wages rise. Third, the measured productivity $\Phi_i(\varphi)$ of new export entrants increases; this is the net effect of a fall in $\Phi_i(\varphi)$ upon export entry holding φ^*_{ii} fixed and a rise in $\Phi_i(\varphi)$ associated with the rise in φ^*_{ii} and $\varphi^*_{ii}/\varphi^*_{ij}$. Note that the unweighted average of "true" firm productivity φ increases due to and only due to the first channel, namely leftward truncation.

Trade liberalization may either increase or decrease the covariance between firms' measured productivity and employment share, Cov_i. Reforms generally shift production activity towards more productive firms: In response to reductions in trade costs, firms with higher theoretical efficiency φ expand their foreign sales more and contract their domestic sales less than firms with lower φ. In addition, the adjustments in the domestic and export productivity thresholds increase measured productivity disproportionately more for exporters than for non-exporters. Nevertheless, the relative change in sales shares can vary non-monotonically along the productivity distribution without further parameter restrictions, such that the covariance term can move in either direction.

Proposition 1 summarizes the predicted impact of globalization on aggregate welfare and productivity in the case of flexible wages.

Proposition 1 *Consider the case when $\beta = 1$ and wages w_i adjust endogenously in response to trade liberalization. Bilateral and unilateral trade liberalizations (i.e. reductions in τ_{ij}, τ_{ji}, or both τ_{ij} and τ_{ji}) increase welfare w_i/P_i, measured aggregate productivity $\tilde{\Phi}_i$, and measured unweighted average productivity $\overline{\Phi}_i$, but have an ambiguous effect on theoretical aggregate productivity $\widetilde{\varphi}_i$ and measured OP gap Cov_i.*

2.4 Trade Liberalization With Inflexible Wages

We next evaluate the welfare and productivity consequences of trade liberalization when $\beta < 1$. In this case, the homogeneous good is freely tradeable and produced under constant returns to scale, such that wages are exogenously fixed by the marginal product of labor in the homogenous sector. Wages thus do not respond to trade reforms, and can be normalized to 1.

in technology upgrading would dampen or reverse this effect as import penetration curtails domestic firms' market share.

In this environment, unilateral export liberalization and bilateral trade liberalization continue to exert the same effects as under endogenous wages. By contrast, unilateral import liberalization no longer does: instead, it now lowers aggregate welfare and measured productivity in the liberalizing country. This is known as the Metzler paradox. The impact of trade reforms on theoretical aggregate productivity remains ambiguous.

With exogenously fixed wages, unilateral import liberalization triggers two mechanisms that are also active with flexible wages, but their overall effect reverses in general equilibrium. A reduction in import costs τ_{ji} lowers the productivity cut-off for exporting from country j to the liberalizing economy i, φ^*_{ji}. With free entry, the productivty threshold for domestic activity in j, φ^*_{jj}, must correspondingly rise. The former channel intensifies import competition in i, reducing demand for its home varieties and pushing its domestic productivity cut-off φ^*_{ii} upwards. However, the latter channel makes j a more competitive market for firms from i, which raises the cut-off φ^*_{ij} for exporting from i to j, and with free entry acts to depress the productivity threshold for survival in i, φ^*_{ii}.

When wages are flexible, the second effect is mitigated by their endogenous adjustment and the first effect dominates: Since both wages and productivity cut-offs shape firms' expected profits from entry, smaller cut-off movements are required for the free entry condition to continue to hold when wages can move as well. When wages are fixed on the other hand, the second effect dominates, and thus cut-off productivity φ^*_{ii} and aggregate welfare w_i/P_i decline. This argument builds on Lemmas 1, 2 and 3, and has been analyzed by Demidova (2008) and Bagwell and Lee (2016).

While it can also be shown that unilateral import liberalization decreases measured aggregate productivity $\tilde{\Phi}$, the general equilibrium forces at play are now sufficiently complex that the impact on the unweighted average productivity $\overline{\Phi}_i$ and the OP gap Cov_i can no longer be analytically signed without additional restrictions on model parameters.

Proposition 2 *Consider the case when $\beta < 1$ and wages w_i are exogenously fixed to 1.*

(i) Bilateral trade liberalization and unilateral export liberalization (i.e. reductions in τ_{ij} or both τ_{ij} and τ_{ji}) increase welfare w_i/P_i, measured aggregate productivity $\tilde{\Phi}_i$, and measured unweighted average productivity $\overline{\Phi}_i$, but have an ambiguous effect on theoretical aggregate productivity $\widetilde{\varphi}_i$ and measured OP gap Cov_i.

(ii) Unilateral import liberalization (i.e. reduction in τ_{ji}) reduces w_i/P_i and $\tilde{\Phi}_i$, but has an ambiguous effect on $\widetilde{\varphi}_i$, $\overline{\Phi}_i$ and Cov_i.

2.5 Trade Liberalization With Resource Misallocation

We next examine the impact of trade liberalization in the presence of resource misallocation across firms. In particular, we consider a distortion η to the amount of inputs (labor) that firms can employ. Given our modeling approach, this distortion to input quantities is isomorphic to alternatively allowing for firm-specific distortions to input costs in factor markets or firm-specific taxes in output markets.[7] Our theoretical formulation thus ensures tractability without loss of generality. Note that all misallocation in our model can be attributed to imperfect institutions that generate frictions in factor or output markets. In our environment with CES preferences and constant mark-ups, no additional misallocation arises from variable mark-ups across firms as in Dhingra and Morrow (2016).

Under resource misallocation, we assume that firms in country i draw a pair of attributes upon entry – true productivity φ as before and a distortionary wedge η – from a known joint distribution $G_i(\varphi, \eta)$. Firms' variable production cost per unit of output is now $w_i/(\varphi\eta)$ instead of w_i/φ. Formally, this corresponds to a firm-specific wedge in the first order condition for profit maximization, as in Hsieh and Klenow (2009) and Bartelsman, Haltiwanger and Scarpetta (2013). Conceptually, η captures any deviation from the first-best allocation of labor across firms. If a firm can access "too much" labor, this would be equivalent to a subsidy of $\eta > 1$. Conversely, if it faces a sub-optimal capacity constraint, this would correspond to a tax of $\eta < 1$.

Firm choices and outcomes depend on φ and η only through "distorted productivity" $\underline{\varphi} = \varphi\eta$. Profit maximization thus implies the following expressions for firm revenues, profits, and the distorted productivity thresholds for domestic production and exporting:

$$r_{ij}(\varphi, \eta) = \beta R_j \left(\frac{\alpha P_j \underline{\varphi}}{\tau_{ij} w_i}\right)^{\sigma-1}, \qquad \pi_{ij}(\varphi, \eta) = \frac{r_{ij}(\varphi, \eta)}{\sigma} - w_i f_{ij}, \tag{2.15}$$

$$r_{ii}(\underline{\varphi}^*_{ii}) = \sigma w_i f_{ii}, \qquad r_{ij}(\underline{\varphi}^*_{ij}) = \sigma w_i f_{ij}. \tag{2.16}$$

While it would be socially optimal to allocate input factors and output sales based on true firm productivity φ, in the market equilibrium this allocation is instead pinned down by distorted productivity $\underline{\varphi}$. For example, a highly productive firm may not be able to survive if it endures prohibitively high distortive taxes $\eta < 1$, while a less productive firm might be able to export if it benefits from an especially high subsidy $\eta > 1$.

Defining $\underline{G}_i(\underline{\varphi})$ to be the distribution of $\underline{\varphi}$ derived from $G_i(\varphi, \eta)$, the free entry condition becomes:

$$f_{ii} \int_{\underline{\varphi}^*_{ii}}^{\infty} \left[\left(\frac{\underline{\varphi}}{\underline{\varphi}^*_{ii}}\right)^{\sigma-1} - 1\right] d\underline{G}_i(\underline{\varphi}) + f_{ij} \int_{\underline{\varphi}^*_{ij}}^{\infty} \left[\left(\frac{\underline{\varphi}}{\underline{\varphi}^*_{ij}}\right)^{\sigma-1} - 1\right] d\underline{G}_i(\underline{\varphi}) = f_i^E. \tag{2.17}$$

As before, the free entry condition implies that whenever the domestic distorted cut-off $\underline{\varphi}^*_{ii}$ increases, the distorted export cut-off $\underline{\varphi}^*_{ij}$ must fall.

In general equilibrium, total income and expenditure must account for the distortions in the economy. We assume that any subsidy to (tax from) firms located in country i is collected from (distributed to) consumers in i.[8] Thus consumer welfare, w_i/P_i, becomes a complex function of the distorted productivity

[7] For example, specifying the distortion on the revenue side instead of the cost side would imply that firm profits equal $\pi_{ij}(\varphi, \eta) = \eta p_{ij} q_{ij} - w_i l_{ij}$.

[8] As above, when $\beta < 1$ and the homogeneous-good sector is active, the model is closed with an additional condition that relates the mass of firm entrants to the mass of active firms and an exogenous probability of firm death. When $\beta = 1$, general equilibrium further imposes balanced trade in the differentiated goods sector.

cut-off for survival φ_{ii}^* and the tax schedule through the joint distribution of firm productivity and distortions:

$$\frac{w_i}{P_i} = \left(\frac{\beta \underline{L}_i}{\sigma f_{ii}}\right)^{\frac{1}{\sigma-1}} \alpha \underline{\varphi}_{ii}^*. \tag{2.18}$$

Here $\underline{L}_i \equiv L_i - M_i^E w_i^{-1} \sum_j \int_{\underline{\varphi} > \underline{\varphi}_{ij}^*} (\eta - 1) \left(\frac{\underline{\varphi}}{\underline{\varphi}_{ij}^*}\right)^{\sigma-1} dG_i(\varphi, \eta)$ and M_i^E is the mass of firm entrants. Intuitively, $\underline{L}_i$ reflects the amount of labor resources that are put towards socially optimal production, which is less than the total labor endowment L_i because of the sub-optimal survival and exporting of less productive firms.

Resource misalocation also affects measured firm productivity:

$$\underline{\Phi}_i(\varphi, \eta) = \frac{r_i(\varphi, \eta)}{P_i l_i(\varphi, \eta)} = \frac{w_i}{\alpha P_i \eta} \left[1 - \frac{f_i(\varphi, \eta)}{l_i(\varphi, \eta)}\right]. \tag{2.19}$$

In the presence of resource misallocation, economies operate in a second-best state of distortions. As is well known from the theory of the second best, it thus becomes impossible to unambiguously determine the impact of exogenous shocks on aggregate welfare. Trade liberalization could magnify existing distortions if firms with inefficiently abundant access to factor inputs are able to expand their activity relatively more than firms with inefficiently constrained productive resources. Conversely, trade liberalization could have a cleansing effect on the economy and serve to reallocate activity towards truly more productive firms. Likewise, trade shocks have theoretically ambiguous effects on aggregate productivity, both in the model and as it is empirically measured. All of these comparative statics now hinge on initial state variables characterizing the economy and on model parameters, in particular the shape of the joint distribution $G_i(A, \eta)$.

Proposition 3 *Consider the case of resource misallocation. Bilateral and unilateral trade liberalizations (i.e. reductions in τ_{ij}, τ_{ji}, or both τ_{ij} and τ_{ji}) have an ambiguous effect on welfare w_i/P_i, theoretical aggregate productivity $\widetilde{\varphi}_i$, measured aggregate productivity $\tilde{\Phi}_i$, measured unweighted average productivity $\overline{\Phi}_i$, and measured OP gap Cov_i.*

2.6 Numerical Simulation (in progress)

Given the theoretically ambiguous predictions for the welfare and productivity effects of different globalization scenarios, we explore the model's implications through numerical simulations. We consider the impact of trade reforms on the five objects of interest: welfare w_i/P_i, theoretical aggregate productivity $\widetilde{\varphi}_i$, measured aggregate productivity $\tilde{\Phi}_i$, measured unweighted average productivity $\overline{\Phi}_i$, and measured OP gap Cov_i.

For the simulation, we set $\sigma = 3$ and $\beta = 0.7$, so that wages are fixed at unity. We assume that both countries have a unit measure of consumers and symmetric fixed costs: $f_{ii} = 1.2$, $f_{ij} = 1.75$, and $f_i^E = 0.1$. We specify the joint distribution of productivity and distortion draws $G(\varphi, \eta)$ as bivariate lognormal:

$$\begin{bmatrix} \ln \varphi \\ \ln \eta \end{bmatrix} \sim \mathcal{N}(\mu, \Sigma), \quad \mu = \begin{bmatrix} \mu_\varphi \\ \mu_\eta \end{bmatrix}, \quad \Sigma = \begin{bmatrix} \sigma_\varphi^2 & \rho \sigma_\varphi \sigma_\eta \\ \rho \sigma_\varphi \sigma_\eta & \sigma_\eta^2 \end{bmatrix}.$$

We choose $\mu_\varphi = 1$ and $\mu_\eta = 1$ for both countries. For the foreign country, we fix Σ and set $\sigma_\varphi = 1$, $\sigma_\eta = 0.05$, and $\rho = 0$. For the home country, we set $\sigma_\varphi = 1$ and consider varying values of $\sigma_\eta \in \{0, 0.05, 0.15\}$ and $\rho \in [-0.5, 0.5]$.

Figures 1 and 2 display the change in each productivity term of the OP decomposition associated with a 20% reduction in trade costs from an initial value of $\tau_{ij} = 1.81$. Three different types of experiments are considered: unilateral reduction in import cost, unilateral reduction in export cost, and bilateral reduction. Table 1 tabulates a snapshot of these numerical exercises for the case of no misallocation ($\sigma_\eta = 0$) and misallocation with an intermediate level of distortion dispersion ($\sigma_\eta = 0.05$) and negative, zero or positive correlation between the productivity and distortion draws ($\rho \in \{-0.5, 0, 0.5\}$).

Three patterns stand out in Table 1. First, bilateral and unilateral trade liberalizations can have very different aggregate effects even in the absence of misallocation. As predicted by theory, bilateral trade liberalization and unilateral export liberalization both increase aggregate welfare w_i/P_i, measured aggregate productivity $\tilde{\Phi}_i$, and measured average productivity $\overline{\Phi}_i$. In this and most reasonable parameterizations we have experimented with, allocative efficiency Cov_i also increases. By contrast, unilateral import liberalization can reduce all four outcomes of interest in a large segment of the parameter space, including this parameterization.

Second, both components of the OP productivity decomposition matter in an economic sense. On average, changes in average productivity $\overline{\Phi}_i$ account for about 75-80% of the total change in aggregat productivity $\tilde{\Phi}_i$, while allocative efficiency Cov_i mediates about 20-25% of the adjustment. This indicates that both firm entry/exit and reallocations of activity across active firms are important mechanisms of adjustment in response to trade shocks.

Finally, the nature and magnitude of misallocation can dramatically affect the gains from trade. When distortions are orthogonal to firm productivity, i.e. $\rho = 0$, the gains from trade are moderately reduced but otherwise follow the same qualitative pattern as in the absence of distortions. In the case of $\sigma_\eta = 0.05$, for example, the aggregate effects of bilateral trade reforms are <5% lower, but this loss increases with the spread of distortions. By contrast, when distortions are positively (negatively) correlated with productivity, i.e. $\rho = 0.5$ ($\rho = -0.5$), the productivity and welfare gains from trade can be significantly higher (lower) than in the absence of misallocation. In the case of $\sigma_\eta = 0.05$, for instance, the aggregate effects of bilateral trade reforms are 50% higher (60% lower). Moreover, the sign of the effect of trade on aggregate productivity and its constituent parts may be changed, as obseved for unilateral import libealization.

It is useful to foreshadow our empirical results in light of these numerical calculations. Our baseline empirical results will be consistent with the pattern in Columns 4-9 of the bottom row of Table 1, suggesting that both import and export activity stimulate aggregate productivity, while misallocation might also be at play.

3 Data

We empirically evaluate the impact of international trade on aggregate productivity using rich cross-country, cross-sector panel data from two primary data sources, CompNet and WIOD. This section describes the key variables of interest, and presents stylized facts about the cross-sectional and time-series variation in productivity, allocative efficiency, export and import activity in the panel.

3.1 CompNet: Productivity and Allocative Efficiency

We exploit unique new data on the evolution of macroeconomic indicators for 20 NACE-2 manufacturing sectors in 14 European countries over the 1998-2011 period from the CompNet Micro-Based Dataset.[9] Two features of the data make it unprecedented in its level of detail and ideally suited to our analysis. First, it contains not only aggregate measures at the country-sector-year level, but also multiple moments of the underlying distribution of economic activity across firms in each country-sector-year cell. This includes for example totals, means, standard deviations and skewness of various firm characteristics, as well as key moments of the joint distributions of several such characteristics. The dataset is built from raw firm-level data that are independently collected in each country and maintained by national statistical agencies and national central banks. These raw data were standardized and systematically aggregated to the country-sector-year level as part of the Competitiveness Research Network initiative of the European Central Bank and the European System of Central Banks. Lopez-Garcia et al. (2015) provide a detailed overview of the data methodology and structure.

Second, CompNet includes several productivity measures that are constructed specifically to permit an Olley-Pakes (1996) decomposition of aggregate productivity in country i, sector k and year t ($Prod_{ikt}$) into an unweighted average firm productivity ($AvgProd_{ikt}$) and a covariance term between firm productivity and firm share of economic activity ($CovProd_{ikt}$).[10]

Our baseline analysis examines labor productivity defined as real value-added per worker and firms' share of total employment at the country-sector-year level. The advantage of the labor productivity measure is that it relies on directly observable data rather than on results from production function estimates that are often subject to endogeneity and omitted variable concerns.

Tables 2 and 3 document the variation in aggregate productivity and its two constituent terms across countries, sectors and years in our sample. The panel contains 3,183 observations and is unbalanced because of different time coverage across countries. Aggregate productivity averages 3.16 in the panel, with allocative efficiency contributing 0.23 (7.3%) towards this average as proxied by the covariance

[9] The 14 countries are: Austria, Belgium, Estonia, Finland, France, Germany, Hungary, Italy, Lithuania, Poland, Portugal, Slovakia, Slovenia, Spain. While CompNet covers all NACE 2-digit industries in the European classification, we restrict the sample to 20 manufacturing industries for which we can obtain WIOD data on trade activity. These correspond to NACE-2 sectors 10 to 31 without sectors 12 (tobacco products) and 19 (coke and refined petroleum products).

[10] Adapting the expression above, the Olley-Pakes decomposition at the country-sector-year level becomes:

$$Prod_{ikt} = \underbrace{\frac{1}{N_{ikt}} \sum_f Prod_{ikft}}_{AvgProd_{ikt}} + \underbrace{\sum_f \left(Prod_{ikft} - \overline{Prod}_{ikt}\right)\left(\theta_{ikft} - \overline{\theta}_{ikt}\right)}_{CovProd_{ikt}} \tag{3.1}$$

term. However, there are sizable differences in the level and composition of $Prod_{ikt}$ across countries, with $CovProd_{ikt}$ capturing only 1.4% in Austria and 2.5% in Germany to 24.7% in Lithuania and 32.4% in Hungary. Moreover, the standard deviation of aggregate productivity across sectors and years reaches 1.14 for the average country, with allocative efficiency accounting for almost 20% of this variation. Thus economy-wide productivity could be significantly lower if labor were randomly assigned across firms with heterogeneous productivity levels.

Table 3 also provides summary statistics for aggregate productivity growth at 1-, 3- and 5-year horizons. Figure 3 shows that changes in the allocation of labor across firms can in some cases represent a substantial share of aggregate labor productivity growth, as is the case for some Eastern European economies such as Lithuania, Croatia and Hungary prior to the 2008-2009 global financial crisis.

3.2 WIOD: Export and Import Activity

We use data on international trade activity by country, sector and year from WIOD, the World Input-Output Database. While standard trade statistics report gross tarde flows by country and sector, WIOD exploits country-specific input-output tables to infer trade in value added by sector of final use. For example, this makes it possible to identify the amount of domestic value added embedded in a country's exports, as well as the amount of foreign value added contained in a country's imports. WIOD also decomposes imports of a given sector into imports used for final consumption and imports used as intermediate inputs for production in downstream sectors. Although the data construction imposes certain proportionately assumptions in value added and input use across countries and sectors, WIOD is the first such data of its kind and it has been used in recent pathbreaking studies of global value chains such as Bems-Johnson (2015).

WIOD reports the gross value of sales from input sector k in origin country i to output sector s in destination country j in year t, X_{ijkst}. Input sectors are in the NACE 2-digit classification, while output sectors comprise all NACE-2 sectors plus several components of final consumption. Trade values are recorded in US dollars, which we convert into euros using annual exchange rates.

We proxy export demand for exporting country i in sector k and year t, $ExpDemand_{ikt}$, with the log value of i's gross exports in sector k. Similarly, we measure import competition in importing country i, sector k and year t, $ImpComp_{ikt}$, with the log of the value of i's imports in sector k, less the value of sector k imports used by i in the production of sector k goods; we intentionally do not remove sector k imports used by i in the production of other sectors since such imports too compete with locally produced k goods.

$$ExpDemand_{ikt} = \ln\left[\sum_{j,s} X_{ijkst}\right], \quad ImpComp_{ikt} = \ln\left[\sum_{j,s\neq k} X_{jikst}\right], \tag{3.2}$$

We are able to construct $ExpDemand_{ikt}$ and $ImpComp_{ikt}$ for all 14 countries and 20 NACE-2 sectors in our 1998-2011 panel. $ExpDemand_{ikt}$ averages 7.46 in the data, with a proportionately large standard deviation of 1.82. The corresponding mean and dispersion are 6.28 and 1.99 for $ImpComp_{ikt}$, respectively.

We summarize individual countries' trade exposure in Table 2, and plot its evolution over time in Figure 4. While all countries experienced steady import and export expansion prior to the 2008 crisis, they underwent a sharp contraction in 2009 before regaining some ground by 2011 (Figure 4A). Although EU-15 members and new EU member states display broadly comparable import activity, the latter attained dramatically faster export growth rates during the period we study (Figures 4B and 4C).

Since observed trade flows capture aggregate supply and demand in general equilibrium, $ExpDemand_{ikt}$ does not cleanly identify foreign demand for the products of country i, and instead confounds it with i's production supply capacity. Analogously, $ImpComp_{ikt}$ reflects both the supply of foreign products to country i and i's demand for such imports. While we use $ExpDemand_{ikt}$ and $ImpComp_{ikt}$ as baseline measures of export demand and import competition, an important contribution of our analysis is constructing instrumental variables to isolate the exogenous components of export demand and import competition from observed export and import flows. These instrumental variables rely on import tariffs and Bartik-style shocks to foreign export supply and import demand, import tariffs. We also exploit the rise of China in world markets as an alternative exogenous shock to import competition, and instrument for it accordingly as well.

4 Trade and Aggregate Productivity: OLS Correlation

We empirically examine the effects of international trade on aggregate productivity and the mechanisms that mediate these effects in several steps. In this Section, we first provide baseline evidence from OLS regression analysis which reveals that countries' export and import activity is systematically related to their aggregate output, value added, employment and productivity. We view this evidence as informative and suggestive but not conlusive because the empirical specifications cannot fully address concerns about the endogeneity of trade outcomes and aggregate economic performance. In order to identify the causal effects of globalization, we therefore pursue an IV-2SLS estimation strategy in Section 5 and present a series of robustness checks on our IV specification. Finally, we exploit the channels through which export demand and import competition shape aggregate productivity through additional exercises in Section 6.

4.1 Baseline OLS Specification

We explore the link between international trade activity and aggregate economic performance with the following baseline OLS specification:

$$Y_{ikt} = \alpha + \beta_{EX}\, ExpDemand_{ikt} + \beta_{IM}\, ImpComp_{ikt} + \Gamma Z_{ikt} + \varphi_{it} + \varepsilon_{ikt}. \tag{4.1}$$

Here Y_{ikt} refers to aggregate productivity in country i, sector k and year t, $Prod_{ikt}$, or its two sub-components, the unweighted average firm productivity, $AvgProd_{ikt}$, and the covariance between firm productivity and employment share, $CovProd_{ikt}$. Since the Olley-Pakes decomposition connects the three productivity outcomes, the coefficient estimates from regressions for $AvgProd_{ikt}$ and $CovProd_{ikt}$ mechanically sum up to the coefficient estimate from regressions for $Prod_{ikt}$. There is nevertheless value in separately estimating all three regressions in order to determine the sign, economic magnitude and statistical significance of the effects of globalization on aggregate productivity, productivity upgrading within firms, and allocative efficiency across firms. There are no efficiency gains from estimating the three regressions as a simultaneous system of equations because they all include the same set of fixed effects and right-hand side variables.

The main coefficients of interest, β_{EX} and β_{IM}, would in principle identify the causal productivity impact of exogenous shocks to export demand and to import competition if the latter are accurately measured. Given the endogeneity of our baseline proxies for $ExpDemand_{ikt}$ and $ImpComp_{ikt}$, we therefore interpret OLS estimates of β_{EX} and β_{IM} simply as indicative correlations.

Specification (4.1) includes country-year pair fixed effects, φ_{it}, for the 14 nations and 13 years in our sample, such that β_{EX} and β_{IM} are identified from the variation across sectors within countries at a given point in time. The φ_{it} account for macroeconomic supply and demand shocks at the country-year level that affect trade and productivity symmetrically in all sectors, such as movements in GDP, GDP per capita, exchange rates, aggregate price index, productivity, employment, interest rates, etc. Implicitly the fixed effects also account for non-transient country characteristics such as broad institutional quality, general infrastructure, geographic remoteness, capital and labor market frictions, as well as for global shocks that are common across countries such as the 2008-2009 financial crisis. We report Huber-White heteroskedasticity robust standard errors ε_{ikt}.

We include several other control variables Z_{ikt} to alleviate concerns with omitted variable bias, measurement error and sample selection. First, there may be worldwide sector trends in supply and demand conditions. To capture these, we condition on the average log number of active firms, $\overline{\ln N}_{kt}$, and the average log employment, $\overline{\ln L}_{kt}$, by sector-year in our data, which we obtain by averaging $\ln N_{ikt}$ and $\ln L_{ikt}$ across countries in our panel. In alternative specifications we further include sector or sector-year fixed effects.

Second, the national firm-level data that underly the CompNet dataset are subject to cross-country differences in the minimum firm size threshold for inclusion in national statistics. These thresholds do not change within countries over time and are implicitly controlled for with the country-year pair fixed effects. As extra precaution, we also include the log number of firms by country-sector-year, $\ln N_{ikt}$, but our results are not sensitive to this control.

Third, measurement error may bias β_{EX} and β_{IM} either upwards or downwards. On the one hand, classical measurement error in firm size L_{ikft} in the raw data would introduce correlated noise in firms' labor productivity and employment share, and result in misleadingly low values for $CovProd_{ikt}$. This would lead us to underestimate β_{EX} and β_{IM} in specifications for allocative efficiency. On the other hand, non-classical measurement error in $\ln N_{ikt}$ may generate mechanical correlation between the left- and right-hand side variables of interest. Controlling for $\ln N_{ikt}$ addresses both of these concerns.

Finally, in unreported regressions we have confirmed that our results are not driven by outliers in our panel data. We have alternatively dropped from the regression sample one country at a time; country-sector-year observations that are based on underlying data for fewer than 20 firms; and observations in the top and bottom percentile by annual growth in productivity and trade activity.

4.2 Baseline OLS Results

As a preliminary step, we assess the correlation between trade and aggregate economic activity. In Table 4, we estimate specification (4.1) applied to log total output, log value added and log employment by country, sector and year as the outcome variable Y_{ikt}. We obtain these data from CompNet such that they are consistent with our productivity measures. We find that export expansion is associated with higher overall output, greater value added in production, and more factor resources (labor) engaged in manufacturing. Conversely, more intense import penetration is correlated with lower total domestic output and employment, but nevertheless higher value added.

We begin to examine the trade-productivity nexus with equation (4.1) in Table 5. In Column 1, we document that aggregate exports and imports are both positively correlated with aggregate productivity. These correlations are highly statistically significant at 1% and of large economic magnitude: A one-standard-deviation rise in $ExpDemand_{ikt}$ and $ImpComp_{ikt}$ is associated with 22% and 21% higher $Prod_{ikt}$ respectively. At the same time, these comparable overall magnitudes mask important differences between export and import activity. Export expansion is accompanied by both stronger average firm productivity $AvgProd_{ikt}$ and more efficient allocation across firms $CovProd_{ikt}$, with the former channel roughly twice the size of the latter. By contrast, deeper import penetration entails higher firm productivity on average, but reduced allocative efficiency.

Although not causal, this evidence is nevertheless consistent with increased foreign demand boosting aggregate productivity and production activity, and with stiffer import competition stimulating productivity growth while depressing overall production. The OLS results also raise the possibility that different aspects of globalization may influence aggregate productivity through different mechanisms.

4.3 OLS First Differences

Specification (4.1) identifies the correlation between productivity and trade outcomes in the long run, by defining all relevant variables in log levels. To explore how this correlation may differ in the short to medium term, we analyze how changes in productivity co-move with concurrent changes in trade activity over different horizons:

$$\Delta Y_{ikt} = \alpha + \beta_{EX}\, \Delta ExpDemand_{ikt} + \beta_{IM}\, \Delta ImpComp_{ikt} + \Gamma \Delta Z_{ikt} + \varphi_t + \varepsilon_{ikt}. \tag{4.2}$$

We examine the change in log productivity, log exports and log imports over 1-year, 3-year and 5-year overlapping periods. We include year fixed effects to subsume global macroeconomic shocks affecting all countries and sectors. This specification is in some regards more stringent than equation (4.1) in that it implicitly allows for country-sector pair fixed effects to affect the level of all variables, since these would drop out during first-differencing.

The results in Table 6 are in line with our earlier findings. Expanding exports and imports is correlated with higher aggregate labor productivity. While export activity operates both through improvements in average firm productivity and through enhanced resource allocation, import penetration is positively associated with the former, but negatively associated with the latter. While the patterns are stronger in terms of magnitude and significance at medium horizons of 3 to 5 years, they are nevertheless sizeable even in the very short run of 1 year.

5 Impact of Trade on Aggregate Productivity: IV Causation

5.1 The Endogeneity Problem

The OLS estimation results above characterize the correlation between countries' participation in international trade and their aggregate productivity performance. As common with analyses at the aggregate level, this correlation may not identify the causal effect of globalization on productivity because of two potential sources of endogeneity: simultaneity and reverse causality.

One possibility is that trade and productivity performance are jointly determined by some omitted variable. Given the country-year fixed effects in the OLS specification, such omitted variable bias would have to vary systematically across sectors within country-years to explain our findings. This rules out many alternative explanations based on country-year characteristics such as strong institutions, favorable macroeconomic conditions, or abundant physical and human capital.

Reverse causality poses a more important concern: Aggregate productivity can endogenously affect trade activity. In general equilibrium, observed export flows reflect both endogenous supply conditions in the exporting country and exogenous demand conditions in the importing country. Standard trade theory implies that firms in a more productive country-sector would be more competitive on world markets and therefore undertake more exports. As a result, the OLS estimates of β_{EX} would be positively biased. Symmetrically, observed import flows capture both endogenous demand conditions in the importing country and exogenous supply conditions in the exporting country. Given local demand, a less productive domestic country-sector would be less competitive from the perspective of foreign firms and could thus induce more entry by foreign suppliers. This would introduce negative bias in the OLS esimates of β_{IM}. These examples illustrate only two of various possible mechanisms that could generate reverse causality and bias our estimates of the productivity impact of globalization either positively or negatively.

5.2 2SLS IV Strategy

In order to identify the causal effect of international trade on aggregate productivity, we adopt a two-stage least squares (2SLS) estimation strategy. In the first stage, we use instrumental variables IV_{ikt} to identify arguably exogenous movements in export and import activity from observed export and import trade flows, $\widehat{ExpDemand}_{ikt}$ and $\widehat{ImpComp}_{ikt}$. In the second stage, we then regress the three aggregate productivity outcomes of interest on these predicted exogenous values in place of their endogenonus counterparts, $ExpDemand_{ikt}$ and $ImpComp_{ikt}$:

$$Y_{ikt} = \alpha + \beta_{EX}\, \widehat{ExpDemand}_{ikt} + \beta_{IM}\, \widehat{ImpComp}_{ikt} + \Gamma Z_{ikt} + \varphi_{it}(+\varphi_k) + \varepsilon_{ikt} \text{ (second stage)} \tag{5.1}$$

$$\{ExpDemand_{ikt},\, ImpComp_{ikt}\} = \alpha_{IV} + \Gamma_{IV} Z_{ikt} + \Theta IV_{ikt} + \phi_{it}(+\phi_k) + \epsilon_{ikt} \text{ (first stage)} \tag{5.2}$$

Our IV estimation continues to condition on country-year pair fixed effects, φ_{it} and ϕ_{it}, as well as the same controls Z_{ikt} as above. We present results both with and without additional sector fixed effects, φ_k and ϕ_k, which account for stable differences in supply and demand conditions across sectors that affect all countries, such as skill and capital intensity or consumer tastes. We report robust standard errors.

The ideal instruments for trade exposure would be valid by having predictive power in explaining trade flows, and would meet the exclusion restriction by affecting productivity only through the trade channel. In the case of $ExpDemand_{ikt}$, we would therefore like to isolate exogenous foreign demand for ik products in year t from country i's endogenous supply of sector k goods in year t. In the case of $ImpComp_{ikt}$, we would like to separate exogenous foreign supply of k products to i in year t from i's endogenous import demand for k goods in year t.

Our first two instruments are Bartik-style shocks to foreign export supply and import demand, which we construct by combining information on countries' initial trade structure at the beginning of our panel with the contemporaneous trade flows of their trade partners with the rest of the world. This IV strategy capitalizes on two ideas: First, the share of country i's exports in sector k going to destination d at time $t = 0$, $\frac{X_{idk,t=0}}{X_{ik,t=0}}$, and the share of i's imports coming from origin country o at time $t = 0$, $\frac{M_{oik,t=0}}{M_{ik,t=0}}$, are not influenced by subsequent exogenous shocks respectively to aggregate demand in d and to aggregate supply in o. Second, aggregate demand for sector k goods in destination d at time t can be proxied with d's total absorption of k products, defined as domestic production plus worldwide imports minus worldwide exports, $Y_{dkt} + M_{dkt} - X_{dkt}$. Symmetrically, aggregate supply of sector k goods from origin country o at time t can be measured with o's export value added for final consumption of k products, XVA_{okt}^{final}.

For each country-sector-year triplet ikt in our sample, we instrument export demand with foreign demand conditions, $FDemand_{ikt}$, computed as the weighted average absorption by i's export partners using i's initial export shares as weights. We instrument import competition with foreign supply capacity, $FSupply_{ikt}$, calculated as the weighted average export value added for final consumption by i's import partners, using i's initial import shares as weights. We construct both variables using the WIOD data. To guard against outliers due to measurement error or business cycle shocks, we average the initial import and export weights across the first three years in our data, 1998-2000. These two instruments are similar in spirit to those in Hummels et al. (2014) and Berman et al. (2015) among others.

$$FDemand_{ikt} = \ln\left[\sum_{d\neq i}\frac{X_{idk,t=0}}{X_{ik,t=0}}\left(Y_{dkt} + M_{dkt} - X_{dkt}\right)\right], \tag{5.3}$$

$$FSupply_{ikt} = \ln\left[\sum_{o\neq i}\frac{M_{oik,t=0}}{M_{ik,t=0}}XVA_{okt}^{final}\right], \tag{5.4}$$

$$MTariff_{ikt} = \frac{1}{NP_k}\sum_{p\subset\Omega_k}\tau_{ipt}. \tag{5.5}$$

In addition to these two Bartik-style instruments, we also exploit the variation in import tariffs across countries, sectors and years, $MTariff_{ikt}$. We take the simple average applied tariff τ_{ipt} across all products p in sector k at time t using tariff data from WITS, where NP_k denotes the number of products mapped to a sector. $MTariff_{ikt}$ captures trade policy shocks that affect the degree of import competition by influencing foreign producers' incentives to enter the domestic market.

Conceptually, we think of $FDemand_{ikt}$ as an instrument for $ExpDemand_{ikt}$, and we view $FSupply_{ikt}$ and $MTariff_{ikt}$ as instruments for $ImpComp_{ikt}$. In practice of course, all three instruments enter as IV_{ikt} for both endogenous variables in the first stage of the estimation.

5.3 Baseline IV Results

The results in Table 7 indicate that our three instruments perform well in the first stage. In Columns 1 and 3, the Bartik-style measure of exogenous foreign demand has a positive impact on observed export flows $ExpDemand_{ikt}$ at the country-sector-year level, while the measure of exogenous foreign supply has a positive effect on observed import penetration $ImpComp_{ikt}$. These patterns are highly statistically and economically significant, and they are moreover robust to adding sector fixed effects in Columns 2 and 4. The more conservative economic magnitudes based on the estimates in Columns 2 and 4 imply that a one-standard-deviation improvement in $FDemand_{ikt}$ leads to 35% higher $ExpDemand_{ikt}$, while a one-standard-deviation rise in $FSupply_{ikt}$ increases $ImpComp_{ikt}$ by 60%. While import tariffs have strong predictive power in the specifications for import activity, their correlation with import volumes turns from positive when we do not account for persistent cross-sector differences to negative when we include the ϕ_k dummies. In the latter case, reducing average import barriers by 10% translates into 9.6% lower import penetration. The R-squared in these regressions reaches 89%-99% across the various specifications.

Table 8 presents our main findings for the causal effect of international trade exposure on aggregate productivity. Two findings stand out. First, export demand and import competition both significantly increase aggregate productivity $Prod_{ikt}$ at the country-sector level. In our baseline without sector fixed effects in Column 1, a one-standard-deviation growth in export demand boosts overall productivity by 74.3%, while a one-standard-deviation rise in import competition leads to 9.8% higher productivity. Export demand and import competition exert large effects of comparable magnitudes when we include sector fixed effects in Column 4. A one-standard-deviation expansion in either export activity or import penetration now induces 57-58% stronger productivity.

Second, Table 8 reveals that the productivity gains from export and import activity are mediated through different channels. Export growth induces both sizeable improvements in the average productivity across firms, $AvgProd_{ikt}$, and a reallocation of economic activity towards more productive firms as manifested in higher $CovProd_{ikt}$. Enhanced allocative efficiency contributes one quarter (Column 3) to one third (Column 6) of the total productivity benefit. By contrast, all of the productivity gains from import competition result from higher average firm productivity, and these gains are moreover partly countered by a shift in economic activity towards less productive firms. This reduction in allocative efficiency negates about one third of average productivity growth in the case of no sector dummies (Column 3), and diminishes to a negligible value with sector fixed effects (Column 6).

These two messages from our baseline 2SLS estimation survive a series of robustness checks. In the next few subsections, we demonstrate that very similar patterns obtain when we consider alternative measures of import competition, additional controls, and different sensitivity analyses. In the interest of space, we typically tabulate and discuss only specifications without sector fixed effects, but note that the baseline IV findings with sector fixed effects are equally stable across the various robustness checks.

5.4 Import Competition from China

We first consider an alternative dimension of and corresponding instrument for import competition: the dramatic rise of China on global markets. Chinese worldwide exports grew rapidly after China joined the WTO in 2001, and experienced a second burst after MFA binding quotas on Chinese textiles and apparel were lifted in 2005. These developments constitute large trade shocks that are exogenous from the perspective of individual countries and sectors in Europe, and they can serve as a quasi-natural experiment for identification purposes. Additionally, comparing the productivity impacts of Chinese import competition and overall import penetration can illuminate how local firms respond to increased market entry by foreign firms with relatively lower vs. higher levels of productivity, cost and quality.

We operationalize the China shock by replacing our baseline measure of total import penetration, $ImpComp_{ikt}$, with the log value of imports specifically from China, $ChinaImpComp_{ikt}$. As before, we use WIOD data to compute this measure separately for each importing country i, sector k and year t, and we subtract the value of sector k imports used by i in the production of sector k goods.

$$ChinaImpComp_{ikt} = \ln\left[\sum_{s\neq k} X_{China\rightarrow i,kst}\right], \tag{5.6}$$

$$ChinaSupply_{ikt} = \left\{\ln\left[\frac{M_{China\rightarrow i,k,t=0}}{M_{ik,t=0}} XVA^{final}_{China,kt}\right], \ln\left[\sum_{p\subset\Omega_k}\frac{M_{ip,t=0}}{M_{ik,t=0}} X_{China\rightarrow US,pt}\right]\right\} \tag{5.7}$$

We develop two new Bartik instruments $ChinaSupply_{ikt}$ for $ChinaImpComp_{ikt}$ that are in the spirit of Autor et al. (2015) and Bloom et al. (2015) who use a related identification strategy. The first captures China's global export supply in sector k and year t with Chinese total export value added for final consumption $XVA^{final}_{China,kt}$, and recognizes that the impact of this supply shock will vary across importing countries i based on China's initial share of i's imports of k goods at time $t = 0$, $\frac{M_{China,ik,t=0}}{M_{ik,t=0}}$. The second instrument focuses specifically on Chinese exports to the US as one reference country to exploit finer product disaggregation in the data and to avoid contamination from Chinese sales to the European countries in our panel. We start with Chinese exports to the US by NACE 4-digit products p that belong to sector k, $X_{China\rightarrow US,pt}$, and we obtain a China supply shock specific to country i by taking the weighted average of $X_{China\rightarrow US,pt}$ across these products using their share of i's total initial imports in sector k from anywhere in the world, $\frac{M_{ip,t=0}}{M_{ik,t=0}}$.

We modify the two-stage estimation procedure above by examining the productivity impact of Chinese import competition $ChinaImpComp_{ikt}$ along with that of global export expansion $ExpDemand_{ikt}$ in the second stage. In the new first stage, we retain $FDemand_{ikt}$ and $MTariff_{ikt}$ as instruments, but we use

$ChinaSupply_{ikt}$ in place of $FSupply_{ikt}$. Note that once China enters the WTO, it is granted MFN status by all countries in our sample, such that $MTariff_{ikt}$ reflects the import tariffs relevant to Chinese goods.

We present our results in Panel A of Table 9. Our findings for the productivity impact of worldwide export demand remain quantitatively and qualitatively similar. As with overall import competition, Chinese import competition too significantly raises average firm productivity and has either an insignificant or a negative significant effect on allocative efficiency. Its net impact on aggregate productivity however is sensitive to the inclusion of sector fixed effects: it is null in the baseline with country-year fixed effects only, and turns large, positive and highly significant when we add sector dummies to account for systematic cross-sector differences. In the latter case, a one-standard-deviation rise in $ChinaImpComp_{ikt}$ translates into 25% rise in total productivity $Prod_{ikt}$.

5.5 Import Competition Ratio

We next establish that our results are robust to using a relative indicator of import competition instead of an absolute one. Our baseline measure $ImpComp_{ikt}$ identifies the scale of foreign suppliers' presence in the home market, with the size of the home market implicitly controlled for in the regressions with country-year fixed effects. Through the lens of theory, an equally valid measure of import competition is the ratio of imports to domestic sales. The ratio of imports to domestic employment provides yet another alternative which has the advantage of being independent of local factor or good prices. We therefore construct both of these two ratios using the CompNet data. In order to circumvent concerns with the scale of domestic production endogenously adjusting to import penetration, we average turnover and employment by country and industry over our sample period.

$$ImpCompRatio_{ikt} = \left\{ \ln\left[\frac{\sum_{j,s\neq k} X_{jikst}}{\overline{Output}_{ik}}\right], \ln\left[\frac{\sum_{j,s\neq k} X_{jikst}}{\overline{Employment}_{ik}}\right] \right\} \tag{5.8}$$

Panel B of Table 9 reports our results from estimating specification (5.1) using either import competition ratio $ImpCompRatio_{ikt}$ in place of $ImpComp_{ikt}$ and a symmetrically constructed $FSupplyRatio_{ikt}$ instrument in place of $FSupply_{ikt}$. The evidence corroborates our baseline IV findings.

5.6 Sensitivity Analysis

We perform several sensitivity analyses that confirm the stability of our results to alternative specification choices. First, we implement our two-stage estimation procedure using each measure of trade exposure one at a time. When we focus on export activity alone, we include only $ExpDemand_{ikt}$ in the second stage and use $FDemand_{ikt}$ as the single instrument in the first stage. When we examine import penetration, we likewise introduce only $ImpComp_{ikt}$ in the second stage and exploit both $FSupply_{ikt}$ and $MTariff_{ikt}$ as instruments in the first stage. Columns 1-6 in Appendix Table 1 shows that this approach delivers qualitatively similar and quantitatively slightly bigger results for each dimension of globalization.

Second, we confirm in Columns 7-9 of Appendix Table 1 that our baseline results are robust to controlling for both country-year and sector-year fixed effects. This specification is more stringent than the one with country-year and sector fixed effects as it accounts for both permanent and transient differences across sectors. Yet this specification delivers both statistically and economically more significant results, especially in the case of import competition.

Third, our baseline IV estimation ensures that outliers are not driving our results. In particular, we drop observations at the country-sector-year level that have been aggregated across fewer than 20 firms. We also exclude observations with excessive annual growth rate in aggregate productivity, average productivity, covariance term, number of firms, exports, import competition, foreign demand or foreign supply in the bottom or top 1 percentiles. These two filters lead us to remove 11% of the raw sample. To further alleviate concerns with sample selection bias, we have confirmed that our results survive when we drop each individual country or sector one at a time.

6 How Trade Affects Productivity: Interpretation and Mechanisms

How shall we interpret our empirical results in light of the theoretical framework in Section 2? Consider first the case of no resource misallocation. On the export side, increased export demand would in the first instance facilitate export entry by less productive firms by lowering the productivity cut-off for exporting. In general equilibrium with free entry, this would be accompanied by a rise in the productivity cut-off for domestic production and, correspondingly, in average firm productivity $AvgProd_{ikt}$. It would also tend to enhance allocative efficiency $CovProd_{ikt}$, as more productive firms would expand their exports by a bigger margin. In addition, surviving firms may upgrade productivity in response to higher expected export profits if they benefit from economies of scale in technological innovation and adoption. However, this force cannot be too strong or else it would reduce $CovProd_{ikt}$, assuming that exporters in the middle of the productivity distribution have the biggest incentive to upgrade as in Bustos (2011).

On the import side, increased import competition has ambiguous effects on aggregate productivity due to the Metlzer paradox. It can raise or depress average firm productivity by triggering either exit or entry by relatively less productive firms. With economies of scale in innovation, import competition can likewise either discourage innovation by reducing profits from domestic sales, or conversely incentivize incumbents to upgrade productivity in order to become more competitive and dampen the fall in domestic demand for their products. These adjustments could shift economic activity towards either more or less productive firms, such that $CovProd_{ikt}$ could either grow or decline. The evidence of a positive effect of import penetration on $Prod_{ikt}$ and $AvgProd_{ikt}$ and a negative or insignificant effect on $CovProd_{ikt}$ thus points to a potentially important role for within-firm productivity growth.

The logic above corresponds to the analysis of unilateral export and import liberalization in our model, respectively. Given our empirical approach, it seems appropriate to interpret our findings as indeed identifying independent effects of export demand and of import competition. It is nevertheless worth recalling that according to theory, bilateral trade reforms would exert the same qualitative effects as unilateral export reforms and none of the ambiguity of unilateral import reforms.

Turning to the case of resource misallocation, Section 2 demonstrates that both export demand and import competition can have ambiguous effects on aggregate productivity, as well as on the underlying channels of firm entry/exit, within-firm productivity growth, and cross-firm reallocation of activity. This theoretical ambiguity implies that the empirical results above cannot conclusively differentiate between alternative economic mechanisms.

In view of this discussion, in this section we perform several exercises that shed light on the channels through which globalization affects aggregate productivity.

6.1 Firm Selection

We first examine the impact of trade exposure on the extensive margin of firm selection into domestic production. We aim to assess whether globalization raises or lowers average firm productivity and allocative efficiency by inducing firm exit or entry at the bottom end of the productivity distribution in a given economy. To this end, we obtain a measure of the minimum productivity $\min Prod_{ikt}$ observed across active firms in a country, sector and year from CompNet. We take the first percentile of log value added per worker to guard against outliers due to measurement error or idiosyncratic firm-specific shocks. In Panel A of Table 10, Columns 1 and 5 show that export demand and import competition both raise this productivity threshold. Our estimates imply that it would increase by 41% and 13% following a one-standard-deviation expansion in export activity and import penetration respectively.

We next quantify the contribution of firm selection to the overall productivity impact of trade. In the rest of Panel A in Table 10, we expand our baseline IV specification (5.1) to include $\min Prod_{ikt}$. Compared to the baseline in Table 8, the point estimates for β_{EX} and β_{IM} are on average halved in the regressions for $AvgProd_{ikt}$. This suggests that half of the trade-induced improvement in average firm productivity observed in the data stems from the exit of relative less productive firms. By deduction, the remaining half of this improvement must arise from productivity upgrading within incumbent firms.

Where significant, the coefficients β_{EX} and β_{IM} become slightly less negative or more positive in the regressions for $CovProd_{ikt}$. This implies that firm exit from the lower end of the productivity distribution tends to reduce allocative efficiency, although this mechanism is small in magnitude. In light of Section 2, this is consistent with two explanations. It could be attributed to within-firm productivity growth concentrated among firms in the middle of the productivity distribution that find themselves close to the productivity cut-off for survival when trade exposure intensifies. Alternatively, trade could reduce misallocation on the extensive margin by cleansing the economy of low-productivity firms that sustain operations when it is socially inefficient, but nevertheless increase overall misallocation through reallocations on the intensive margin. This is because a rise in $\min Prod_{ikt}$ is guaranteed to improve allocative efficiency in the absence of resource misallocation, but it could either enhance or diminish it in the presence of market frictions.

Overall, we conclude that improved firm selection contributes 1/3 of the estimated impact of export demand and 40-80% of the impact of import competition on aggregate productivity $Prod_{ikt}$. This decomposition is based on the reduction in the estimates for β_{EX} and β_{IM} in the specifications for $Prod_{ikt}$ when we condition on the minimum productivity level.

6.2 Productivity Upgrading

We next evaluate the effect of export expansion and import penetration on productivity upgrading at the firm level. Conceptually, we would like to capture productivity-enhancing activities inside the firms affected by international trade, be it via the development of new technologies or the adoption of existing technologies that bring a firm closer to the frontier. We proxy the aggregate amount of investment in productivity upgrading with the log total expenditures on research and development at the country-sector-year level as reported in CompNet. In Panel B of Table 10, we find that export demand growth stimulates aggregate R&D activity, while the effect of import competition is sensitive to the inclusion of sector dummies (Columns 1 and 5). Note that the latter is not inconsistent with individual firms making productivity-enhancing investments at such points along the productivity distribution so as to increase average productivity $AvgProd_{ikt}$ as per the discussion above.

We assess the extent to which globalization shapes aggregate productivity by altering R&D activity in the rest of Panel B of Table 10. We do so by adding R&D as an additional control in our baseline IV specification. We find that the point estimates on export demand nad import competition are not significantly affected in Columns 2-4. When we add sector fixed effects in Columns 6-8 on the other hand, β_{EX} rises while β_{IM} drops in magnitude and becomes insignificant.

6.3 Imperfect Institutions and Market Frictions

Finally, we explore the role of resource misallocation in mediating and moderating the impact of international trade exposure on aggregate productivity. This poses several challenges. First, we cannot directly observe resource misallocation in the data. Second, models with different microfoundations for the emergence of resource misallocation have different implications for observable outcomes in the data, such that the latter cannot be readily interpreted. As we discuss below for example, the measured dispersion in revenue-based TFP and in the marginal revenue product of capital or labor across firms implies resource misallocation under specific assumptions about production technology and market structure, but not necessarily when these assumptions are relaxed. Third, even if observable outcomes could be uniquely mapped to misallocation on theoretical grounds, in practice they are equilbrium outcomes of supply and demand conditions that may introduce endogeneity.

We circumvent these challenges by exploiting indicators of the strength of different institutions that govern the efficiency of factor and product markets. This approach rests on the premise that institutional imperfections constitute structural problems in an economy that generate an inefficient allocation of capital and labor inputs and of output market shares across firms. Institutional indicators thus identify primitive root causes that are behind various microfoundations for resource misallocation and that are exogenous to supply and demand conditions that shape observed outcomes.

We use four measures of institutional strength that are often employed in the literature. The first is rule of law from the *World Justice Project*. This is a comprehensive index of overall institutional capacity that arguably affects the allocation of economic activity both in input and output markets. It has a mean of 1.02 and a standard deviation of 0.55 in our panel.

The remaining three measures in turn characterize institutional efficiency specifically in input markets for labor and capital and in output product markets. We quantify labor market flexibility with an index that varies from 0 to 6 and is the average of 21 indicators for firing and hiring costs from the *OECD Employment Database* (mean 3.47, standard deviation 0.66). We proxy financial market development with an index that varies from 0 to 12 and captures the strength of creditor rights' protection which are necessary to support financial contracts from the *World Bank Doing Business Report* (mean 5.06, standard deviation 1.69). Finally, we assess the tightness of product market regulation with the average of 18 indices for state control, barriers to entrepreneurship, and barriers to trade and investment from the *OECD Market Regulation Database* (mean 1.84, standard deviation 0.25).

Note that low values for product market regulation and high values for rule of law, labor market flexibility, and financial market development signify more efficient and effective institutional design.

Recall from Section 2 that exposure to more export opportunities and import competition has theoretically ambiguous effects on aggregate productivity in the presence of resource misallocation. It is also theoretically ambiguous whether these effects increase or decline when the underlying frictions that generate misallocation are reduced. Intuitively, this ambiguity arises because on the one hand, countries with more efficient institutions, factor and product markets may more effectively adjust to trade reforms and thus engender higher welfare gains from globalization. On the other hand, such countries are closer to the first best to begin with, and may stand to reap lower additional gains on the margin from further trade liberalization. By constrast, in more distorted environments, trade shocks may trigger reallocations across firms that bring the economy closer to an efficient allocation and thereby generate higher productivity increases.

Hence this is ultimately an empirical question. We examine it by expanding our baseline IV specification (5.1) to include interactions of export demand and import competition with the four measures of institutional efficiency one at a time. In these regressions, the level effect of institutions is subsumed by the country-year fixed effects. We instrument the various main and interaction trade terms using the same instruments as before and their respective interactions with the relevant institutional variable.

Table 11 reveals consistent patterns in the data: Strong rule of law and efficient factor and product markets amplify the productivity gains from import competition, but dampen the productivity gains from export expansion. This is true for aggregate productivity at the country-sector-year level, as well as for each of its constituent components, average firm productivity and allocative efficiency. These findings obtain with or without sector fixed effects (Panels A and B respectively). They are also highly statistically and economically significant across the board, except for some regressions with creditor rights' protection.

These results indicate the complex interactions between international trade and market frictions in shaping aggregate activity and productivity in an economy. In particular, the empirical patterns point to an important asymmetry between the impacts of positive and negative shocks to domestic firms. Economies subject to more frictions in resource allocation appear to realize greater productivity gains from growth opportunities such as increased export demand. This suggests that export expansion episodes can correct some of the resource misallocation that has accumulated over time because of the "wrong" firms obtaining more resources than they should in the first best. This may occur if the "right" productive firms that start out with fewer than optimal resources are more effective at scaling up production activities, with their existing or additional resources, than the "wrong" less productive firms. By contrast, shocks that induce contraction in the economy such as heightened import competition may exert a greater cleansing effect on aggregate productivity and welfare in environments with more efficient resource allocation, such that "wrong" firms contract disproportinately more.

Of note, this asymmetry raises the possibility that the "right" firms may be able to access relatively more resources than the "wrong" firms during boom times, compared to bust times. In the case of financial market frictions for example, this would be consistent with asymmetric information playing out in different ways during peaks and troughs. Financiers may have imperfect knowledge of firms' fundamentals and make financing decisions based both on firms' expected future profit stream (which is presumably increasing in firm fundamentals such as productivity) and on firms' past performance and collateralizable assets (which are a function of previously accumulated distortions in capital allocation). Since rises in export demand and import competition have opposing effects on firm profits, our results are consistent with lenders being more willing to extend capital based on the net present value of future profit streams during boom times, and conversely tying funding more closely to accrued collateral from past operations during bust times.

6.4 Misallocation Measures in the Literature

Our analysis relies on the Olley-Pakes (1996) decomposition of aggregate productivity into average firm productivity and a covariance term between firms' productivity and share of economic activity. As argued in Section 2.3, this decomposition sheds light on the mechanisms through which aggregate productivity evolves, with the covariance term capturing allocative efficiency in particular.

We conclude by examining the impact of international trade on several measures of productivity and mark-up dispersion that have been proposed in the literature as theoretically micro-founded indicators of resource misallocation. Under specific assumptions about the economic environment, Hsieh-Klenow (2009) and Gopinath et al. (2015) show that the observed dispersion across firms in revenue-based total factor productivity (TFPR), in the marginal revenue product of capital (MRPK), and in the marginal revenue product of labor (MRPL) is monotonically increasing with resource misallocation in input markets and with distortions in output markets. Given certain assumptions, Edmond et al. (2015) find that the observed disperion in the price-cost mark-up (PCM) across firms likewise signals output-market distortions.

There are several concerns with interpreting these dispersion indicators and using them to assess the impact of trade on productivity and allocative efficiency. First, measurement error in firm-level TFPR, MRPK, MRPL and PCM can inflate their observed dispersion across firms. Since these variables are also estimated rather than directly observed in the data, treating them as regression outcome variables can complicate econometric inference. These concerns are arguably less applicable to the OP covariance term we work with as it is based on value added per worker and firms' employment share.

Second and more importantly, the nature of production technology and market competition can affect the productivity and mark-up dispersion even in the absence of resource misallocation. In terms of market structure, Foster et al. (20080) and Berman et al. (2012) show that TFPR, MRPK and MRPL dispersion implies misallocation of production inputs under constant mark-ups, but not under variable mark-ups. At the same time, Dhingra-Morrow (2014) demonstrate that market-share misallocation arises in product markets with variable mark-ups even when there are no distortions in factor markets. Turning to production technology, Bartelsman et al. (2013) and Foster et al. (2015, 2016) prove that TFPR, MRPK and MRPL dispersion signals resource misallocation under constant returns to scale and no shocks to firm demand or quantity-based productivity (TFPQ). However, this is no longer the case when firms experience increasing returns to scale or adjustment costs in responding to shocks. It is thus difficult to interpret the four dispersion measures in practice given empirical evidence in the literature of variable mark-ups, increasing returns to scale, and adjustment costs. By contrast, Bartelsman et al. (2013) theoretically establish that the covariance term reflects the degree of allocative efficiency regardless of the exact market structure or production technology.

Table 12 explores the effect of export expansion and import competition on TFPR, MRPK, MRPL and PCM dispersion in our data. For each country, sector and year, the CompNet data reports the standard deviations of TFPR, MRPK and MRPL, as well as the 80th-20th interpercentile range for PCM. When we apply our IV strategy to each of these outcome variables, we typically find significant positive effects of both export exposure and import competition on the dispersion measures (on PCM, see also DeLoecker and Warczinsky 2012). This illustrates the difficulty of interpreting these dispersion indicators in general economic environments: Were they a sign of misallocation, our conclusion of a positive impact of export expansion on allocative efficiency as measured by $CovProd_{ikt}$ would have been consistent with the dispersion metrics declining rather than rising.

7 Conclusion

We examine the impact of international trade on aggregate productivity. Theoretically, we show that bilateral and unilateral export liberalization increase aggregate productivity, while unilateral import liberalization can either raise or reduce it. However, all three trade reforms have ambiguous effects in the presence of resource misallocation. Using unique new data on 14 European countries and 20 manufacturing industries during 1998-2011, we establish empirically that exogenous shocks to both export demand and import competition generate large gains in aggregate productivity. Although both trade activities increase average firm productivity, export expansion enhances allocative efficiency across firms, while import penetration leaves it unchanged or diminished. These effects operate through a combination of improved firm selection, within-firm productivity upgrading, and reallocation across firms. Finally, efficient institutions, factor and product markets amplify the productivity gains from import competition, but dampen those from export expansion.

Our findings have important implications for policy design in developing countries that aspire to promote growth through greater economic integration but suffer from weak institutions and significant frictions in capital, labor and product markets. The analysis suggests that reallocations across firms are an important margin of adjustment and that alleviating market distortions is important for realizing the full welfare gains from globalization. Our results further indicate that developed economies also stand to gain from import and export liberalization, despite concerns about the impact of import competition from low-wage countries.

There remains much scope for further research. Richer data would make it possible to examine how international trade affects the incentives for technological upgrading across the firm productivity distribution. From a policy perspective, it would also be valuable to assess the impact of different frictions in capital, labor and product markets on firm selection, within-firm innovation activity, and reallocations across firms. These constitute some steps towards ultimately understanding how to jointly design trade policy and structural reforms that remove institutional and market imperfections in order to maximize economic welfare.

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Table 1. Numerical Simulation: Productivity Gains from Trade Liberalization

This table reports the results from numerically simulating the model to assess the productivity impact of reducing bilateral trade costs, unilateral export costs or unilateral import costs by 20%. Each cell shows the predicted change in aggregate productivity, average firm productivity and the covariance of firms' productivity and employment share under different trade and misallocation scenarios. We compare the case of no misallocation in row 1 (when the standard deviation of firm distortion is σ_η=0) to three possible degrees of misallocation in rows 2-4 (when $\sigma\eta$=0.05 and the correlation between firm productivity and distortion is $\rho(\varphi,\eta)$={-0.5,0,0.5}). All other parameter values are calibrated as discussed in the text.

	Bilateral Liberalization			Export Liberalization			Import Liberalization		
	Aggr Prod	Avg Prod	Cov Term	Aggr Prod	Avg Prod	Cov Term	Aggr Prod	Avg Prod	Cov Term
No Misallocation: $\sigma_\eta = 0$									
	3.51%	2.75%	0.75%	4.89%	3.84%	1.05%	-0.59%	-0.47%	-0.12%
Misallocation: $\sigma_\eta = 0.05$									
$\rho = -0.5$	1.37%	0.98%	0.38%	3.46%	2.70%	0.76%	-1.35%	-1.17%	-0.18%
$\rho = 0$	3.31%	2.62%	0.69%	4.61%	3.63%	0.98%	-0.50%	-0.39%	-0.11%
$\rho = 0.5$	5.31%	4.27%	1.03%	6.03%	4.79%	1.24%	0.14%	0.20%	-0.06%

Table 2. Sumary Statistics

This table provides an overview of CompNet and WIOD data coverage. It also summarizes the variation in the three productivity terms of the OP decomposition (aggregate productivity, average productivity, covariance term) and in trade activity across countries and sectors in the 1998-2011 panel. The unit of observation is the country-sector-year triplet.

	Years	# Sector-Year Obs	Avg # Firms per Sector-Year	ln Aggregate Productivity		ln Average Productivity		Covariance Term		ln Exports	ln Imports of Final Goods
				Mean	St Dev	Mean	St Dev	Mean	St Dev		
AUSTRIA	2000-2011	222	60	4.35	0.53	4.29	0.53	0.06	0.10	7.93	6.73
BELGIUM	1998-2010	260	709	4.08	0.56	3.88	0.56	0.20	0.17	8.22	6.93
ESTONIA	1998-2011	274	166	2.03	0.62	1.74	0.62	0.29	0.25	4.83	3.82
FINLAND	1999-2011	260	585	4.05	0.56	3.87	0.56	0.18	0.21	7.11	5.68
FRANCE	1998-2009	240	3,488	4.05	0.48	3.86	0.48	0.19	0.15	9.13	8.10
GERMANY	1998-2011	280	719	4.51	0.40	4.40	0.40	0.11	0.09	9.88	8.63
HUNGARY	2003-2011	180	1,446	1.63	0.66	1.10	0.66	0.53	0.31	6.96	5.72
ITALY	2001-2011	220	4,327	3.53	0.43	3.25	0.43	0.28	0.09	9.15	7.76
LITHUANIA	2000-2011	240	220	1.91	0.63	1.44	0.63	0.47	0.26	4.89	4.24
POLAND	2005-2011	140	717	2.33	0.80	2.15	0.80	0.18	0.15	8.12	6.62
PORTUGAL	2006-2011	120	1,607	2.79	0.63	2.50	0.63	0.28	0.11	7.12	6.16
SLOVAKIA	2001-2011	218	102	2.15	0.63	2.01	0.63	0.14	0.20	6.68	5.30
SLOVENIA	1998-2011	249	211	2.32	0.59	2.20	0.59	0.12	0.19	6.04	4.69
SPAIN	1998-2011	280	3,125	3.47	0.44	3.16	0.44	0.31	0.15	8.39	7.44
Average		227	1,249	3.08	0.57	2.85	0.57	0.24	0.17	7.46	6.27

Table 3. Summary Statistics

This table summarizes the variation in the level and growth of the three productivity terms of the OP decomposition (aggregate productivity, average productivity, covariance term) across countries and sectors in the 1998-2011 panel. The unit of observation is the country-sector-year triplet.

	Aggregate Productivity	Average Productivity	Covariance Term
Avg across countries, sectors, years	3.16	2.93	0.23
St dev across sector-years for avg country	1.14	1.20	0.22
Avg change: 1 year	0.04	0.03	0.01
Avg change: 3 years	0.10	0.09	0.01
Avg change: 5 years	0.18	0.16	0.02

Table 4. Trade and Economic Activity

This table examines the relationship between aggregate economic activity and trade exposure at the country-sector-year level. The outcome variable is log output, log value added, log employment or log aggregate productivity as indicated in the column heading. All columns include country-year pair fixed effects, and control for the log number of firms by country-sector-year, as well as the average log number of firms and the average log employment across countries by sector-year. Robust standard errors reported in parentheses. ***, **, * indicate significance at 1%, 5% and 10%.

	ln Output (ikt)	ln Value Added (ikt)	ln Employ-ment (ikt)	ln Aggr Prod (ikt)
Exp Dem (ikt)	**0.381***	**0.371***	**0.238***	**0.122***
	(0.017)	**(0.016)**	**(0.010)**	**(0.012)**
Imp Comp (ikt)	**-0.137***	**0.040***	**-0.067***	**0.105***
	(0.008)	**(0.010)**	**(0.005)**	**(0.008)**
ln N Firms (ikt)	0.565***	0.577***	0.738***	-0.160***
	(0.022)	(0.024)	(0.016)	(0.018)
Avg ln N Firms (kt)	-0.990***	-0.718***	-0.730***	0.019
	(0.030)	(0.035)	(0.021)	(0.026)
Avg ln Employment (kt)	1.301***	0.658***	0.860***	-0.180***
	(0.035)	(0.036)	(0.022)	(0.026)
# Observations	2,809	2,809	2,809	2,809
R-squared	0.924	0.928	0.948	0.849
Country * Year FE	Y	Y	Y	Y

Table 5. Trade and Aggregate Productivity: OLS Baseline

This table examines the relationship between aggregate productivity and trade exposure at the country-sector-year level. The outcome variables follow the OP productivity decomposition and are indicated in the column heading. All columns include country-year pair fixed effects and the full set of controls in Table 4. Robust standard errors reported in parentheses. ***, **, * indicate significance at 1%, 5% and 10%.

	ln Aggr Prod (ikt)	ln Avg Prod (ikt)	Cov Term (ikt)
Exp Dem (ikt)	**0.122*** **	**0.081*** **	**0.041*** **
	(0.012)	**(0.011)**	**(0.005)**
Imp Comp (ikt)	**0.105*** **	**0.123*** **	**-0.018*** **
	(0.008)	**(0.007)**	**(-0.003)**
# Observations	2,809	2,809	2,809
R-squared	0.849	0.868	0.514
Ctry*Year FE, Controls	Y	Y	Y

Table 6. Trade and Aggregate Productivity Growth: OLS in First Differences

This table examines the relationship between aggregate productivity and trade exposure at the country-sector-year level. The outcome variables follow the OP productivity decomposition and are indicated in the column heading. All left and right-hand side variables are first differences over rolling 1-year, 3-year and 5-year overlapping periods. All columns include year fixed effects and the full set of controls in Table 4. Robust standard errors reported in parentheses. ***, **, * indicate significance at 1%, 5% and 10%.

	Δ = 1 year			Δ = 3 years			Δ = 5 years		
	Δ ln Aggr Prod (ikt)	Δ ln Avg Prod (ikt)	Δ Cov Term (ikt)	Δ ln Aggr Prod (ikt)	Δ ln Avg Prod (ikt)	Δ Cov Term (ikt)	Δ ln Aggr Prod (ikt)	Δ ln Avg Prod (ikt)	Δ Cov Term (ikt)
Δ Exp Dem (ikt)	**0.115*** **	**0.033**	**0.082*** **	**0.137*** **	**0.049** **	**0.088*** **	**0.157*** **	**0.085*** **	**0.072*** **
	(0.028)	**(0.024)**	**(0.028)**	**(0.025)**	**(0.023)**	**(0.018)**	**(0.027)**	**(0.025)**	**(0.019)**
Δ Imp Comp (ikt)	**0.082*** **	**0.101*** **	**-0.019**	**0.064*** **	**0.103*** **	**-0.039** **	**0.079*** **	**0.108*** **	**-0.029* **
	(0.023)	**(0.022)**	**(0.021)**	**(0.025)**	**(0.024)**	**(0.016)**	**(0.027)**	**(0.025)**	**(0.015)**
Observations	2,544	2,544	2,544	2,071	2,071	2,071	1,585	1,585	1,585
R-squared	0.113	0.114	0.022	0.099	0.115	0.043	0.095	0.093	0.034
Year FE, Controls	Y	Y	Y	Y	Y	Y	Y	Y	Y

Table 7. Instrumenting Export Demand and Import Competition: IV First Stage

This table presents the first stage of the baseline IV 2SLS regression. It examines the impact of foreign import demand, foreign export supply, and import tariffs on export exposure and import penetration at the country-sector-year level. The outcome variable is indicated in the column heading. All columns include country-year pair fixed effects and the full set of controls in Table 4. Columns 2 and 4 also include sector fixed effects. Robust standard errors reported in parentheses. ***, **, * indicate significance at 1%, 5% and 10%.

	Exp Dem (ikt)		Imp Comp (ikt)	
Foreign Demand (ikt)	**0.647***	**0.448***	**0.117***	**-0.007**
	(0.023)	**(0.061)**	**(0.012)**	**(0.028)**
Foreign Supply (ikt)	**0.127***	**0.148****	**0.874***	**0.420***
	(0.010)	**(0.060)**	**(0.005)**	**(0.027)**
Import Tariff (ikt)	**-4.090***	**0.233**	**3.078***	**-0.958****
	(0.417)	**(0.603)**	**(0.351)**	**(0.475)**
ln N Firms (ikt)	0.557***	0.566***	0.007	0.007
	(0.026)	(0.024)	(0.014)	(0.013)
Avg ln N Firms (kt)	-0.708***	-0.539***	-0.046**	0.110
	(0.031)	(0.205)	(0.019)	(0.085)
Avg ln Employment (kt)	0.307***	0.497***	0.059***	-0.042
	(0.043)	(0.160)	(0.019)	(0.068)
# Observations	2,775	2,775	2,775	2,775
R-squared	0.893	0.922	0.979	0.985
Country*Year FE	Y	Y	Y	Y
Sector FE	N	Y	N	Y

Table 8. Impact of Trade on Aggregate Productivity: IV Second Stage

This table presents the second stage of the baseline IV 2SLS regression. It examines the impact of instrumented export demand and import competition on aggregate productivity at the country-sector-year level. The outcome variables follow the OP productivity decomposition and are indicated in the column heading. All columns include country-year pair fixed effects and the full set of controls in Table 4. Columns 4-6 also include sector fixed effects. Robust standard errors reported in parentheses. ***, **, * indicate significance at 1%, 5% and 10%.

	ln Aggr Prod (ikt)	ln Avg Prod (ikt)	Cov Term (ikt)	ln Aggr Prod (ikt)	ln Avg Prod (ikt)	Cov Term (ikt)
^Exp Dem (ikt)	**0.408*** **	**0.316*** **	**0.092*** **	**0.315*** **	**0.207** **	**0.108*** **
	(0.027)	**(0.026)**	**(0.008)**	**(0.100)**	**(0.090)**	**(0.039)**
^Imp Comp (ikt)	**0.049*** **	**0.077*** **	**-0.028*** **	**0.294** **	**0.306*** **	**-0.012**
	(0.010)	**(0.009)**	**(0.003)**	**(0.117)**	**(0.107)**	**(0.042)**
ln N Firms (ikt)	-0.329***	-0.262***	-0.068***	-0.266***	-0.191***	-0.075***
	(0.023)	(0.022)	(0.009)	(0.063)	(0.057)	(0.025)
Avg ln N Firms (kt)	0.326***	0.351***	-0.026**	0.070	0.033	0.037
	(0.037)	(0.034)	(0.013)	(0.168)	(0.152)	(0.053)
Avg ln Employment (kt)	-0.454***	-0.471***	0.017	0.042	0.013	0.029
	(0.039)	(0.037)	(0.013)	(0.142)	(0.130)	(0.045)
Observations	2,775	2,775	2,775	2,775	2,775	2,775
R-squared	0.817	0.849	0.489	0.868	0.895	0.633
Ctry*Year FE, Controls	Y	Y	Y	Y	Y	Y
Sector FE	N	N	N	Y	Y	Y

Table 9. Alternative Measures of Import Competition

This table examines the stability of the impact of instrumented export demand and import competition on aggregate productivity at the country-sector-year level. The outcome variables follow the OP productivity decomposition and are indicated in the column heading. Import competition is measured by the level of import competition from China in Panel A and by the ratio of overall import competition to domestic turnover or employment in Panel B. All columns include country-year pair fixed effects and the full set of controls in Table 4. Columns 4-6 in Panel A also include sector fixed effects. Robust standard errors reported in parentheses. ***, **, * indicate significance at 1%, 5% and 10%.

Panel A. Import Competition from China

	ln Aggr Prod (ikt)	ln Avg Prod (ikt)	Cov Term (ikt)	ln Aggr Prod (ikt)	ln Avg Prod (ikt)	Cov Term (ikt)
^Exp Dem (ikt)	**0.431*** **	**0.384*** **	**0.047*** **	**0.304*** **	**0.199*** **	**0.105*** **
	(0.022)	**(0.022)**	**(0.006)**	**(0.083)**	**(0.075)**	**(0.032)**
^China Imp Comp (ikt)	**-0.001**	**0.023*** **	**-0.024*** **	**0.102*** **	**0.106*** **	**-0.004**
	(0.008)	**(0.008)**	**(0.002)**	**(0.036)**	**(0.033)**	**(0.013)**
Observations	2,775	2,775	2,775	2,775	2,775	2,775
R-squared	0.811	0.835	0.542	0.878	0.903	0.634
Ctry*Year FE, Controls	Y	Y	Y	Y	Y	Y
Sector FE	N	N	N	Y	Y	Y

Panel B. Import Competition Ratio

	Imp Comp Ratio: Turnover			Imp Comp Ratio: Employment		
	ln Aggr Prod (ikt)	ln Avg Prod (ikt)	Cov Term (ikt)	ln Aggr Prod (ikt)	ln Avg Prod (ikt)	Cov Term (ikt)
^Exp Dem (ikt)	**0.416*** **	**0.319*** **	**0.097*** **	**0.386*** **	**0.285*** **	**0.101*** **
	(0.024)	**(0.022)**	**(0.007)**	**(0.024)**	**(0.023)**	**(0.008)**
^Imp Comp Ratio (ikt)	**0.058*** **	**0.093*** **	**-0.035*** **	**0.074*** **	**0.101*** **	**-0.027*** **
	(0.007)	**(0.007)**	**(0.002)**	**(0.008)**	**(0.007)**	**(0.003)**
Observations	2,794	2,794	2,794	2,794	2,794	2,794
R-squared	0.817	0.853	0.509	0.824	0.857	0.479
Ctry*Year FE, Controls	Y	Y	Y	Y	Y	Y

Table 10. Mechanisms: Firm Selection and Innovation Activity

This table examines the mechanisms through which instrumented export demand and import competition affect aggregate productivity at the country-sector-year level. The outcome variables follow the OP productivity decomposition and are indicated in the column heading. In Columns 1 and 5 the outcome variables change to the log productivity of the firm at the first percentile and the log R&D expenditure respectively. These variables then enter as controls in Columns 2-4 and 6-8. All columns include country-year pair fixed effects and the full set of controls in Table 4. Columns 5-8 also include sector fixed effects. Robust standard errors reported in parentheses. ***, **, * indicate significance at 1%, 5% and 10%.

Panel A. Firm Selection

	ln min Prod (ikt)	ln Aggr Prod (ikt)	ln Avg Prod (ikt)	Cov Term (ikt)	ln min Prod (ikt)	ln Aggr Prod (ikt)	ln Avg Prod (ikt)	Cov Term (ikt)
^Exp Dem (ikt)	**0.225*** **	**0.264*** **	**0.151*** **	**0.113*** **	**0.257** **	**0.178** **	**0.048**	**0.130*** **
	(0.025)	**(0.019)**	**(0.016)**	**(0.008)**	**(0.102)**	**(0.074)**	**(0.058)**	**(0.038)**
^Imp Comp (ikt)	**0.066*** **	**0.011**	**0.031*** **	**-0.020*** **	**0.067**	**0.171** **	**0.193*** **	**-0.022**
	(0.009)	**(0.007)**	**(0.006)**	**(0.003)**	**(0.119)**	**(0.082)**	**(0.067)**	**(0.039)**
ln min Prod (ikt)		0.652***	0.737***	-0.085***		0.638***	0.672***	-0.034***
		(0.018)	(0.015)	(0.007)		(0.021)	(0.019)	(0.009)
Observations	2,749	2,749	2,749	2,749	2,749	2,749	2,749	2,749
R-squared	0.910	0.913	0.948	0.482	0.930	0.937	0.959	0.618
Ctry*Year FE, Controls	Y	Y	Y	Y	Y	Y	Y	Y
Sector FE	N	N	N	N	Y	Y	Y	Y

Panel B. Innovation Activity

	ln R&D (ikt)	ln Aggr Prod (ikt)	ln Avg Prod (ikt)	Cov Term (ikt)	ln R&D (ikt)	ln Aggr Prod (ikt)	ln Avg Prod (ikt)	Cov Term (ikt)
^Exp Dem (ikt)	**0.097**	**0.406*** **	**0.301*** **	**0.106*** **	**0.533* **	**0.386*** **	**0.279*** **	**0.107** **
	(0.067)	**(0.027)**	**(0.026)**	**(0.008)**	**(0.312)**	**(0.114)**	**(0.100)**	**(0.042)**
^Imp Comp (ikt)	**0.123*** **	**0.048*** **	**0.086*** **	**-0.038*** **	**-2.555*** **	**0.221**	**0.180**	**0.041**
	(0.025)	**(0.010)**	**(0.009)**	**(0.003)**	**(0.354)**	**(0.135)**	**(0.120)**	**(0.048)**
ln R&D (ikt)		-0.018**	-0.043***	0.025***		-0.037**	-0.061***	0.025***
		(0.008)	(0.007)	(0.003)		(0.017)	(0.016)	(0.006)
Observations	2,775	2,775	2,775	2,775	2,775	2,775	2,775	2,775
R-squared	0.999	0.819	0.853	0.517	0.999	0.863	0.896	0.633
Ctry*Year FE, Controls	Y	Y	Y	Y	Y	Y	Y	Y
Sector FE	N	N	N	N	Y	Y	Y	Y

Table 11. Mechanisms: Imperfect Institutions and Market Frictions

This table examines the role of resource misallocation arising from imperfect institutions in moderating the impact of export demand and import competition on aggregate productivity at the country-sector-year level. The outcome variables follow the OP productivity decomposition and are indicated in the column heading. Institutional efficiency is measured by indices for rule of law in Columns 1-3, labor market flexibility in Columns 4-6, creditor rights protection in in Columns 7-9, and product market regulation in Columns 10-12. All insitutional measures are described in the text. All columns include country-year pair fixed effects and the full set of controls in Table 4. Panel B also includes sector fixed effects. Robust standard errors reported in parentheses. ***, **, * indicate significance at 1%, 5% and 10%.

Panel A. No sector fixed effects

Institutional Efficiency Measure	Rule of Law (World Justice Project Index)			Labor Market Flexibility (OECD Index)			Creditor Rights Protection (World Bank)			Product Market Regulation (OECD Index)		
	ln Aggr Prod (ikt)	ln Avg Prod (ikt)	Cov Term (ikt)	ln Aggr Prod (ikt)	ln Avg Prod (ikt)	Cov Term (ikt)	ln Aggr Prod (ikt)	ln Avg Prod (ikt)	Cov Term (ikt)	ln Aggr Prod (ikt)	ln Avg Prod (ikt)	Cov Term (ikt)
^Exp Dem (ikt)	1.099***	0.924***	0.175***	3.528***	3.016***	0.512**	0.567***	0.473***	0.094***	-1.018***	-0.899***	-0.119**
	(0.084)	(0.078)	(0.025)	(1.253)	(1.078)	(0.252)	(0.102)	(0.095)	(0.024)	(0.203)	(0.189)	(0.056)
^Imp Comp (ikt)	-0.168***	-0.102***	-0.067***	-0.573*	-0.449	-0.124*	-0.075*	-0.056	-0.019**	0.282***	0.236***	0.046**
	(0.036)	(0.033)	(0.009)	(0.327)	(0.282)	(0.064)	(0.039)	(0.036)	(0.009)	(0.082)	(0.078)	(0.023)
^Exp Dem (ikt) x	**-0.490*** **	**-0.432*** **	**-0.058*** **	**-0.886*** **	**-0.756*** **	**-0.130* **	**-0.032* **	**-0.030* **	**-0.002**	**0.760*** **	**0.646*** **	**0.113*** **
Institution Efficiency (itk)	**(0.048)**	**(0.044)**	**(0.014)**	**(0.341)**	**(0.293)**	**(0.069)**	**(0.017)**	**(0.016)**	**(0.004)**	**(0.114)**	**(0.106)**	**(0.031)**
^Imp Comp (ikt) x	**0.163*** **	**0.132*** **	**0.031*** **	**0.176** **	**0.146* **	**0.030* **	**0.024*** **	**0.025*** **	**-0.002**	**-0.130*** **	**-0.090** **	**-0.040*** **
Institution Efficiency (itk)	**(0.024)**	**(0.022)**	**(0.006)**	**(0.089)**	**(0.077)**	**(0.018)**	**(0.007)**	**(0.006)**	**(0.002)**	**(0.046)**	**(0.043)**	**(0.012)**
Observations	2,775	2,775	2,775	2,775	2,775	2,775	2,775	2,775	2,775	2,596	2,596	2,596
R-squared	0.784	0.827	0.471	0.766	0.806	0.465	0.814	0.847	0.491	0.814	0.842	0.462
Ctry*Year FE, Controls	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

Panel B. Sector fixed effects

Efficiency Measure	Rule of Law (World Justice Project Index)			Labor Market Flexibility (OECD Index)			Creditor Rights Protection (World Bank)			Product Market Regulation (OECD Index)		
	ln Aggr Prod (ikt)	ln Avg Prod (ikt)	Cov Term (ikt)	ln Aggr Prod (ikt)	ln Avg Prod (ikt)	Cov Term (ikt)	ln Aggr Prod (ikt)	ln Avg Prod (ikt)	Cov Term (ikt)	ln Aggr Prod (ikt)	ln Avg Prod (ikt)	Cov Term (ikt)
^Exp Dem (ikt)	1.402***	1.195***	0.207**	1.441***	0.561	0.880***	0.581***	0.482***	0.099***	-1.009***	-0.953***	-0.056
	(0.278)	(0.248)	(0.084)	(0.554)	(0.468)	(0.208)	(0.102)	(0.095)	(0.025)	(0.205)	(0.194)	(0.051)
^Imp Comp (ikt)	-0.532***	-0.473***	-0.060	0.344***	0.405***	-0.061	0.215	0.302**	-0.087	0.818***	0.720***	0.098**
	(0.200)	(0.179)	(0.057)	(0.119)	(0.099)	(0.045)	(0.149)	(0.126)	(0.072)	(0.150)	(0.139)	(0.038)
^Exp Dem (ikt) x	**-0.578*** **	**-0.522*** **	**-0.056** **	**-0.352** **	**-0.155**	**-0.197*** **	**-0.001**	**0.031**	**-0.033** **	**0.514*** **	**0.535*** **	**-0.021**
Institution Efficiency (itk)	**(0.093)**	**(0.084)**	**(0.027)**	**(0.137)**	**(0.116)**	**(0.051)**	**(0.038)**	**(0.033)**	**(0.015)**	**(0.164)**	**(0.155)**	**(0.048)**
^Imp Comp (ikt) x	**0.172*** **	**0.137*** **	**0.035*** **	**0.073* **	**0.024**	**0.049*** **	**0.011**	**0.000**	**0.010**	**-0.162** **	**-0.131** **	**-0.031* **
Institution Efficiency (itk)	**(0.035)**	**(0.032)**	**(0.009)**	**(0.039)**	**(0.034)**	**(0.014)**	**(0.016)**	**(0.014)**	**(0.006)**	**(0.065)**	**(0.060)**	**(0.018)**
Observations	2,775	2,775	2,775	2,775	2,775	2,775	2,775	2,775	2,775	2,596	2,596	2,596
R-squared	0.801	0.846	0.613	0.852	0.896	0.539	0.879	0.910	0.455	0.840	0.869	0.603
Ctry*Year FE, Controls	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Sector FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

Table 12. Trade, Productivity and Mark-Up Dispersion

This table examines the impact of export demand and import competition on productivity and mark-up dispersion across firms at the country-sector-year level. The outcome variable is the standard deviation of the marginal revenue product of capital, the standard deviation of the marginal revenue product of labor, the standard deviation of revenue-based total factor productivity, and the 80th-20th interpercentile range of the price-cost mark-up as indicated in the column heading. All variables are defined in the text. All columns include country-year pair fixed effects and the full set of controls in Table 4. Columns 5-8 also include sector fixed effects. Robust standard errors reported in parentheses. ***, **, * indicate significance at 1%, 5% and 10%.

	MRPK St Dev	MRPL St Dev	TFPR St Dev	PCM p80 / p20	MRPK St Dev	MRPL St Dev	TFPR St Dev	PCM p80 / p20
^Exp Dem (ikt)	**-0.137*** **	**0.279*** **	**0.297*** **	**0.026*** **	**0.372*** **	**0.074**	**0.095**	**-0.144*** **
	(0.032)	**(0.025)**	**(0.032)**	**(0.008)**	**(0.142)**	**(0.084)**	**(0.133)**	**(0.041)**
^Imp Comp (ikt)	**0.213*** **	**0.081*** **	**0.043*** **	**-0.011*** **	**0.280* **	**0.288*** **	**0.633*** **	**0.176*** **
	(0.013)	**(0.009)**	**(0.011)**	**(0.003)**	**(0.161)**	**(0.095)**	**(0.141)**	**(0.049)**
Observations	2,775	2,775	2,382	2,773	2,775	2,775	2,382	2,773
R-squared	0.560	0.809	0.783	0.695	0.708	0.876	0.813	0.725
Ctry*Year FE, Controls	Y	Y	Y	Y	Y	Y	Y	Y
Sector FE	N	N	N	N	Y	Y	Y	Y

Appendix Table 1. Robustness

This table examines the stability of the impact of instrumented export demand and import competition on aggregate productivity at the country-sector-year level. The outcome variables follow the OP productivity decomposition and are indicated in the column heading. All columns include country-year pair fixed effects and the full set of controls in Table 4. Columns 7-9 also include sector-year pair fixed effects. Robust standard errors reported in parentheses. ***, **, * indicate significance at 1%, 5% and 10%.

	ln Aggr Prod (ikt)	ln Avg Prod (ikt)	Cov Term (ikt)	ln Aggr Prod (ikt)	ln Avg Prod (ikt)	Cov Term (ikt)	ln Aggr Prod (ikt)	ln Avg Prod (ikt)	Cov Term (ikt)
^Exp Dem (ikt)	**0.456*** **	**0.360*** **	**0.096*** **				**0.381*** **	**0.232** **	**0.149*** **
	(0.024)	**(0.023)**	**(0.009)**				**(0.118)**	**(0.107)**	**(0.043)**
^Imp Comp (ikt)				**0.141*** **	**0.149*** **	**-0.008*** **	**0.498*** **	**0.598*** **	**-0.101* **
				(0.008)	**(0.007)**	**(0.003)**	**(0.169)**	**(0.155)**	**(0.056)**
Observations	2,809	2,809	2,809	2,775	2,775	2,775	2,775	2,775	2,775
R-squared	0.808	0.840	0.455	0.842	0.865	0.498	0.854	0.886	0.642
Ctry*Year FE, Controls	Y	Y	Y	Y	Y	Y	Y	Y	Y
Sector*Year FE	N	N	N	N	N	N	Y	Y	Y

Figure 1. Numerical Simulation: Bilateral Trade Liberalization

This figure displays results from numerically simulating the model to assess the productivity impact of reducing bilateral trade costs by 20%. Each line shows how the predicted change in aggregate productivity, average firm productivity and the covariance of firms' productivity and employment share on the vertical axis varies with the correlation between firm productivity and distortion $\rho(\phi,\eta)$ on the horizontal axis. The flat line corresponds to the case of no misallocation (when the standard deviation of firm distortion is σ_η=0) to two possible degrees of misallocation (when σ_η={0.05,0.15}). All other parameter values are calibrated as discussed in the text.

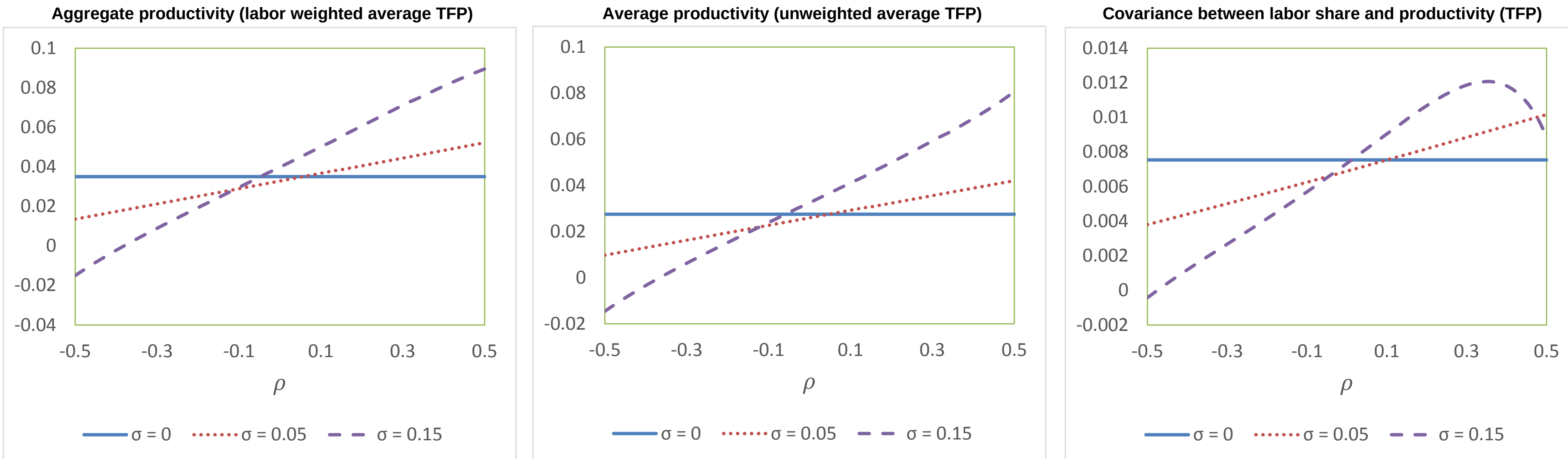

Figure 2. Numerical Simulation: Unilateral Trade Liberalization

This figure displays results from numerically simulating the model to assess the productivity impact of reducing unilateral export or import costs by 20%. Each line shows how the predicted change in aggregate productivity, average firm productivity and the covariance of firms' productivity and employment share on the vertical axis varies with the correlation between firm productivity and distortion $\rho(\phi,\eta)$ on the horizontal axis. The flat line corresponds to the case of no misallocation (when the standard deviation of firm distortion is σ_η=0) to two possible degrees of misallocation (when σ_η={0.05,0.15}). All other parameter values are calibrated as discussed in the text.

Figure 2A. Unilateral Export Liberalization

Aggregate productivity (labor weighted average TFP) | **Average productivity (unweighted average TFP)** | **Covariance between labor share and productivity (TFP)**

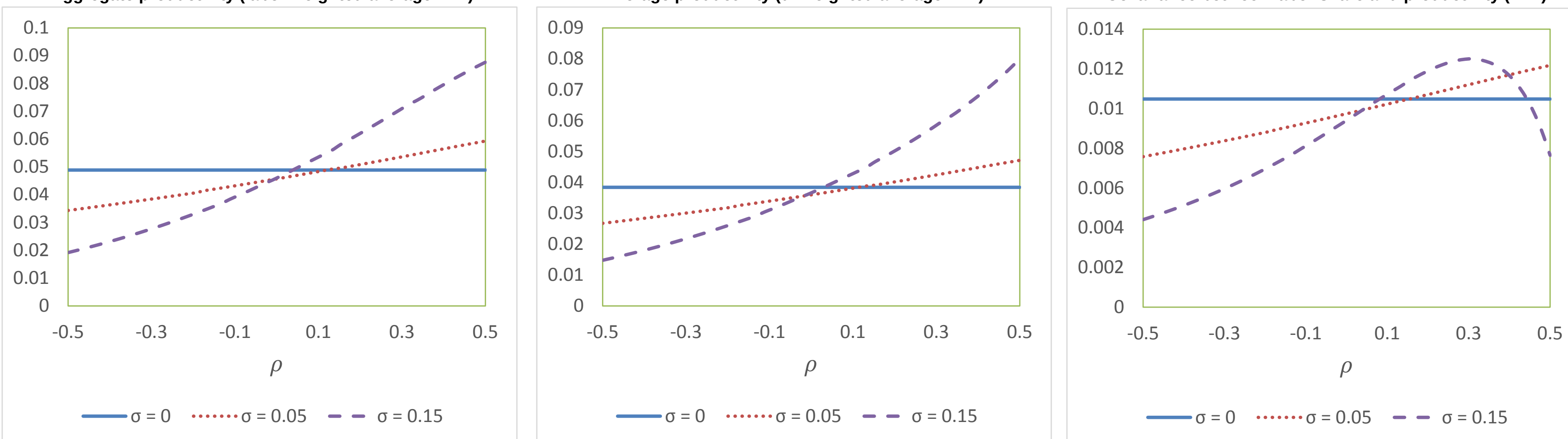

Figure 2B. Unilateral Import Liberalization

Aggregate productivity (labor weighted average TFP) | **Average productivity (unweighted average TFP)** | **Covariance between labor share and productivity (TFP)**

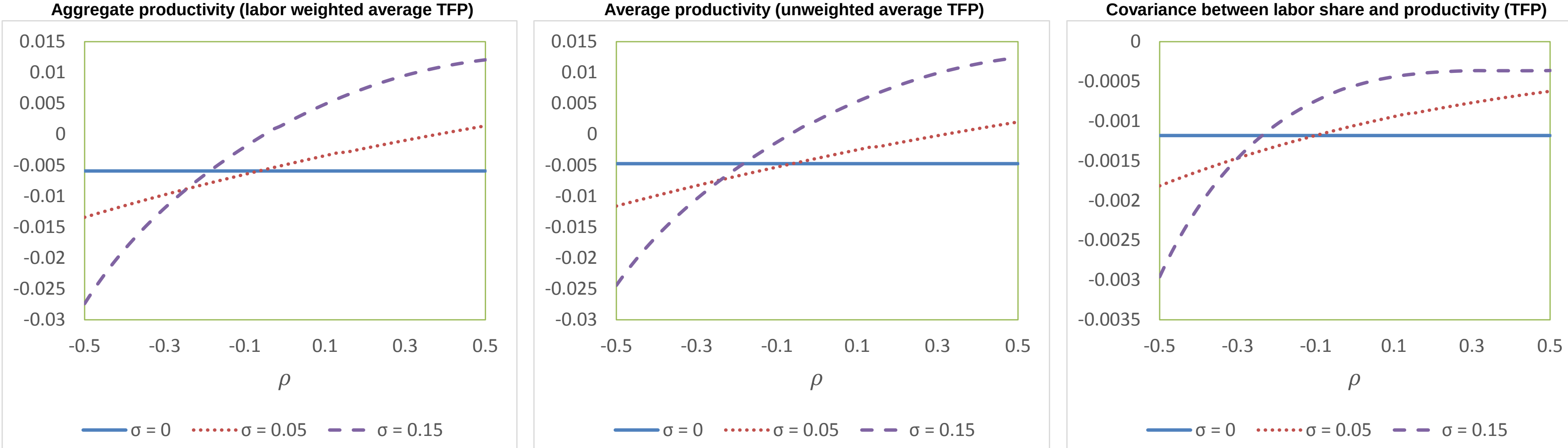

Figure 3. Sources of Productivity Growth: Overlapping 3-Year Growth Rates

This figure displays the variation in the 3-year growth rates of aggregate productivity and its OP decomposition components across countries in the panel. Each bar averages overlapping 3-year growth rates across sectors and years within a country. Figures 3A and 3B focus on the pre- and post-crisis periods of 2003-2007 and 2008-2011 respectively.

Figure 3A. Growth 2003-2007

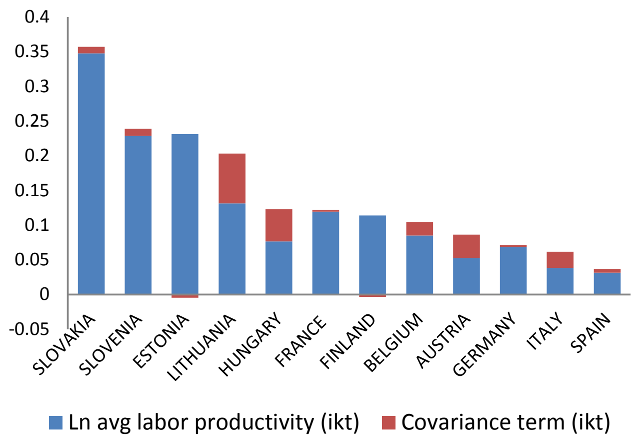

Figure 3B. Growth 2008-2011

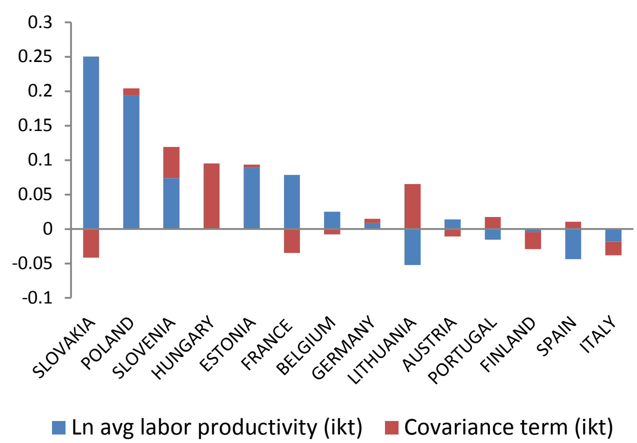

Figure 4. Trade Exposure Over Time

This figure displays the evolution of export and import activity in the panel. Each point represents an average value across countries and sectors in a given year. Each trade flow series is normalized to 1 in year 2000. Figure 4A covers all countries, while Figures 4B and 4C distinguish between EU-15 countries and new EU member states.

Figure 4A. All countries

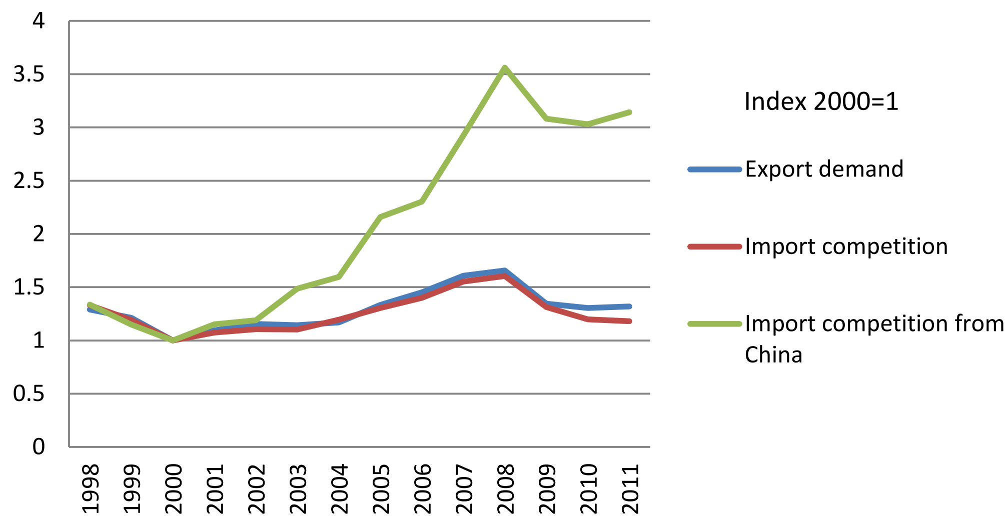

Figure 4B. New member states

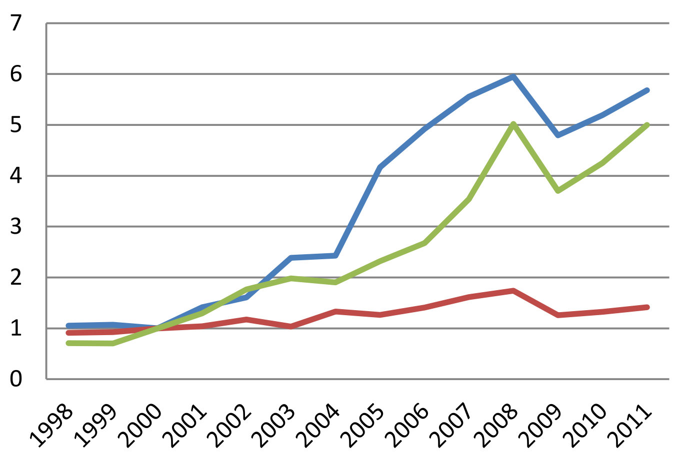

Figure 4C. EU 15 countries