# Trade, Productivity and (Mis)allocation*

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**Abstract**

We examine the gains from trade in the presence of firm heterogeneity and resource misallocation. Theoretically, we show that measured domestic aggregate productivity ($\tilde{\Phi}$) captures the effective productive capacity of an economy with or without distortions. However, it is generally not monotonic with welfare ($W$), which depends on the degree of misallocation and the prices of both domestic and imported varieties. Under allocative efficiency, bilateral and export liberalizations increase $W$ and $\tilde{\Phi}$, but import liberalization has ambiguous effects. Misallocation can amplify, dampen or reverse these gains from trade. Empirically, we then use unique new data on 14 European countries and 20 industries in 1998-2011, and establish that exogenous rises in export demand and import competition both increased $\tilde{\Phi}$ in this sample. Further empirical analysis suggests that these effects operated through reallocations across firms in the presence of distortions, with important asymmetries between export and import shocks: (i) Both export and import expansion increased effective average firm productivity, but the former also shifted activity towards firms with higher effective productivity, while the latter acted in reverse. (ii) Both trade shocks increased minimum effective firm productivity, but the latter was not a sufficient statistic for $\tilde{\Phi}$. (iii) Efficient institutions, factor and product markets amplified the gains from import competition, but dampened those from export access.

*Keywords*: Gains from trade, aggregate productivity, allocative efficiency, misallocation.

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# 1 Introduction

World trade has grown faster than world GDP since the early 1970s, and it expanded twice as quickly between 1985 and 2007.[1] 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, amidst rising concerns about employment, inequality and China's dramatic expansion. In developing countries, trade reforms have not always yielded all or only desired benefits, leading policymakers to question the merits of trade openness in the face of weak macroeconomic fundamentals and slow structural transformation.

Trade 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 and welfare gains. Moreover, heterogeneous-firm models emphasize the importance of reallocation across firms in mediating these gains (e.g. Melitz 2003, Lileeva and Trefler 2010). While trade theory traditionally assumes instantaneous and efficient reallocation, however, macroeconomics and growth research highlights that 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 poorly understood.

This paper is one of the first to investigate the gains from trade in the presence of firm heterogeneity and resource misallocation. Theoretically, we show that measured domestic aggregate productivity ($\tilde{\Phi}$) captures the effective productive capacity of an economy with or without distortions. However, it is generally not monotonic with welfare ($W$), which depends on the degree of misallocation and the prices of both domestic and imported varieties. Under allocative efficiency, bilateral and export liberalizations increase $W$ and $\tilde{\Phi}$, while import liberalization has ambiguous effects. Misallocation can in principle amplify, dampen, or reverse these impacts, as economies transition from one distorted state to another.

Empirically, we then use unique new data on 14 European countries and 20 industries in 1998-2011, and establish that exogenous rises in export demand and import competition both increased $\tilde{\Phi}$ in this sample. Guided by theory, we provide evidence consistent with these effects operating through reallocations across firms in the presence of distortions. We also document asymmetries between export and import shocks. First, we decompose the aggregate productivity gains. Both export and import expansion increased effective average firm productivity, but the former also shifted activity towards firms with higher effective productivity, while the latter acted in reverse. Second, both trade channels increased the minimum effective firm productivity, but the latter was not a sufficient statistic for $\tilde{\Phi}$. Finally, efficient institutions, factor and product markets amplified the gains from import competition, but dampened those from export access.

Our first contribution is theoretical. We examine the gains from international trade in a general-equilibrium model with firm heterogeneity and resource misallocation. We anchor the analysis in the

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

canonical Melitz (2003) trade model with exogenous firm productivity $\varphi$, and introduce exogenous firm-specific distortionary taxes/subsidies $\eta$ as in the standard Klenow (2009) and Bartelsman et al (2013) macro models. This approach allows us to tractably and transparently build intuition and obtain rich results for the role of misallocation without having to specify its microfoundations. Distortions create a wedge between social and private marginal costs of production, and generate an inefficient allocation of productive resources and market shares across firms.

We first theoretically characterize the relationship between welfare and aggregate productivity. We establish that measured real value added per worker is monotonic in effective firm productivity inclusive of any distortions $\underline{\varphi} = \varphi\eta$ (conditional on export status). Since measured domestic aggregate productivity $\tilde{\Phi}$ is the employment-weighted average real value added per worker of domestic firms, it accurately reflects the effective productive capacity of an economy, with or without misallocation.[2] However, welfare $W$ is generally not monotonic in $\tilde{\Phi}$, because consumers purchase both domestic and imported varieties and because distortions affect disposable income and the consumer price index.

We then analytically and numerically assess the impact of globalization on welfare and effective domestic aggregate productivity. In the absence of misallocation, reductions in bilateral trade costs or unilateral export costs unambiguously raise $W$ and $\tilde{\Phi}$, as in Melitz (2003) and Melitz and Redding (2014). By contrast, unilateral import reforms generate gains under flexible wages and losses under fixed wages, in line with Demidova (2008) and Bagwell and Lee (2018). Gains from trade result from economic activity shifting from less towards more productive firms along the extensive margin (higher productivity threshold for production) and the intensive margin (higher market shares for more productive firms).

Under misallocation, all three types of globalization have ambiguous consequences for welfare and effective aggregate productivity. Moreover, the presence of distortions can amplify, dampen or reverse the gains from trade relative to the first best. This occurs because the economy transitions from one distorted state to another: Intuitively, distortions affect firm selection on the extensive margin and firm market shares on the intensive margin. Although trade reforms do not change firm distortion draws, they change the actual degree of misallocation across firms. Trade liberalization can magnify existing distortions if subsidized firms with inefficiently abundant access to inputs expand their activity, while firms with inefficiently constrained resources enter and grow less than they would in the absence of distortions. This would reduce aggregate welfare and productivity or increase them by less than in the first best. Conversely, globalization can have a cleansing effect on the economy and reallocate activity towards truly more productive firms. This would generate higher welfare and productivity gains or lower losses than in the first best.

We use the model to bridge theory and data in order to empirically evaluate the theoretically ambiguous impact of globalization. We demonstrate that there is no observable summary statistic for the degree of misallocation without strict parametric assumptions. However, three distinctive predictions of the models with vs. without misallocation *can* determine whether misallocation is at play. First, we

[2] Statistical agencies such as BLS and STAN-OECD typically measure aggregate labor productivity as real GDP per worker, ideally using sectoral deflators. This corresponds exactly to employment-weighted average real value added per worker across firms and thus to our CompNet data, see Section 2.3.

decompose effective aggregate productivity into average effective firm productivity and the covariance of effective productivity and employment share across firms, as in Olley and Pakes (1996). Numerical simulations indicate that trade liberalization can move the two productivity components in opposite directions only under misallocation. Second, the measured domestic productivity cut-off is a sufficient statistic for $\tilde{\Phi}$ only without distortions. And third, countries with different observed levels of institutional efficiency should respond differently to trade shocks only if there is misallocation.

Our second contribution is empirical. We assess the impact of international trade on measured aggregate domestic productivity in Europe, which captures economies' effective productive capacity that policy makers care about. To this end, we exploit unique new data assembled by the Competitive Research Network of the European Central Bank (CompNet) for 14 European countries and 20 manufacturing industries in 1998-2011. These data are unprecedented in recording not only aggregate outcomes, but also multiple moments of the underlying distribution across firms, such that we can *both* implement the OP decomposition of aggregate productivity *and* exploit differences in institutional frictions and trade shocks across countries. We can thus for the first time overcome a key trade-off in the prior literature between using micro data for one country (to study firm reallocation after a specific trade reform) and using macro data for multiple countries (to harness cross-country variation).

We first identify and quantify the causal effect of globalization on $AggProd_{ikt}$ (the data counterpart to $\tilde{\Phi}_i$). Its sign is theoretically ambiguous because of the possibility that European economies are subject to misallocation, and its magnitude of independent policy interest. We find that export access and import penetration both significantly increased effective aggregate domestic productivity in Europe over the 1998-2011 period. The estimates imply that a 20% rise in export demand and import competition generates productivity gains of 7.6%-8.2% and 1%-10% respectively.

Our baseline measures of export access and import competition are gross exports and gross imports (net of own-sector imported inputs) from the World Input-Output Database (WIOD). We establish causality with an IV strategy that exploits variation in the initial composition of countries' trade baskets and contemporaneous value-added trade flows by sector of final use. We instrument for export demand with the weighted average absorption across a country's export destinations, by sector. We instrument for import supply with import tariffs and the weighted average of value-added exports for final consumption across a country's import origins, by sector. These shift-share instruments improve on the prior literature by proxying demand with absorption instead of imports (to account for domestic production and exports) and by using value-added instead of gross trade flows (to account for global value chains).[3]

The second part of the empirical analysis informs the mechanisms through which trade operates. We conclude that globalization increased effective aggregate productivity in Europe by reallocating activity across heterogeneous firms in the presence of misallocation. Since misallocation cannot be observed or inferred without strict parametric assumptions, we confirm its presence by taking to the data three pre-

[3] We focus on export access and import competition and abstract away from the role of imported inputs. In the data, exports and imports of upstream inputs are sufficiently highly correlated to prevent the identification of both channels. Our productivity and trade measures however account for the use of imported inputs, see Sections 3 and 5.2.

dictions of the model with vs. without distortions. In the process, we also uncover important differences in the adjustment to export and import shocks. Given the theoretically ambiguous welfare effects under misallocation, our results suggest that the gains from trade in Europe during the sample period may have been amplified, weakened or negated due to distortions.

First, the OP decomposition reveals that export growth raised both average effective firm productivity (61-77%) and the effective productivity-size covariance (23-39%). By contrast, the gains from import competition stemmed entirely from higher average effective productivity (117-136%), and were partly offset by a shift in activity towards firms with lower effective productivity (- 17-36%). The sign pattern of these effects is consistent only with numerical simulations of the model with distortions.

Second, both export and import exposure increased the minimum effective firm productivity, consistent with trade triggering exit from the left tail of the distribution. In the model, changes in this minimum effective productivity would be a sufficient statistic for changes in aggregate effective productivity only in the absence of misallocation. That this is not the case in the data is consistent with misallocation, with the caveat that the sufficient statistic result in the model may be sensitive to functional forms.

Finally, efficient institutions, factor and product markets amplified the productivity gains from import competition and dampened those from export expansion. We measure broad institutional quality with rule of law and corruption, and proxy institutional frictions in specific input and output markets with indices of labor market flexibility, creditor rights' protection and product market regulation. As these measures capture the primitive drivers of misallocation, this constitutes prima facie evidence that misallocation does modifies the impact of globalization. It further reveals that the theoretically ambiguous sign of this moderating force is asymmetric for export and import shocks.

We contribute to several strands of literature. We advance research on the role of firm heterogeneity for the gains from trade. Work-horse trade models emphasize how reallocations across heterogeneous firms generate welfare and productivity gains from globalization (e.g. Arkolakis et al. 2012, Melitz and Redding 2014), and prior empirical work has found consistent evidence in micro data for individual countries undergoing trade reforms. For example, Bernard et al. (2006) show that following a decline in U.S. trade barriers, productivity grew in liberalized sectors both because the least productive firms exited and because more productive firms expanded more. Pavcnik (2002) estimates that about 2/3 of the aggregate productivity gains from trade reforms in Chile in the late 1970s can be attributed to the OP covariance, while Harrison et al. (2013) conclude that trade liberalization in India during 1990-2010 mostly improved the average productivity of surviving firms.[4] We provide the first causal, cross-country evidence that nevertheless informs the firm dimension, compares export and import shocks, and explores the variation in institutional strength across countries.

We also add to a large macro literature on the implications of misallocation for growth. A key finding

[4]There is also evidence of adjustments within surviving firms in response to trade reforms, such as 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 products (Bernard et al. 2011, Mayer et al. 2014, Manova and Yu 2016), and product scope expansion (Goldberg et al. 2010, Khandelwal and Topalova 2013). Baqaee and Farhi (2019a) derive higher gains from trade in a model with trade in intermediates.

is that frictions in input and output markets distort the allocation of production resources across firms and lower aggregate productivity (e.g. Restuccia and Rogerson 2008, Hsieh and Klenow 2009, Bartelsman et al. 2013, Hopenhayn 2014, Gopinath et al. 2017, Foster et al. 2008, Foster et al. 2016, Baqaee and Farhi 2019b). Quantifying misallocation in the data poses challenges, however, because different micro-foundations for misallocation have different implications for the dispersion in measured productivity, marginal products of capital and labor across firms. We extend these insights to an open economy, general-equilibrium trade model and generate rich additional results about the gains from trade with vs. without misallocation. We also theoretically characterize the disconnect between welfare and effective domestic aggregate productivity inclusive of any distortions, and shift empirical focus to the latter as an observable outcome of policy relevance.[5]

Most directly, we contribute to vibrant research on the impact of institutional and market frictions on international trade. This body of work departs from the traditional assumption in the trade literature that resources are efficiently and instantaneously reallocated across firms. Evidence indicates that credit constraints disrupt multiple aspects of firm and aggregate trade activity (e.g. Chor and Manova 2012, Manova 2013, Foley and Manova 2015), while labor market frictions shape the allocation of workers across firms and the adjustment to trade reforms (e.g. Helpman et al. 2010, Ruggieri 2018, Dix-Careino et al. 2019, Kim and Vogel 2020).

We extend this research to the fundamental question of the gains from trade. Our analysis implies that welfare results from standard quantifiable gravity trade models (Costinot and Rodriguez-Clare 2014, Donaldson 2015) no longer hold in the presence of resource misallocation. This is consistent with the empirical literature on trade reforms in developing countries (Atkin and Khandelwal 2019) and recent theoretical work on the role of intersectoral and interregional misallocation for the gains from trade (Swiecki 2017, Caliendo et al. 2017, Hornbeck and Rotemberg 2019).

Our work is most closely related to concurrent studies on the role of firm-level distortions in a trade context. Bai et al. (2019) consider the effects of bilateral liberalization from autarky to free trade in the presence of distortionary sales taxes and subsidies on heterogeneous producers. Their numerical exercise, based on a one-sector model calibrated to the Chinese economy, shows that misallocation in this case generates welfare losses from trade. Sandoz (2018) establishes that access to cheaper imported inputs fosters aggregate productivity growth by improving resource allocative efficiency, and offers quantitative evidence for France. Bajgar (2016) finds that the gains from trade tend to increase with distortions to domestic sales only, to fall with distortions to exports only, and to become ambiguous with both distortions. Chung (2018) demonstrates how (potentially different) subsidies and taxes on domestic and export sales influence the observed dispersion in firm productivity and the gains from trade, and provides empirical evidence for China.

In comparison, we fully characterize the impact of bilateral and unilateral gradual trade reforms on both welfare and aggregate productivity, map theoretical objects to observed data, and decompose

[5] Burstein and Cravino (2015) explore the relationship between measured aggregate productivity, real GDP, real consumption and gains from trade in the absence of misallocation.

measured aggregate productivity. We formally consider the impact of misallocation both when trade brings welfare gains and when trade begets welfare losses (Metzler paradox) in the first best. We then theoretically and numerically establish that misallocation can generate gains or losses from trade and that it can amplify, dampen or reverse trade gains/losses compared to the first best. We also use reduced-form estimation to establish causal effects of import and export expansion on measured aggregate productivity and to thereby empirically inform the role of misallocation.

Also related are studies of other sources of misallocation in trade. Khandelwal et al. (2013) find that the inefficient allocation of quota rights across producers affected Chinese export activity under the Multi-Fiber Agreement, while Ben Yahmed and Dougherty (2017) show that the impact of import competition on firm productivity depends on the degree of product market regulation.[6] Separately, variable mark-ups also entail market share misallocation across firms and limit the welfare gains from increased trade or market size (Epifani and Gancia 2011, Edmond et al. 2015, Feenstra and Weinstein 2017, Dhingra and Morrow 2019, Arkolakis et al. 2019, Baqaee and Farhi 2020).

The rest of the paper is organized as follows. Section 2 theoretically and numerically examines the impact of globalization on welfare and aggregate productivity. Section 3 introduces the CompNet and WIOD data, and Section 4 presents baseline OLS estimates. Section 5 develops the IV estimation strategy, reports the main IV results, and performs extensive sensitivity analysis. Section 6 explores the mechanisms that mediate the productivity effects of trade. The last section concludes.

## 2 Theoretical Framework

We examine the gains from trade in a general-equilibrium model with firm heterogeneity and resource misallocation. In the interest of transparency and tractability, we introduce exogenous firm-specific distortionary taxes and subsidies as in Klenow (2009) and Bartelsman et al (2013) into a standard Melitz (2003) trade model with exogenous firm productivity. We relegate detailed proofs to Appendix A.

The model serves three goals. Our first goal is to characterize the relationship between welfare $W$ and measured domestic aggregate productivity $\tilde{\Phi}$. We show that $\tilde{\Phi}$ accurately reflects the effective productive capacity of an economy, with or without distortions, but is generally not monotonically related to welfare $W$. Our second goal is to assess the impact of globalization on $W$ and $\tilde{\Phi}$. We establish that in the absence of misallocation, bilateral and unilateral export liberalizations always raise $W$ and $\tilde{\Phi}$, while unilateral import liberalization generates gains under flexible wages and losses under fixed wages. With misallocation, by contrast, all three types of globalization have ambiguous consequences, and misallocation can amplify, dampen, or reverse the gains from trade compared to the first best. Our third goal is to facilitate a bridge between theory and empirics. We demonstrate that there is no summary statistic for the degree of misallocation without strict parametric assumptions, and we can therefore not measure misallocation in the data. Instead, we derive distinctive predictions of the models with vs.

[6] Ding et al. (2016) show that import competition reduces observed productivity dispersion in China, consistent with improved allocative efficiency under certain modeling assumptions (e.g. Hsieh and Klenow 2009).

without misallocation that can determine whether misallocation is at play.

## 2.1 Set Up

**Economic environment:** Consider a two-country world, in which a measure $L_i$ of consumers inelastically supply a unit of labor and aggregate expenditure is $E_i$ in country $i = 1, 2$.[7] The representative consumer derives utility $U_i$ from consuming a homogenous good $H_i$ and differentiated varieties $z \in \Omega_i$:

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

Demand $q_i(z)$ for variety $z$ with price $p_i(z)$ in country $i$ is thus $q_i(z) = \beta E_i P_{iQ}^{\sigma-1} p_i(z)^{-\sigma}$, where $\beta E_i$ is total expenditure on differentiated goods, $P_{iQ} = \left[ \int_{z \in \Omega_i} p_i(z)^{1-\sigma} \, dz \right]^{1/(1-\sigma)}$ is the ideal price index in the differentiated sector, and $\sigma \equiv 1/(1-\alpha) > 1$ is the elasticity of substitution across varieties.

The homogeneous good is freely tradeable and produced under CRS technology that converts one unit of labor into one unit of output. When $\beta$ is sufficiently low, both countries produce the homogeneous good, such that it serves as the numeraire, $P_{iH} = 1$, and fixes wages to unity, $w_i = 1$. We will refer to this case simply as $\beta < 1$. When $\beta = 1$ by contrast, only differentiated goods are consumed, and wages are endogenously determined in equilibrium. The aggregate consumer price index is thus $P_i = P_{iQ}^{\beta}$.

In each country, a continuum of monopolistically competitive firms produce horizontally differentiated varieties under free entry. Firms pay a sunk entry cost $w_i f_i^E$ and, should they commence production, fixed operation costs $w_i f_{ii}$ and constant marginal costs. Exporting from $i$ to $j$ requires fixed overhead costs $w_i f_{ij}$ and iceberg trade costs $\tau_{ij}$, where $\tau_{ii} = 1$ and $\tau_{ij} > 1$ if $i \neq j$. We allow for $\tau_{ij} \neq \tau_{ji}$ to assess the impact of different trade reforms.

**Firm productivity and resource misallocation:** In the absence of misallocation, firms in country $i$ draw productivity $\varphi$ upon entry from a known Pareto distribution $G_i(\varphi) = 1 - (\varphi_i^m/\varphi)^{\theta}$, where $\theta > \sigma - 1$ and $\varphi_i^m > 0$.[8] This fixes firms' constant marginal cost to $w_i/\varphi$. Under resource misallocation on the other hand, firms draw both productivity $\varphi$ and distortion $\eta$ from a known joint distribution $H_i(\varphi, \eta)$. Firms' marginal cost is now $w_i/\underline{\varphi} = w_i/(\varphi\eta)$, where $\underline{\varphi} = \varphi\eta$ captures their realized productive capacity. We refer to $\underline{\varphi}$ as *effective* or *distorted productivity*.[9] For comparability with the case of no misallocation, we assume that $\underline{\varphi}$ is Pareto distributed with scale parameter $\underline{\varphi}_i^m$ and shape parameter $\theta$.

Conceptually, $\eta$ captures any distortion that creates a wedge between the social marginal cost of an input bundle and the private marginal cost to the firm. Formally, this implies a firm-specific wedge in the first-order condition for profit maximization. Such a wedge may result from frictions in capital or labor

[7] The model can be easily extended to a world with $N$ asymmetric countries. In the global equilibrium, the equilibrium conditions below would hold for each country. From the perspective of country $i$, the impact of import or export liberalization in $i$ that is symmetric with respect to all other countries would be independent of $N$; the impact of bilateral reforms with trade partner $j$ would be qualitatively the same but moderated by $j$'s relative market size.

[8] The assumption of Pareto-distributed firm productivity is motivated by empirical evidence and theoretical tractability. We consider both Pareto and log-normal productivity distributions in the numerical exercise.

[9] Our propositions would continue to hold if firms instead used a composite input such as a Cobb-Douglas combination of labor, capital, and intermediates. Firms receiving a subsidy $\eta > 1$ would still acquire more input bundles and produce more than they otherwise would. Since $\eta$ would not distort the composition of the input bundle, the distribution of firm size would respond to trade shocks as in the baseline.

markets or from generally weak contractual institutions that support inefficient practices like corruption and nepotism.[10] Distortions will lead to deviations from the first-best allocation of productive resources across firms: If a firm can access "too much" labor "too cheaply", this would be equivalent to a subsidy of $\eta > 1$. Conversely, capacity constraints, hiring and firing costs would correspond to a tax of $\eta < 1$.

Under misallocation, firm activity will depend on $\varphi$ and $\eta$ only through distorted productivity $\underline{\varphi} = \varphi\eta$, while optimal resource allocation in the first best will depend on $\varphi$ alone. Thus two parameters regulate the degree of misallocation: the dispersion of the distortion draw, $\sigma_\eta$, and the correlation between the distortion and productivity draws, $\rho(\varphi, \eta)$.[11] Misallocation occurs if and only if $\sigma_\eta > 0$, but we will see that its severity need not vary monotonically in the $\sigma_\eta - \rho(\varphi, \eta)$ space.[12]

Introducing distortions on the input side is qualitatively isomorphic to allowing for distortions in output markets, such as firm-specific sales taxes.[13] Our theoretical formulation thus ensures tractability without loss of generality. In the empirical analysis, we correspondingly exploit different measures of broad institutional quality, capital and labor market frictions, and product market regulations.

## 2.2 Economy Equilibrium

**Firm behavior:** Profit maximizing firms optimally choose their price $p_{ij}(\varphi)$ and quantity $q_{ij}(\varphi)$ separately in each market $j$. With no distortions, the problem of a firm with productivity $\varphi$ is:

$$\max_{p_{ij}(\varphi), q_{ij}(\varphi)} \pi_{ij}(\varphi) = p_{ij}q_{ij} - w_i\tau_{ij}q_{ij}/\varphi - w_i f_{ij} \quad \text{s.t.} \quad q_{ij} = \beta E_j P_{jQ}^{\sigma-1} p_{ij}^{-\sigma} \tag{2.2}$$

$$p_{ij}(\varphi) = \frac{w_i\tau_{ij}}{\alpha\varphi}, \quad q_{ij}(\varphi) = \beta E_j P_{jQ}^{\sigma-1}\left(\frac{\alpha\varphi}{w_i\tau_{ij}}\right)^{\sigma}, \tag{2.3}$$

$$l_{ij}(\varphi) = f_{ij} + \frac{\tau_{ij}q_{ij}(\varphi)}{\varphi}, \quad c_{ij}(\varphi) = w_i\left(f_{ij} + \frac{\tau_{ij}q_{ij}(\varphi)}{\varphi}\right), \tag{2.4}$$

$$r_{ij}(\varphi) = \beta E_j\left(\frac{\alpha P_{jQ}\varphi}{w_i\tau_{ij}}\right)^{\sigma-1}, \quad \pi_{ij}(\varphi) = \frac{r_{ij}(\varphi)}{\sigma} - w_i f_{ij}. \tag{2.5}$$

where $l_{ij}(\varphi)$, $c_{ij}(\varphi)$ and $r_{ij}(\varphi)$ are the employment, costs and revenues associated with sales in $j$.

Since profits are monotonically increasing in productivity, firms in country $i$ sell in market $j$ only if their productivity exceeds threshold $\varphi^*_{ij}$. The domestic and export cut-offs are implicitly defined by:

$$r_{ii}(\varphi^*_{ii}) = \sigma w_i f_{ii}, \quad r_{ij}(\varphi^*_{ij}) = \sigma w_i f_{ij}. \tag{2.6}$$

Upon entry, firms commence production if their productivity is above $\varphi^*_{ii}$, and exit otherwise. We assume as standard that the parameter space guarantees selection into exporting, $\varphi^*_{ij} > \varphi^*_{ii}$, for any $\tau_{ij} > 1$.

[10] Examples include the allocation of MFA export quota rights in China based on firms' state ownership and political connections, labor regulations that depend on firm size, and credit provision based on asymmetric creditor-borrower information, personal or political connections (e.g. Khandelwal et al 2013, Midrigan and Zhu 2014, Brandt et al 2013).

[11] For example, with imperfect credit markets, lenders may base loan decisions on a noisy signal of firm productivity, such that $0 < \rho(\varphi, \eta) < 1$. On the other hand, labor market regulations are tougher on bigger firms in many countries and matching costs may be higher for more skilled workers that more productive firms tend to hire, such that $\rho(\varphi, \eta) < 0$.

[12] We consider numerical simulations for the case of joint log-normal distribution $H_i(\varphi, \eta)$, which is fully characterized by $\rho(\varphi, \eta) < 1$ and $\sigma_\eta$. Higher-order moments may also matter under alternative distributional assumptions.

[13] For example, one can specify the distortion on the revenue side such that firm profits equal $\pi_{ij}(\varphi, \eta) = \eta p_{ij}q_{ij} - w_i l_{ij}$ and variable profits and firm decisions depend on $\varphi\eta^{1/\alpha}$.

In the case of misallocation, the profit-maximization problem of a firm with effective distorted productivity $\underline{\varphi} = \varphi\eta$ generates the following second-best outcomes:

$$\max_{p_{ij}(\varphi,\eta),q_{ij}(\varphi,\eta)} \pi_{ij}(\varphi,\eta) = p_{ij}q_{ij} - w_i\tau_{ij}q_{ij}/\varphi\eta - w_i f_{ij} \quad \text{s.t.} \quad q_{ij} = \beta E_j P_{jQ}^{\sigma-1} p_{ij}^{-\sigma} \tag{2.7}$$

$$p_{ij}(\varphi,\eta) = \frac{w_i\tau_{ij}}{\alpha\varphi\eta}, \quad q_{ij}(\varphi,\eta) = \beta E_j P_{jQ}^{\sigma-1}\left(\frac{\alpha\varphi\eta}{w_i\tau_{ij}}\right)^{\sigma}, \tag{2.8}$$

$$l_{ij}(\varphi,\eta) = f_{ij} + \frac{\tau_{ij}q_{ij}(\varphi,\eta)}{\varphi}, \quad c_{ij}(\varphi,\eta) = w_i\left(f_{ij} + \frac{\tau_{ij}q_{ij}(\varphi,\eta)}{\varphi\eta}\right), \tag{2.9}$$

$$r_{ij}(\varphi,\eta) = \beta E_j\left(\frac{\alpha P_{jQ}\varphi\eta}{w_i\tau_{ij}}\right)^{\sigma-1}, \quad \pi_{ij}(\varphi,\eta) = \frac{r_{ij}(\varphi,\eta)}{\sigma} - w_i f_{ij}. \tag{2.10}$$

While it would be socially optimal to allocate production resources and consequently market shares based on true firm productivity $\varphi$, in the market equilibrium this allocation is instead pinned down by effective productivity $\underline{\varphi}$.[14] Along the intensive margin, firms with low (high) distortions $\eta$ produce less (more) than in the first best and set higher (lower) prices than efficient. Along the extensive margin, a highly productive firm might be forced to exit if it faces prohibitively high taxes, while a less productive firm might be able to operate or export if it benefits from especially high subsidies. Firms thus sell in the domestic and foreign market if their distorted productivity exceeds cut-offs $\underline{\varphi}_{ii}^*$ and $\underline{\varphi}_{ij}^*$, respectively:

$$r_{ii}(\underline{\varphi}_{ii}^*) = \sigma w_i f_{ii}, \quad r_{ij}(\underline{\varphi}_{ij}^*) = \sigma w_i f_{ij}. \tag{2.11}$$

Note that within the differentiated sector, all firms charge a constant mark-up $\mu = 1/\alpha > 1$ and there is no additional misallocation due to variable mark-ups as in Dhingra and Morrow (2016). When $\beta < 1$, however, there will also be misallocation across sectors because homogeneous-good producers charge no mark-up and the differentiated sector is "too small".

**General equilibrium:** The general equilibrium is characterized by conditions that define free entry, labor market clearing, income-expenditure balance, and consumer price index in each country.

Consider first the case of no misallocation. With free entry, ex-ante expected profits must be zero:

$$\sum\nolimits_j \mathbf{E}_i\left[\pi_{ij}(\varphi)\mathbf{I}(\varphi \geq \varphi_{ij}^*)\right] = w_i f_i^E, \tag{2.12}$$

where $\mathbf{E}_i[\cdot]$ is the expectation operator and $\mathbf{I}(\cdot)$ is the indicator function.[15]

A key implication of the free-entry condition is that the productivity cut-offs in country $i$ for production and exporting must always move in opposite directions following trade reforms that affect $\tau_{ij}$ or $\tau_{ji}$. Intuitively, any force that lowers $\varphi_{ij}^*$ tends to increase expected export profits conditional on production. For free entry to continue to hold, $\varphi_{ii}^*$ must therefore rise, such that the probability of survival conditional on entry falls and overall expected profits from entry remain unchanged.

[14] To be precise, note that employment $l_{ij}(\varphi,\eta)$ depends on both true and distorted productivity, $\varphi$ and $\varphi\eta$, while all other firm outcomes are functions of $\varphi\eta$ alone.

[15] The expanded version of equation (2.12) is $f_{ii}\int_{\varphi_{ii}^*}^{\infty}\left[\left(\frac{\varphi}{\varphi_{ii}^*}\right)^{\sigma-1} - 1\right]dG_i(\varphi) + f_{ij}\int_{\varphi_{ij}^*}^{\infty}\left[\left(\frac{\varphi}{\varphi_{ij}^*}\right)^{\sigma-1} - 1\right]dG_i(\varphi) = f_i^E$.

Let $L_{iH}$ and $L_{iQ}$ denote respectively total labor employed in the homogeneous and differentiated sectors. Labor market clearing in country $i$ requires:

$$L_i = L_{iH} + L_{iQ} = L_{iH} + M_i f_i^E + \sum_j M_i \mathbf{E}_i \left[ l_{ij}(\varphi) \mathbf{I}(\varphi \geq \varphi_{ij}^*) \right], \tag{2.13}$$

where $M_i$ is the mass of entering firms in the differentiated sector. When $\beta < 1$, we restrict the parameter space to ensure $L_{iH} > 0$, such that the wage is determined by productivity in the homogenous-good sector. When $\beta = 1$ and $L_{iH} = 0$, by contrast, wages are flexible and determined by $L_i = L_{iQ}$.

In equilibrium, aggregate income must equal aggregate expenditure. With free entry, aggregate corporate profits net of entry costs are 0, such that total income corresponds to the total wage bill:[16]

$$\beta w_j L_j = \beta E_j = \sum\nolimits_i M_i \mathbf{E}_i \left[ r_{ij}(\varphi) \mathbf{I}(\varphi \geq \varphi_{ij}^*) \right]. \tag{2.14}$$

Consider next the case of misallocation. The free entry and labor market clearing conditions are analogous to those above, accounting for distorted productivity $\underline{\varphi} = \varphi\eta$. The income-expenditure balance, however, has to be amended. While firm $(\varphi, \eta)$ incurs production costs $c_{ij}(\varphi, \eta) = w_i \left( f_{ij} + \frac{\tau_{ij} q_{ij}(\varphi,\eta)}{\varphi\eta} \right)$, the payment received by workers is $c'_{ij}(\varphi, \eta) = w_i \left( f_{ij} + \frac{\tau_{ij} q_{ij}(\varphi,\eta)}{\varphi} \right)$. The gap $c'_{ij}(\varphi, \eta) - c_{ij}(\varphi, \eta)$ is the social cost of distortionary taxes and subsidies, which we assume are covered through lump-sum taxation $T_i$ of consumers in $i$. When a firm is subsidized and $c_{ij}(\varphi, \eta) < c'_{ij}(\varphi, \eta)$ for example, it pays its employees less than what it would have without the subsidy, and consumers pay the difference. The distorted-equilibrium conditions become:

$$\sum\nolimits_j \mathbf{E}_i \left[ \pi_{ij}(\varphi, \eta) \mathbf{I}(\varphi\eta \geq \underline{\varphi}_{ij}^*) \right] = w_i f_i^E, \tag{2.15}$$

$$\begin{aligned} L_i &= L_{iH} + L_{iQ} = L_{iH} + M_i f_i^E + \sum_j M_i \mathbf{E}_i \left[ l_{ij}(\varphi, \eta) \mathbf{I}(\varphi\eta \geq \underline{\varphi}_{ij}^*) \right], && (2.16) \\ \beta(w_j L_j - T_j) &= \beta E_j = \sum\nolimits_i M_i \mathbf{E}_i \left[ r_{ij}(\varphi, \eta) \mathbf{I}(\varphi\eta \geq \underline{\varphi}_{ij}^*) \right], && (2.17) \\ T_i &= \sum\nolimits_j M_i \mathbf{E}_i \left[ [c'_{ij}(\varphi, \eta) - c_{ij}(\varphi, \eta)] \mathbf{I}(\varphi\eta \geq \underline{\varphi}_{ij}^*) \right]. && (2.18) \end{aligned}$$

**Welfare:** Welfare in country $i$ is given by real consumption per capita and can be expressed as:

$$W_i = \left\{ \begin{array}{ll} (1-\beta)^{1-\beta} \beta^\beta \frac{w_i}{P_i} \chi_i & \text{if } \beta < 1 \\ \frac{w_i}{P_i} \chi_i & \text{if } \beta = 1 \end{array} \right\} \text{ where } \chi_i = \frac{E_i}{w_i L_i} = \frac{w_i L_i - T_i}{w_i L_i}. \tag{2.19}$$

Welfare is thus proportional to the real wage, $w_i/P_i$, and the ratio of disposable income to gross income, $\chi_i$. In the absence of misallocation, all income accrues to worker-consumers, such that $E_i = w_i L_i$ and $\chi_i = 1$. In the presence of misallocation, by contrast, some income is not available to consumers due to the tax burden of distortions, such that $E_i = w_i L_i - T_i$ and $\chi_i < 1$.

Misallocation also affects welfare through the price index $P_i$. Within the differentiated sector, this reflects distortions to firm selection on the extensive margin and to firm prices and market shares on the

[16] When $\beta = 1$, general equilibrium requires an additional condition for balanced trade in the differentiated-good sector that links productivity thresholds and wages across countries: $\sum_i M_i \mathbf{E} \left[ r_{ik}(\varphi) \mathbf{I}(\varphi \geq \varphi_{ik}^*) \right] = \sum_j M_j \mathbf{E} \left[ r_{kj}(\varphi) \mathbf{I}(\varphi \geq \varphi_{kj}^*) \right]$.

intensive margin. In the two-sector general equilibrium, $P_i$ further captures misallocation across sectors because of the higher mark-up $\mu > 1$ in the differentiated sector. One cannot analytically decompose these two sources of misallocation, and their relative contribution is state-dependent.[17]

One can show that in the first best, the productivity cut-off for production, $\varphi^*_{ii}$, is a sufficient statistic for welfare: A higher $\varphi^*_{ii}$ implies a shift in economic activity towards more productive firms, which tends to lower the aggregate price index and increase real income. With misallocation on the other hand, welfare is a function of two equilibrium outcomes: the effective productivity cut-off for production, $\underline{\varphi}^*_{ii}$, and the share of disposable income, $\chi_i$:[18]

$$W_i \propto \left\{ \begin{array}{ll} \left(\frac{L_i}{\sigma f_{ii}}\right)^{\frac{\beta}{\sigma-1}} (\varphi^*_{ii})^{\beta} & \text{without misallocation} \\ \left(\frac{L_i}{\sigma f_{ii}}\right)^{\frac{\beta}{\sigma-1}} (\chi_i)^{\frac{\beta+\sigma-1}{\sigma-1}} (\underline{\varphi}^*_{ii})^{\beta} & \text{with misallocation} \end{array} \right\}. \tag{2.20}$$

**Lemma 1** *The domestic productivity cut-off is a sufficient statistic for welfare if and only if there is no misallocation. Without misallocation, welfare increases with the domestic productivity cut-off,* $\frac{dW_i}{d\varphi^*_{ii}} > 0$. *With misallocation, welfare increases with the distorted domestic productivity cut-off (holding* $\chi_i$ *fixed),* $\frac{\partial W_i}{\partial \underline{\varphi}^*_{ii}} > 0$, *and with the share of disposable income in gross income (holding* $\underline{\varphi}^*_{ii}$ *fixed),* $\frac{\partial W_i}{\partial \chi_i} > 0$.

Note Lemma 1 implies that the welfare impact of trade liberalization depends on how a reduction in $\tau_{ij}$ affects $\varphi^*_{ii}$, $\underline{\varphi}^*_{ii}$, and $\chi_i$.

### 2.3 From Theory to Empirics

We next consider the relationship between measured productivity and theoretical objects of interest. One takeaway will be that observed aggregate productivity correctly captures the effective productive capacity of an economy, inclusive of any distortions. This means that empirically assessing the impact of trade on aggregate productivity will be informative. A second takeaway will be that there is no observable measure of misallocation. This means that we will not aim to empirically differentiate between potential productivity and misallocation. However, we will introduce an accounting decomposition for aggregate productivity into two components. In the next section, we will then see that the combined response of aggregate productivity and its components to trade shocks *can* reveal whether misallocation is present.

**Firm productivity:** A common empirical measure of firm productivity $\Phi_i(\cdot)$ is real value added per worker. This measure indeed underlies the CompNet data we exploit. It corresponds to the ratio of total firm revenues $r_i(\cdot)$ and employment $l_i(\cdot)$, normalized by the price index in the differentiated

[17] Of interest may be the impact of trade on aggregate welfare and productivity when there are distortions in the differentiated sector but a benevolent government can always neutralize the mark-up driven cross-sector misallocation. In theory, this would present a complex dynamic problem and require state-dependent adjustment of the labor allocation across sectors that is endogenous to trade reforms and that may violate labor market clearing. In practice, this would necessitate complete information on policy makers' part and highly effective policy levers. We leave these questions to future work.

[18] The exact expressions for $W_i$ include an additional constant term: $\alpha$ when $\beta = 1$ and $(1-\beta)^{1-\beta}\beta^{\beta}\alpha^{\beta}$ when $\beta < 1$.

industry $P_{iQ} = P_i^{1/\beta}$:

$$\Phi_i(\cdot) = \begin{cases} \Phi_i(\varphi) = \frac{r_i(\varphi)}{P_{iQ} l_i(\varphi)} = \frac{w_i}{\alpha P_i^{1/\beta}} \left[1 - \frac{f_i(\varphi)}{l_i(\varphi)}\right] & \text{without misallocation} \\ \Phi_i(\varphi, \eta) = \frac{r_i(\varphi,\eta)}{P_{iQ} l_i(\varphi,\eta)} = \frac{w_i}{\alpha P_i^{1/\beta} \eta} \left[1 - \frac{f_i(\varphi,\eta)}{l_i(\varphi,\eta)}\right] & \text{with misallocation} \end{cases}. \tag{2.21}$$

With no misallocation, $r_i(\varphi) = \sum_j r_{ij}(\varphi)\mathbf{I}(\varphi \geq \varphi_{ij}^*)$, $l_i(\varphi) = \sum_j l_{ij}(\varphi)\mathbf{I}(\varphi \geq \varphi_{ij}^*)$, and $f_i(\varphi) = \sum_j f_{ij}\mathbf{I}(\varphi \geq \varphi_{ij}^*)$ denotes labor used toward fixed costs. Otherwise, $r_i(\varphi, \eta)$, $l_i(\varphi, \eta)$, and $f_i(\varphi, \eta)$ are defined analagously for the case of misallocation.

One can show that $\Phi_i(\cdot)$ is a valid proxy for effective firm productivity, inclusive of any distortions. In other words, one need not know whether there are distortions or not, if all one requires is a measure of a firm's productive capacity to transform input resources into output. In the absence of misallocation, measured real value added per worker increases monotonically with true firm productivity conditional on export status, $\Phi_i'(\varphi|\varphi < \varphi_{ij}^*) > 0$ and $\Phi_i'(\varphi|\varphi \geq \varphi_{ij}^*) > 0$.[19] Under misallocation, it is instead monotonic in distorted productivity conditional on export status, $\Phi_i'(\varphi\eta|\varphi\eta < \underline{\varphi}_{ij}^*) > 0$ and $\Phi_i'(\varphi\eta|\varphi\eta \geq \underline{\varphi}_{ij}^*) > 0$.

**Domestic aggregate productivity:** Standard measures of aggregate productivity $\tilde{\Phi}_i$ are constructed as the weighted average productivity $\Phi_i(\cdot)$ of firms producing in an economy, using their share $\theta_i(\cdot)$ of aggregate employment as weights.[20] In other words, $\tilde{\Phi}_i$ reflects a country's effective productive capacity, inclusive of any distortions.

In the CompNet data, $\tilde{\Phi}_i$ will indeed be defined as the employment-weighted average real value added per worker $\Phi_i(\cdot)$ across firms.[21] One can express it as a function of the (distorted) productivity cut-off for production. In equilibrium, one can rewrite $\Phi_i(\cdot)$ in terms of the real wage, $w_i/P_i$, and the size-weighted average distortion across firms, $\tilde{\eta}_i$, where $\eta \equiv \tilde{\eta}_i = 1$ without misallocation:

$$\tilde{\Phi}_i \equiv \begin{cases} \int_{\varphi_{ii}^*}^{\infty} \theta_i(\varphi)\Phi_i(\varphi) \, \frac{dG_i(\varphi)}{1-G_i(\varphi_{ii}^*)} = \frac{\sigma\theta}{\sigma\theta-(\sigma-1)} \frac{w_i}{P_i^{1/\beta}} & \text{without misallocation} \\ \int_{\underline{\varphi}_{ii}^*}^{\infty} \theta_i(\varphi\eta)\Phi_i(\varphi\eta) \, \frac{dG_i(\varphi\eta)}{1-G_i(\underline{\varphi}_{ii}^*)} = \frac{\sigma\theta}{(\sigma-1)\theta\tilde{\eta}_i+\theta-(\sigma-1)} \frac{w_i}{P_i^{1/\beta}} & \text{with misallocation} \end{cases}, \tag{2.22}$$

$$\text{where } \tilde{\eta}_i = \frac{\sum_j \mathbf{E}_i \left[\eta r_{ij}(\varphi, \eta)\mathbf{I}(\varphi\eta \geq \underline{\varphi}_{ij}^*)\right]}{\sum_j \mathbf{E}_i \left[r_{ij}(\varphi, \eta)\mathbf{I}(\varphi\eta \geq \underline{\varphi}_{ij}^*)\right]}.$$

**Lemma 2** *The domestic productivity cut-off is a sufficient statistic for domestic aggregate productivity if and only if there is no misallocation. Without misallocation, domestic aggregate productivity increases*

[19] Sales-to-variable employment, $r_i(\varphi)/[l_i(\varphi) - f_i(\varphi)]$, is invariant across firms because of constant mark-ups, but sales-to-total employment, $r_i(\varphi)/l_i(\varphi)$, rises with $\varphi$ because of economies of scale. Note that the measured productivity of firm $\varphi$ should it not export exceeds its measured productivity should it export, $r_{ii}(\varphi)/l_{ii}(\varphi) > r_i(\varphi)/l_i(\varphi)$. This is due to a downward shift in $\Phi_i(\varphi)$ at the export productivity cut-off, as firms incur trade costs and $r_{ii}(\varphi_{ij}^*)/l_{ii}(\varphi_{ij}^*) > r_{ij}(\varphi_{ij}^*)/l_{ij}(\varphi_{ij}^*)$. Also, $\Phi_i(\cdot)$ depends on the real wage, and implicitly, on the (distorted) productivity thresholds.

[20] Weighting firms by their employment shares ensures that $\tilde{\Phi}_i$ equal the ratio of aggregate revenue to aggregate employment in the differentiated sector, adjusted by the sectoral price index. This parallels how statistical agencies measure aggregate labor productivity with real GDP per worker deflated by sector price indices.

[21] In the data, firm weights are defined such that they sum to 1. Here, $\theta_i(\cdot)$ is defined such that it averages 1 and the residual in the OP decomposition is the covariance of $\Phi_i(\cdot)$ and $\theta_i(\cdot)$. In particular, $\theta_i(\varphi) \equiv l_i(\varphi)/\left[\int_{\varphi_{ii}^*}^{\infty} l_i(\varphi) \, \frac{dG_i(\varphi)}{1-G_i(\varphi)}\right]$ and $\theta_i(\varphi\eta)$ is defined analagously.

*with the domestic productivity cut-off,* $\frac{d\tilde{\Phi}_i}{d\varphi^*_{ii}} > 0$. *With misallocation, this relationship is ambiguous,* $\frac{d\tilde{\Phi}_i}{d\underline{\varphi}^*_{ii}} \gtrless 0$.

Note Equation (2.22) implies that shocks that move the (distorted) productivity cut-offs for production and exporting will shift $\tilde{\Phi}_i$ through their effect on the equilibrium wage $w_i$ (if $\beta = 1$ and wages are flexible), the aggregate price index $P_i$, and the average distortion $\tilde{\eta}_i$.

**Welfare vs. domestic aggregate productivity:** From a policy perspective, welfare and domestic aggregate productivity matter for different objectives: The former captures consumer utility at a point in time, while the latter indicates a country's productive capacity, improvements in which drive growth over time. However, these two objects will generally differ: Welfare in country $i$ depends on the price index $P_i$ faced by consumers in $i$, which reflects the prices of all varieties sold in $i$. Intuitively, $W_i$ is related to the weighted average productivity of all domestic and foreign firms that serve consumers in $i$, using their market share in $i$'s consumption basket as weights. By contrast, $\tilde{\Phi}_i$ is the weighted average productivity of domestic firms, using their total employment as weights. This distinction is irrelevant only in special cases, such as symmetric countries, symmetric bilateral trade costs and no misallocation, when the measure, productivity, prices and market shares of firms exporting from $i$ to $j$ are identical to those of firms exporting from $j$ to $i$.

Lemmas 1 and 2 imply that measured aggregate productivity is a sufficient statistic for welfare only without distortions.[22] Under misallocation, $W_i$ and $\tilde{\Phi}_i$ are not closed-form functions of the misallocation parameters, and we therefore simulate the model using standard parameters from the literature to numerically explore their relationship (see Section 2.5). We assume productivity and distortions are joint log-normal with $\mu_\varphi = \mu_\eta = 1$, $\sigma_\varphi = 1$, and vary the distortion dispersion $\sigma_\eta \in [0, 0.5]$ and the productivity-distortion correlation $\rho(\varphi, \eta) \in [-0.4, 0.4]$.

Figure 1A shows that welfare peaks at $\sigma_\eta = \rho(\varphi, \eta) = 0$ and falls as the distortion dispersion widens for a given $\rho(\varphi, \eta)$. At low levels of $\sigma_\eta$, $W_i$ rises as the distortion and productivity draws become more positively correlated, but the opposite holds at sufficiently high levels of $\sigma_\eta$. While domestic aggregate productivity behaves similarly under this parametrization in Figure 1B, $W_i$ and $\tilde{\Phi}_i$ need not co-move under alternative assumptions (unreported).

**OP decomposition:** As an accounting identity, domestic aggregate productivity, $\tilde{\Phi}_i$, can be decomposed into the unweighted average productivity across firms, $\overline{\Phi}_i$, and the covariance of firms' productivity and share of economic activity, $\ddot{\Phi}_i$ (Olley and Pakes, 1996):

$$\tilde{\Phi}_i = \overline{\Phi}_i + \ddot{\Phi}_i = \int_{\varphi^*_\cdot}^{\infty} \Phi_i(\cdot) \frac{dG_i(\cdot)}{1 - G_i(\varphi^*_\cdot)} + \int_{\varphi^*_\cdot}^{\infty} \left[\Phi_i(\cdot) - \overline{\Phi}_i\right] \left[\theta_i(\cdot) - \overline{\theta}_i\right] \frac{dG_i(\cdot)}{1 - G_i(\varphi^*_\cdot)}, \tag{2.23}$$

where, with some abuse of notation, $\varphi^*_\cdot$ refers to the productivity cut-offs $\varphi^*_{ii}$ or $\underline{\varphi}^*_{ii}$ respectively for the cases of no misallocation and present misallocation.

[22] With free entry, $\tilde{\Phi}_i$ depends on the endogenous mass of firms, $M_i$. With no misallocation, $M_i$ is a constant determined by model parameters when productivity is Pareto distributed. The Pareto assumption is sufficient but not necessary for $\tilde{\Phi}_i$ to be monotonic in $W_i$; numerical simulations indicate that $W_i$ and $\tilde{\Phi}_i$ move in the same direction under other productivity distributions and reasonable parameter values from the literature. Under misallocation, the Pareto assumption for distorted productivity gives tractability, but does not guarantee monotonicity.

It is important to understand what the OP decomposition can and cannot inform. The OP decomposition reveals how adjustments across and within firms shape effective aggregate productivity. Changes in $\overline{\Phi}_i$ reflect firm selection, as the exit and entry into production and exporting modify the set of active firms and their measured productivity. Changes in $\ddot{\Phi}_i$ indicate reallocation of production resources and implicitly output across firms with different effective productivity.

However, the OP decomposition on its own does not provide a sufficient statistic for misallocation. The OP covariance is related to allocative efficiency in that $\ddot{\Phi}_i > 0$ in a frictionless economy (when both $\Phi_i(\varphi)$ and $\theta_i(\varphi)$ conditionally increase in $\varphi$) but $\ddot{\Phi}_i \gtreqless 0$ in the presence of distortions.[23] At the same time, one cannot interpret a rise in $\ddot{\Phi}_i$ as an improvement in allocative efficiency, because the optimal allocation of resources across firms is generally state-dependent and reliant on the economic environment (i.e. demand function, cost function, market structure, productivity distribution). Thus for a given optimal covariance $\ddot{\Phi}_i^*$, both values below and above it would indicate deviations from the first best. Moreover, the absolute difference $|\ddot{\Phi}_i^* - \ddot{\Phi}_i|$ need not be proportional to or even monotonic in the degree of misallocation and the welfare loss associated with it.

Figure 1D illustrates that the OP covariance can indeed be negative, zero or positive at different points in the $\sigma_\eta - \rho(\varphi, \eta)$ space. Given $\rho(\varphi, \eta)$, higher distortion dispersion is associated with lower $\ddot{\Phi}_i$, consistent with more productive firms becoming sub-optimally smaller. Given $\sigma_\eta$, higher $\rho(\varphi, \eta)$ tends to imply lower $\ddot{\Phi}_i$ as productive firms get inefficiently large. Yet $\ddot{\Phi}_i$ does not peak at $\rho(\varphi, \eta) = 0$ if $\sigma_\eta > 0$, when misallocation might intuitively be lowest. Alternative parameterizations can also produce non-monotonic patterns for $\ddot{\Phi}_i$ in $\sigma_\eta$ and $\rho(\varphi, \eta)$.

Inspecting Figures 1A and 1D, the comparative statics for $W_i$ and $\ddot{\Phi}_i$ are not aligned, reinforcing the conclusion that $\ddot{\Phi}_i$ does not fully capture the welfare cost of misallocation.[24] For completeness, Figure 1C plots effective average productivity $\overline{\Phi}_i$ against the misallocation parameters.

## 2.4 Trade Liberalization

We next examine the impact of globalization on welfare $W_i$ and effective aggregate productivity $\tilde{\Phi}_i$. We consider three forms of trade liberalization: symmetric bilateral reduction in variable trade costs $\tau = \tau_{ij} = \tau_{ji}$, unilateral reduction in export costs $\tau_{ij}$, and unilateral reduction in import costs $\tau_{ji}$.[25] We characterize their effects on $W_i$ and $\tilde{\Phi}_i$ analytically here and numerically in the next subsection. Since $\tilde{\Phi}_i$ is accurately observed in the data, we will also empirically evaluate its response in Section 4.

We are also interested in whether and how misallocation shapes the gains from trade. As discussed in the previous subsection, there is no observable indicator of misallocation that permits the decomposition of effective aggregate productivity into potential productivity and distortion-induced deviations from this potential. However, we will show that the OP decomposition is informative, because the combined effect

[23] In the frictionless economy, $\ddot{\Phi}_i > 0$ also requires that the average revenue productivity of exporters is higher than the average revenue productivity of non-exporters, in line with prior evidence in the literature.

[24] Hsieh and Klenow (2009) find that welfare is invariant with $\rho(\varphi, \eta)$ in a closed-economy model. This invariance does not hold in Figure 1A because we allow for free entry and $\rho(\varphi, \eta)$ affects firm selection along the extensive margin. Figure 1D is consistent with results in Bartelsman et al. (2013).

[25] For the case of bilateral liberalization, we also assume symmetric countries.

of trade shocks on aggregate productivity $\tilde{\Phi}_i$, average productivity $\overline{\Phi}_i$ and the productivity covariance $\ddot{\Phi}_i$ *can* reveal the presence of misallocation.

Of note, we consider the impact of trade reforms that lower trade costs $\tau_{ij}$ and/or $\tau_{ji}$, but do not affect the distribution of distortions across firms governed by distortion parameters $\sigma_\eta$ and $\rho(\varphi, \eta)$. Conceptually, changes in $\sigma_\eta$ and $\rho(\varphi, \eta)$ would instead correspond to institutional reforms that influence, for example, frictions in capital and labor markets. Nevertheless, trade reforms can and will change the degree of resource misallocation in the economy, as productive activity shifts across firms.

### 2.4.1 Efficient allocation

In the case of efficient resource allocation, firms respond to trade reforms based on their productivity.

Consider first export liberalization. A fall in $\tau_{ij}$ creates more export opportunities for firms in $i$ by increasing demand from consumers in $j$. This decreases the productivity cut-off for exporting $\varphi^*_{ij}$, more firms commence exporting, and continuing exporters expand sales abroad. For free entry in $i$ to continue to hold, expected profits from domestic sales must fall, and thus the productivity threshold for survival, $\varphi^*_{ii}$, rises. This effect is amplified when wages can flexibly adjust, as export expansion bids up labor demand and wages in $i$, such that a margin of the least productive firms are no longer profitable.

Consider next import liberalization. A decline in $\tau_{ji}$ enables foreign firms to sell more cheaply to $i$. This lowers the productivity cut-off for exporting from $j$ to $i$, $\varphi^*_{ji}$, and induces continuing $j$ exporters to ship more to $i$. The direct effect is tougher import competition in $i$, reducing the aggregate price index and demand for locally produced varieties. This lessens domestic firms' home sales and pushes up $i$'s domestic productivity cut-off, $\varphi^*_{ii}$. The indirect effect is a higher productivity threshold for survival in $j$, $\varphi^*_{jj}$, so that free entry still holds now that $j$ firms expect higher export profits. This makes $j$ a more competitive market, raises the cut-off for exporting from $i$ to $j$, $\varphi^*_{ij}$, and with free entry in $i$, acts to depress the survival threshold, $\varphi^*_{ii}$. When wages are flexible, their fall dampens the indirect effect and the direct effect dominates. Conversely, when wages are fixed, the indirect effect prevails.

A symmetric bilateral liberalization combines the impacts of unilateral export and import reforms. One can show that this raises the domestic productivity cut-off, $\varphi^*_{ii}$, regardless of wage flexibility. This is associated with the reallocation of activity across firms via the exit of low-productivity firms on the extensive margin and the shift in market share towards more productive firms on the intensive margin.

Using Lemmas 1 and 2 which link the productivity threshold $\varphi^*_{ii}$ to aggregate outcomes, we can establish novel results for the effect of trade liberalization on domestic aggregate productivity $\tilde{\Phi}_i$ and confirm well-known results in the literature for its effect on welfare $W_i$. In particular, in the absence of distortions, bilateral and unilateral export liberalizations unambiguously increase $W_i$ (Melitz 2003, Melitz and Redding 2014, Arkolakis et al. 2012, Demidova and Rodriguez-Clare 2013), while unilateral import liberalizations raise $W_i$ under flexible wages, but generate welfare losses under fixed wages (Demidova 2008, Bagwell and Lee 2018).[26] We further establish that $\tilde{\Phi}_i$ moves in the same direction as $W_i$.

Turning to the OP decomposition, it is clear that if globalization raises (lowers) $\tilde{\Phi}_i$, then either

[26] The rise in the consumer price index after import liberalization with fixed wages is known as the Metzler paradox.

average productivity $\overline{\Phi}_i$, or the productivity covariance $\ddot{\Phi}_i$, or both must rise (fall) as well. However, one cannot analytically sign the response of these OP terms without further parameter restrictions. This ambiguity arises due to the counteracting effects of the shift in activity towards more productive firms and the differential change in measured productivity $\Phi_i(\varphi)$ along the productivity distribution.

**Proposition 1** *With flexible wages ($\beta = 1$) and no misallocation, bilateral and unilateral trade liberalizations (i.e. reductions in $\tau_{ij}$, $\tau_{ji}$, or both $\tau_{ij}$ and $\tau_{ji}$) increase welfare $W_i$ and domestic aggregate productivity $\tilde{\Phi}_i$, but have ambiguous effects on average productivity $\overline{\Phi}_i$ and productivity covariance $\ddot{\Phi}_i$.*

**Proposition 2** *With fixed wages ($\beta < 1$) and no misallocation, bilateral and unilateral export liberalizations (i.e. reductions in $\tau_{ij}$ or both $\tau_{ij}$ and $\tau_{ji}$) increase welfare $W_i$ and domestic aggregate productivity $\tilde{\Phi}_i$, but have ambiguous effects on average productivity $\overline{\Phi}_i$ and productivity covariance $\ddot{\Phi}_i$. Unilateral import liberalization (i.e. reduction in $\tau_{ji}$) reduces $W_i$ and $\tilde{\Phi}_i$, but has ambiguous effects on $\overline{\Phi}_i$ and $\ddot{\Phi}_i$.*

### 2.4.2 Resource misallocation

In the presence of misallocation, economies transition from one distorted equilibrium to another in response to trade reforms. Trade liberalization now triggers reallocation across firms based on distorted productivity $\underline{\varphi}$ rather than true productivity $\varphi$. While globalization does not affect the underlying institutions that generate distortions (i.e. $H_i(\varphi, \eta)$), it can in principle improve or worsen allocative efficiency. From the theory of the second best, the impact on aggregate welfare and productivity will therefore be ambiguous and hinge on initial state variables and model parameters, such as the joint distribution $H_i(\varphi, \eta)$.

The effects of trade also need not be monotonic in the variance of distortions $\sigma_\eta$, nor in the initial degree of misallocation. More severe market frictions may amplify, dampen or reverse the gains from globalization. On the one hand, countries with more efficient resource allocation may more effectively adjust to trade reforms and reap greater productivity returns. On the other hand, such countries are closer to the first best to begin with, and may benefit less from further trade liberalization.

Intuitively, misallocation acts by distorting firm selection on the extensive margin and firm market shares on the intensive margin. It would reduce the gains from trade if more productive firms cannot fully respond to growth opportunities, while less productive firms are not forced to shrink or exit. For example, trade liberalization could magnify existing distortions if firms with inefficiently abundant access to inputs expand their activity relatively more than firms with inefficiently constrained resources (e.g. new loans are extended based on collateralizable assets accumulated with past loans that were inefficiently allocated). Conversely, misallocation may increase the gains from trade if trade has a cleansing effect on the economy and serves to reallocate activity towards truly more productive firms (e.g. new loans are granted based on future profitable opportunities regardless of any past misallocation of resources).

Another way to understand the impact of misallocation is to compare two economies that start out with the same marginal productivity distribution, but one of which is also subject to distortionary wedges across firms. If shocked with the same trade reform, the two economies will respond differently and end up with different ex-post marginal productivity distributions.

Note that models with heterogeneous mark-ups across firms also feature static misallocation of market shares (c.f. Edmond et al. 2015, Arkolakis et al. 2019, Dhingra and Morrow 2019). However, what determines the welfare impact of trade liberalization in that environment is the change in the joint distribution of firm mark-ups and productivity. In contrast, we show that even holding fixed the firm-specific wedge $\eta$ and thus the joint distribution of distortions and productivity, trade liberalization can shift the ex-post joint distribution of firm size and productivity which regulates the extent of misallocation.

**Proposition 3** *With misallocation, bilateral and unilateral trade liberalizations (i.e. reductions in $\tau_{ij}$, $\tau_{ji}$, or both $\tau_{ij}$ and $\tau_{ji}$) have ambiguous effects on welfare $W_i$, domestic aggregate productivity $\tilde{\Phi}_i$, average productivity $\overline{\Phi}_i$, and productivity covariance $\ddot{\Phi}_i$.*

## 2.5 Numerical Simulation

We quantify the impact of counterfactual trade reforms through numerical simulations. We consider three scenarios with 20% reductions in trade costs from initial values of $\tau_{ij} = \tau_{ji} = 1.81$: bilateral liberalization (both $\tau_{ij}$ and $\tau_{ji}$), export liberalization (only $\tau_{ij}$), and import liberalization (only $\tau_{ji}$).

We use model parameters from the literature (e.g. Burstein and Cravino 2015), and set the elasticity of substitution to $\sigma = 3$. We assume that both countries have a unit measure of consumers, $L_i = L_j = 1$, and symmetric fixed costs of entry, production and exporting, $f_i^E = f_j^E = 0.1$, $f_{ii} = f_{jj} = 1.2$, and $f_{ij} = f_{ji} = 1.75$. In the case of no misallocation, we let productivity in both countries be distributed Pareto ($\varphi \sim G(\varphi) = 1 - (\varphi^m/\varphi)^\theta$, $\varphi^m = 1$, $\theta = 2.567$) or log-normal ($\ln\varphi \sim \mathcal{N}(\mu_\varphi, \sigma_\varphi)$, $\mu_\varphi = 0$, $\sigma_\varphi = 1$).[27] In the case of misallocation, we assume the productivity and distortion draws are bivariate log-normal distributed, $\begin{bmatrix}\ln\varphi \\ \ln\eta\end{bmatrix} \sim \mathcal{N}(\mu, \Sigma)$, $\mu = \begin{bmatrix}\mu_\varphi \\ \mu_\eta\end{bmatrix}$, $\Sigma = \begin{bmatrix}\sigma_\varphi^2 & \rho\sigma_\varphi\sigma_\eta \\ \rho\sigma_\varphi\sigma_\eta & \sigma_\eta^2\end{bmatrix}$.We set $\mu_\varphi = \mu_\eta = 0$ and $\sigma_\varphi = 1$ in both countries. We fix $\sigma_\eta = 0.05$ and $\rho = 0$ in Foreign, and consider varying degrees of misallocation in Home in the range $\sigma_\eta \in \{0, 0.05, 0.15\}$ and $\rho \in [-0.5, 0.5]$.[28]

Figure 2 visualizes the full set of results for fixed wages; without loss of generality, we set the expenditure share of differentiated goods to $\beta = 0.7$. Table 1 presents snapshots for both fixed and flexible wages for the cases of no misallocation and misallocation with high distortion dispersion ($\sigma_\eta = 0.15$) and different productivity-distortion correlations ($\rho \in \{-0.4, 0, 0.4\}$).

Three patterns stand out in Table 1. First, in the absence of misallocation, bilateral and unilateral export liberalizations increase welfare and domestic aggregate productivity whether wages are flexible or not (Panels A and B). By contrast, unilateral import liberalization increases $W_i$ and $\tilde{\Phi}_i$ when wages are flexible, but reduces both when wages are fixed. This is consistent with Propositions 1 and 2.

Second, resource misallocation can amplify, dampen or reverse the welfare and productivity gains from trade, and this effect is not monotonic in the degree of misallocation, consistent with Proposition

[27] We set $\theta$ based on Head et al. (2014), whose estimate $(\sigma-1)/\theta = 0.779$ implies $\theta = (3-1)/0.779 = 2.567$ when $\sigma = 3$.

[28] The impact of trade liberalization in Home on Home's aggregate welfare and productivity are qualitatively similar when there are no distortions in Foreign and varying degrees of misallocation in Home.

3 (Panel C). With flexible wages, the welfare and productivity gains from trade are either smaller or marginally higher with misallocation than without, and decrease smoothly with the correlation parameter $\rho$. The effects of globalization become more nuanced with fixed wages. Bilateral and unilateral export liberalizations now increase welfare strictly less with than without misallocation, but the gains are non-monotonic in $\rho$: they peak when distortions are close to orthogonal to productivity, but decline significantly and can turn negative away from $\rho \approx 0$. At the same time, unilateral import liberalization can reduce welfare more severely with misallocation than without when $\rho << 0$, but may conversely increase welfare when $\rho >> 0$. As for productivity, trade liberalization generates less negative or higher productivity gains at higher levels of $\rho$. Once again, misallocation can strenghten, moderate or overturn the productivity gains compared to the first best.

Finally, the two components of aggregate productivity $\tilde{\Phi}_i$ - average productivity $\overline{\Phi}_i$ and productivity covariance $\ddot{\Phi}_i$ - move in opposite directions only under misallocation. With no distortions, $\overline{\Phi}_i$ accounts for 75% of the change in $\tilde{\Phi}_i$ on average, while $\ddot{\Phi}_i$ contributes 25%. With frictions, by contrast, it is possible for $\tilde{\Phi}_i$ and $\overline{\Phi}_i$ to both rise even while $\ddot{\Phi}_i$ falls. Extensive numerical exercises indicate that this result cannot obtain in the absence of misallocation under reasonable parameter assumptions. Overall, the behavior of $\overline{\Phi}_i$ and $\ddot{\Phi}_i$ signals that reallocations across firms along both the extensive and the intensive margins of activity are important in the adjustment to trade shocks.

To anticipate our empirical results, Panel D of Table 1 presents the productivity effects of a 20% rise in export demand and import competition implied by our IV estimates. The empirical findings are qualitatively consistent with the last row of Panel C, i.e. misallocation with fixed wages and $\rho = 0.4$. The magnitudes are quantitatively in line with the numerical calculations for exports and higher for imports.

## 2.6 Discussion

Two model features allow us to transition to the empirical analysis. First, for expositional simplicity, we have studied an economy with a single differentiated-good sector. Intuitively, our main conclusions would extend to a world with multiple symmetric differentiated-good sectors $k$, where consumer utility is a Cobb-Douglas aggregate across sector-specific CES consumption indices. The effect of any shock on aggregate productivity $\tilde{\Phi}_i$ would now depend on the weighted average response of sector-level productivities $\tilde{\Phi}_{ik}$. A uniform trade cost reduction would affect $\tilde{\Phi}_{ik}$ equally across sectors, while a disproportionately bigger shock to sector $k'$ would change $\tilde{\Phi}_{ik'}$ disproportionately more. This justifies our estimation strategy which exploits variation across countries, sectors and time for identification purposes.

Second, we have considered reductions to trade costs, $\tau_{ij}$ and $\tau_{ji}$. Exogenous shocks to foreign demand - such as a rise in foreign market size $L_j$ or aggregate expenditure $E_j$ - would exert qualitatively the same effect as a fall in export costs $\tau_{ij}$. Likewise, exogenous shocks to foreign supply - such as foreign firm entry due to a reduction in entry costs $f_j^E$ or a shift in the foreign productivity distribution $G_j(\varphi)$ - would have qualitatively similar impacts as a fall in import costs $\tau_{ji}$. This holds because all of these shocks operate through and only through movements in home's (distorted) productivity cut-offs for production and exporting. This justifies our choice of instruments in the IV analysis.

# 3 Data

Since the impact of international trade on measured aggregate productivity $\tilde{\Phi}_i$ is theoretically ambiguous in general, we would like to examine it empirically. We are able to do so for 14 European countries, for which we have unprecedented 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 productivity and trade activity.

## 3.1 CompNet Productivity Data

We exploit unique new data on macroeconomic indicators for 20 NACE 2-digit manufacturing sectors in 14 European countries over the 1998-2011 period from the CompNet Micro-Based Dataset.[29] CompNet contains not only aggregate measures at the country-sector-year level, but also multiple moments of the underlying firm distribution in each country-sector-year cell. This includes for example means, percentiles and standard deviations of various firm characteristics, as well as moments of their joint distribution. The dataset is built from raw firm-level data that are independently collected in each country and maintained by national statistical agencies and central banks. These raw data have been standardized and consistently 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.[30]

CompNet includes measures $\{AggProd_{ikt}, AvgProd_{ikt}, CovProd_{ikt}\}$ that map exactly to the Olley-Pakes (1996) decomposition in Section 2.3 of measured aggregate productivity in country $i$, sector $k$ and year $t$ ($\tilde{\Phi}_i$) into unweighted average firm productivity ($\overline{\Phi}_i$) and the covariance of firm productivity and share of economic activity ($\ddot{\Phi}_i$).[31] Consistently with the model, firms are weighted by their employment share $\theta_i(\varphi)$ at the country-sector-year level,and firm productivity $Prod_{ikft}$ is measured as log real value added per worker. $Prod_{ikft}$ rightly captures a firm's effective productive capacity, whether or not it is subject to distortions: It is (weakly) monotonic in true firm productivity $\varphi$ in the absence of misallocation and in distorted productivity $\varphi\eta$ in the presence of misallocation. In other words, we observe precisely what we want for the purposes of assessing the impact of globalization on effective aggregate productivity.

In Section 2.3, we defined firm productivity as value added deflated by the consumer price index (CPI) in the differentiated sector $P_{iQ}$, which is equivalent to the aggregate CPI $P_i$ adjusted for the differentiated sector's expenditure share $\beta$, $P_{iQ} = P_i^{1/\beta}$. With multiple years and differentiated sectors, this would correspond to $P_{ikt} = P_{it}^{1/\beta_k}$, which is not observed. In our empirical analysis, we therefore

[29] 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 with WIOD trade data (NACE-2 sectors 10 to 31 without sectors 12 (tobacco) and 19 (coke and refined petroleum)).

[30] See Lopez-Garcia et al. (2015) for details on the data methodology and structure.

[31] The empirical counterpart to the theoretical OP decomposition in equation (2.23) at the country-sector-year level is:

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

control for country-year fixed effects that absorb $P_{it}$ and sector-year fixed effects that absorb $\beta_k$.[32]

Table 2 documents the variation in aggregate productivity across countries, sectors and years in the panel; additional statistics appear in Appendix Table 1. The sample contains 2,811 observations and is unbalanced because of different time coverage across countries. Aggregate productivity averages 3.21 in the panel (standard deviation 1.13), with the covariance term contributing 0.23 (7.2%) on average (standard deviation 0.22). There are sizable differences in the level and composition of $AggProd_{ikt}$ across economies, with $CovProd_{ikt}$ capturing only 1.4% in Austria and 2.5% in Germany but up to 25.9% in Lithuania and 33.3% in Hungary. Moreover, the standard deviations of $AggProd_{ikt}$ and $CovProd_{ikt}$ across sectors and years within a country reach 0.56 and 0.17 on average, respectively. Thus economy-wide productivity could be significantly lower if labor were randomly re-assigned across firms.

Table 2 also provides summary statistics for aggregate productivity growth at 1-, 3- and 5-year horizons. Figure 3 shows that reallocations across firms can account for a substantial share of aggregate growth, as was the case for Austria, Italy, Hungary and Lithuania before the 2008-2009 global crisis.

### 3.2 WIOD Trade Data

We use data on international trade activity from the World Input-Output Database (WIOD). While standard trade statistics report gross flows by exporter, importer and traded sector, WIOD exploits country-specific input-output tables to estimate bilateral value-added flows by both traded sector and sector of final use. Our analysis makes use of the gross sales from input sector $k$ in origin country $i$ to output sector $s$ in destination country $j$ in year $t$, $X_{ijkst}$, as well as the value added by $i$ that is embedded in these sales, $VAX_{ijkst}$.[33] Input sectors are in the NACE 2-digit classification, while output sectors comprise all NACE 2-digit sectors plus several components of final consumption. Trade flows are recorded in US dollars, which we convert to euros using annual exchange rates. Although WIOD relies on proportionality assumptions to allocate input use across countries and sectors, it is the first data of its kind and has been used in path-breaking studies of global value chains (e.g. Bems and Johnson 2017).

Our baseline measure of export demand for exporting country $i$ in sector $k$ and year $t$, $ExpDemand_{ikt}$, is the log value of $i$'s gross exports in sector $k$. We do not distinguish between exports used for final consumption and downstream production since both represent foreign demand from the perspective of $i$. Our baseline measure of import competition in importing country $i$, sector $k$ and year $t$, $ImpComp_{ikt}$, is the log 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 do not remove sector $k$ imports used in $i$ by producers in other sectors since such imports also compete with locally produced $k$ goods.

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

[32] As standard with productivity and GDP data, CompNet deflates firm value added by the Eurostat value-added producer price index by country-sector-year, $VAPPI_{ikt}$. This is consistent wtih measured value added being net of input purchases.

[33] See Timmer et al. (2015) for details on WIOD. We estimate value-added bilateral exports of sector $k$ by origin $i$ to destination $j$ with the product of country-$i$ value added in $i$'s gross output of $k$ and the share of $ijk$ exports in $ik$ output.

Table 2 presents summary statistics for $ExpDemand_{ikt}$ and $ImpComp_{ikt}$ in the matched sample with WIOD and CompNet data. $ExpDemand_{ikt}$ averages 7.65 in the panel, with a standard deviation of 1.74. The corresponding mean and dispersion for $ImpComp_{ikt}$ are 6.41 and 1.97, respectively. We summarize individual countries' trade exposure in Appendix Table 1, and plot its evolution over time in Figure 4. While all countries experienced steady import and export expansion before the 2008-2009 financial crisis, they saw a sharp contraction in 2009 before regaining some ground by 2011 (Figure 4A). Although EU-15 and new EU members display broadly comparable import trends, the latter saw dramatically faster export growth during the sample period (Figures 4B and 4C).

## 4 The Impact of Trade on Aggregate Productivity

We next empirically assess the effects of international trade on measured domestic aggregate productivity $AggProd_{ikt}$ in Europe. We are explicitly interested in economies' effective productive capacity inclusive of any distortions to firm resources, which $AggProd_{ikt}$ accurately captures. For convenience, we use interchangeably "effective aggregate productivity", "measured aggregate productivity", or simply "aggregate productivity", and adopt equivalent shorthand for measured firm productivity.

Our goal is threefold. First, we want to identify and quantify the causal effect of globalization. Its sign is theoretically ambiguous because of the possibility that European economies are subject to misallocation, and its magnitude is of interest regardless of the presence of misallocation. Second, we want to understand the underlying mechanisms that mediate the effect of trade, and establish whether misallocation is at play. Through the lens of theory, there is no observable summary statistic for the degree of misallocation, nor can it be inferred without strict parametric assumptions. Instead, we can test for the presence of misallocation by taking to the data distinctive predictions of the models with vs. without misallocation. And third, should we find evidence indicative of misallocation, we want to establish whether stronger institutions amplify or dampen the impact of globalization, a theoretically ambiguous effect that is of considerable policy interest.

The empirical analysis proceeds in three steps. In this section, we first provide OLS evidence that countries' export and import activity, $ExpDemand_{ikt}$ and $ImpComp_{ikt}$, is systematically correlated with their measured aggregate productivity. Since observed trade flows capture aggregate supply and demand conditions in general equilibrium, we then pursue an IV-2SLS estimation strategy to isolate the exogenous components of export demand and import competition and identify their causal effects. Finally, in Section 5 we perform additional analyses to inform the mechanisms through which trade operates.

To anticipate, a central result is that export demand and import competition have exerted asymmetric effects on measured aggregate productivity in Europe: The sign pattern for the estimated impact of $ExpDemand_{ikt}$ on $\{AggProd_{ikt}, AvgProd_{ikt}, CovProd_{ikt}\}$ is $\{+,+,+\}$, while that for $ImpComp_{ikt}$ is $\{+,+,-\}$. We focus in this section on establishing the robustness of this finding. In the next section, we use it along with other results to conclude that trade has improved effective aggregate productivity in Europe by reallocating activity across heterogeneous firms in the presence of misallocation.

### 4.1 OLS Specification

We explore the link between trade and aggregate productivity with the following OLS specification:

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

Here $Y_{ikt}$ refers to measured aggregate productivity in country $i$, sector $k$ and year $t$, $AggProd_{ikt}$, or its OP components, the unweighted average firm productivity, $AvgProd_{ikt}$, and the covariance between firm productivity and employment share, $CovProd_{ikt}$. By the properties of OLS, the coefficient estimates from the regressions for $AvgProd_{ikt}$ and $CovProd_{ikt}$ will sum to the coefficient estimates from the regression for $AggProd_{ikt}$, but we estimate all three regressions in order to determine the sign, magnitude and significance of each effect. There are no efficiency gains from using a simultaneous system of equations because the regressions feature the same right-hand side variables.

Specification (4.1) includes country-year pair fixed effects, $\psi_{it}$, such that $\beta_{EX}$ and $\beta_{IM}$ are identified from the variation across sectors within countries at a given point in time. The $\psi_{it}$ account for macroeconomic supply and demand shocks at the country-year level that affect all sectors symmetrically, such as movements in aggregate income, labor supply, or exchange rates. The fixed effects also capture non-transient country characteristics such as geographic remoteness and global shocks such as the 2008-2009 financial crisis. We cluster standard errors, $\varepsilon_{ikt}$, by sector-year to accommodate cross-country correlation in sector-specific shocks. The baseline results are robust to alternatively clustering by both sector-year and country-year.

We add several controls $Z_{ikt}$ to alleviate concerns with omitted variable bias and sample selection. First, we capture sector-specific trends in global supply and demand by conditioning on the average log number of firms, $\overline{\ln N}_{kt}$, and the average log employment, $\overline{\ln L}_{kt}$, by sector-year across countries. Second, the firm-level data that underlie CompNet are subject to minimum firm size thresholds that vary across countries and are subsumed by the country-year fixed effects. As extra precaution, we also include the log number of firms by country-sector-year, $\ln N_{ikt}$, but the results are not sensitive to this. Finally, we implement two sample corrections to guard against outliers. We exclude observations that are based on data for fewer than 20 firms or whose key variables exhibit annual growth rates in the top or bottom percentile of their respective distribution ($AggProd_{ikt}$, $AvgProd_{ikt}$, $CovProd_{ikt}$, $ExpDemand_{ikt}$, $ImpComp_{ikt}$, $\ln N_{ikt}$). While these two corrections filter out 11% of all observations, we nevertheless retain 96-97% of all firms, employment and real value added in the raw panel, and later confirm that the baseline results are strenghtened when we winsorize instead of drop outliers.

### 4.2 OLS Results

We first assess the correlation between trade and aggregate economic activity using specification (4.1). In Columns 1-3 of Table 3, we find that export expansion is associated with higher log manufacturing output, log value added and log employment. Conversely, more intense import penetration is correlated with lower domestic output and employment, but nevertheless higher value added.

Turning to the trade-productivity nexus in Columns 4-6, aggregate exports and imports are both positively correlated with measured aggregate productivity. These correlations are economically large and highly statistically significant at 1%: A 20% rise in $ExpDemand_{ikt}$ and $ImpComp_{ikt}$ is associated with 2.5% and 2.1% higher $AggProd_{ikt}$, respectively. While comparable, these magnitudes mask important differences between export and import activity. Export expansion is accompanied by stronger measured average firm productivity and increased concentration of activity in firms with higher measured productivity, i.e. both higher $AvgProd_{ikt}$ and higher $CovProd_{ikt}$. By contrast, deeper import penetration entails higher firm productivity on average, but a shift in activity towards less productive firms.

Figure 5 provides a non-parametric illustration of the conditional correlation between aggregate productivity and trade exposure. A point represents average values across country-sector-year triplets within each of 100 percentile bins, after demeaning by country-year. The bin scatters indicate that $AggProd_{ikt}$ is strongly positively correlated with both $ExpDemand_{ikt}$ and $ImpComp_{ikt}$ across the distribution.

Equation (4.1) identifies the long-run correlation between productivity and trade activity. We consider the short to medium term in Appendix Table 2, where we study how changes in productivity co-move with concurrent changes in imports and exports over 1-, 3- and 5-year overlapping periods.[34] By first-differencing all left- and right-hand side variables and including year fixed effects, we subsume country-sector fixed effects and global growth shocks. The productivity-trade relationship is stronger at medium horizons of 3 to 5 years, but nevertheless sizeable even in the very short run of 1 year.

### 4.3 Endogeneity and IV Strategy

The baseline OLS correlations may not identify the causal effect of globalization on aggregate productivity because of two potential sources of endogeneity. One concern is that trade and productivity are jointly determined by some omitted variable. Given the fixed effects in (4.1), such omitted variable bias would have to vary systematically across sectors within country-years to explain our findings.

Reverse causality poses an arguably more important concern: Aggregate productivity can drive trade activity. In general equilibrium, export flows reflect both endogenous supply conditions in the exporting country and exogenous demand conditions in the importing country. Theory implies that firms in a more productive country-sector would be more competitive on world markets and therefore realize higher exports, biasing OLS estimates of $\beta_{EX}$ positively. Analogously, import flows reflect both endogenous demand conditions in the importing country and exogenous supply conditions in the exporting country. A less productive country-sector would be less competitive from the perspective of foreign firms and induce more entry by foreign suppliers, biasing OLS estimates of $\beta_{IM}$ negatively. Other mechanisms may generate reverse causality that biases $\beta_{EX}$ and $\beta_{IM}$ either upwards or downwards.

In order to identify the causal effects of trade, we use instrumental variables $IV_{ikt}$ to isolate arguably exogenous movements in export demand and import supply, $\widehat{ExpDemand}_{ikt}$ and $\widehat{ImpComp}_{ikt}$, from

[34]The exact estimating equation is $\Delta Y_{ikt} = \alpha + \beta_{EX}\,\Delta ExpDemand_{ikt} + \beta_{IM}\,\Delta ImpComp_{ikt} + \Gamma \Delta Z_{ikt} + \varphi_t + \varepsilon_{ikt}$.

observed exports and imports, $ExpDemand_{ikt}$ and $ImpComp_{ikt}$:

$$Y_{ikt} = \alpha + \beta_{EX}\, \widehat{ExpDemand}_{ikt} + \beta_{IM}\, \widehat{ImpComp}_{ikt} + \Gamma Z_{ikt} + \psi_{it}(+\psi_{kt}) + \varepsilon_{ikt} \text{ (second stage)} \quad (4.2)$$

$$\{ExpDemand_{ikt},\, ImpComp_{ikt}\} = \alpha_{IV} + \Gamma_{IV} Z_{ikt} + \Theta_{IV} IV_{ikt} + \phi_{it}(+\phi_{kt}) + \epsilon_{ikt} \text{ (first stage)} \quad (4.3)$$

We condition on controls $Z_{ikt}$ and country-year fixed effects, $\psi_{it}$ and $\phi_{it}$, as in the OLS baseline. In robustness checks, we further add sector fixed effects, $\psi_k$ and $\phi_k$, or sector-year fixed effects, $\psi_{kt}$ and $\phi_{kt}$. These account respectively for permanent and time-variant differences in supply and demand conditions across sectors that affect all countries, such as factor intensities, technological growth, and consumer preferences. We continue to cluster standard errors, $\varepsilon_{ikt}$ and $\epsilon_{ikt}$, by sector-year.

The ideal instruments would be relevant by having predictive power in explaining trade flows and 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 export 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 $t$.

We construct Bartik-style instruments by combining information on countries' initial trade structure at the start of the panel with their trade partners' contemporaneous trade flows with the rest of the world.[35] 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 $o$ 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 imports minus exports, $Y_{dkt} + M_{-i,dkt} - X_{-i,dkt}$. This corresponds to total expenditure in $d$ on $k$ in the model. Aggregate supply of sector $k$ goods from origin $o$ at time $t$ can be estimated with $o$'s export value added for final consumption of $k$ products, $XVA^{final}_{-i,okt}$. This accounts for the fact that countries use imported inputs in production, and aims to isolate supply shocks specific to $o$. We conservatively focus on exports for final consumption to shut down any global input-output linkages. We exclude bilateral trade between country $i$ and destination $d$ (origin $o$) when constructing foreign demand (supply) shocks pertinent to $i$.

For each country-sector-year triplet $ikt$, we instrument export demand with foreign demand conditions, $FDemand_{ikt}$, computed as the weighted average absorption across $i$'s export destinations 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 across $i$'s import origins, using $i$'s initial import shares as weights. To guard against measurement error or business cycle fluctuations, we take average trade shares over the first three years in the panel, 1998-2000.

In addition to the Bartik instruments, we also exploit the variation in import tariffs across countries, sectors and years, $MTariff_{ikt}$. We take the simple average applied tariff $\tau_{ipt}$ across the $NP_k$ products $p$ within sector $k$ at time $t$, using data from WITS. $MTariff_{ikt}$ captures trade policy shocks that affect

[35] These instruments are similar in spirit to those in Hummels et al. (2014) and Berman et al. (2015) among others.

import competition by influencing foreign producers' incentives to enter the domestic market.

$$FDemand_{ikt} = \ln\left[\sum_{d\neq i}\frac{X_{idk,t=0}}{X_{ik,t=0}}\left(Y_{dkt}+M_{-i,dkt}-X_{-i,dkt}\right)\right], \tag{4.4}$$

$$FSupply_{ikt} = \ln\left[\sum_{o\neq i}\frac{M_{oik,t=0}}{M_{ik,t=0}}XVA^{final}_{-i,okt}\right], \tag{4.5}$$

$$MTariff_{ikt} = \frac{1}{NP_k}\sum_{p\subset\Omega_k}\tau_{ipt}. \tag{4.6}$$

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

### 4.4 Baseline IV Results

Table 4 indicates that the three instruments perform well in the first stage. The measure of exogenous foreign demand has a positive effect on observed exports, the measure of exogenous foreign supply has a positive effect on observed import penetration, and import tariffs strongly deter imports. These patterns are highly statistically and economically significant and robust to adding sector or sector-year fixed effects to the baseline country-year fixed effects. The most conservative estimates in Columns 3 and 6 imply that a one-standard-deviation improvement in $FDemand_{ikt}$ leads to 34% higher $ExpDemand_{ikt}$, while a one-standard-deviation rise in $FSupply_{ikt}$ increases $ImpComp_{ikt}$ by 49%. Reducing import barriers by 10% translates into 13% higher imports. The R-squared in these regressions reaches 89%-99%.

Table 5 presents the second-stage estimates for the causal effects of globalization. Export demand and import competition both significantly increase effective aggregate productivity, $AggProd_{ikt}$. In the baseline with only country-year fixed effects in Column 1, 20% growth in export demand boosts overall productivity by 8%, while 20% rise in import competition leads to 1.4% higher productivity. In the most restrictive specification that adds sector-year fixed effects in Column 7, these productivity gains amount to 7.3% and 10%, respectively.

Table 5 reveals that the productivity impacts of export and import expansion are mediated through different channels. Export growth improves average measured firm productivity, $AvgProd_{ikt}$, and reallocates activity towards more productive firms, as manifested in higher $CovProd_{ikt}$. The latter contributes 26% in the baseline (Column 3) and up to 38% in the most stringent specification (Column 9). By contrast, all productivity gains from import competition result from higher average firm productivity and are partly offset by a shift in resources towards less productive firms. The latter negates 24% of average productivity growth in the baseline (Column 3) and 14% with sector-year fixed effects (Column 9).

### 4.5 Sensitivity Analysis

We can summarize the estimated effects of $ExpDemand_{ikt}$ and $ImpComp_{ikt}$ on $\{AggProd_{ikt}, AvgProd_{ikt}, CovProd_{ikt}\}$ as $\{+,+,+\}$ and $\{+,+,-\}$. In this subsection, we perform extensive sensitivity analysis to establish the robustness of this finding. All results are reported in Appendix Table 3.

**Alternative specification** We first consider each dimension of trade exposure one at a time, to ensure that the estimated effects of export and import activity are not driven by multi-colinearity. When we focus on export access, 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 introduce only $ImpComp_{ikt}$ in the second stage and exploit only $FSupply_{ikt}$ and $MTariff_{ikt}$ as instruments in the first stage. Panel A shows that this delivers qualitatively similar results and quantitatively bigger magnitudes.

Panel B confirms that the baseline results barely change when we lag $ExpDemand_{ikt}$ and $ImpComp_{ikt}$ by one year. This speaks to possible delayed effects of international trade on aggregate productivity, that may for example arise through gradual adjustment within and across firms.

**Alternative measures and controls** The findings are also robust to using a relative instead of an absolute indicator of import competition. The baseline measure $ImpComp_{ikt}$ reflects the scale of foreign suppliers' activity in the home market, where the country-year fixed effects implicitly control for home market size. Through the lens of the model, an equally valid measure of import competition is the ratio of imports to domestic production. We therefore construct $ImpCompRatio_{ikt} = \sum_{j,s\neq k} X_{jikst}/\overline{Output}_{ik}$, averaging the denominator across years within country-industry pairs to mitigate concerns with domestic production endogenously responding to import penetration. Panel C corroborates the main results when we estimate specification (4.2) using $ImpCompRatio_{ikt}$ in place of $ImpComp_{ikt}$ and an analogously constructed instrument $FSupplyRatio_{ikt}$ in place of $FSupply_{ikt}$.[36]

Our analysis focuses on the productivity gains from export access and import competition, and abstracts away from the role of imported inputs in reducing firms' production costs. While the theoretical predictions for the first two trade channels would continue to hold should the latter also be active, we want to ensure that the empirical results for export demand and import penetration are not driven by trade-induced changes in input prices. Recall that our productivity and trade measures are based on value-added data and thus already account for the use of inputs, including potentially imported inputs. In Panel D, we nevertheless confirm that the baseline results hold when we additionally control for country-sector-year specific input price indices from OECD-STAN.[37]

**Alternative outlier treatment** We conduct additional tests to ensure that outliers are not driving the results. The baseline sample already excludes country-sector-year observations that aggregate fewer than 20 firms or exhibit annual growth in the top or bottom percentile for key variables (i.e. $AggProd_{ikt}$, $AvgProd_{ikt}$, $CovProd_{ikt}$, $ExpDemand_{ikt}$, $ImpComp_{ikt}$, $FDemand_{ikt}$, $FSupply_{ikt}$). In Panel E, we show that the main findings survive when we further winsorize these variables at the 1st and 99th percentiles. Of note, winsorizing produces a significant negative effect of $ImpComp_{ikt}$ on $CovProd_{ikt}$ even when the regression includes both country-year and sector-year fixed effects.

[36] The results are also robust to proxying import competition with the ratio of imports to domestic absorption or domestic employment. These two measures are not theoretically founded, but the former reflects the domestic market size, while the latter is independent of local factor and product prices.

[37] Observed exports and inferred imports of upstream inputs are sufficiently highly correlated in WIOD to prevent the separate identification of the imported-input channel. Unlike the input price index, however, the value of imported inputs would anyway not directly reflect their impact on production costs.

## 4.6 Additional Results

We next present a series of additional results that both inform economic questions of interest and help alleviate outstanding econometric concerns.

### 4.6.1 Sector composition

Recall from Section 2.6 that with multiple differentiated sectors, the effect of globalization on economy-wide aggregate productivity is a weighted average of the effects on sector-level productivity. The baseline specification treats sectors symmetrically, such that $\beta_{EX}$ and $\beta_{IM}$ quantify the impact of trade on the average sector. Our findings remain unchanged or stronger when we instead weight observations by the initial country-specific employment share of each industry in Panel A of Table 6. This is a model-consistent measure of an industry's contribution to economy-wide productivity.

In Europe as in other advanced countries, the services sector has grown to capture a majority of aggregate employment and production. Since aggregate productivity and trade data are available only for manufacturing industries, the baseline analysis evaluates the impact of globalization in manufacturing. We can nevertheless account for the variation in the size of the services sector across country-years by weighting observations by the share of manufacturing in total employment by country-year. The weighted regressions in Panel B of Table 6 reveal quantitatively and qualitatively similar patterns as the baseline.

### 4.6.2 Chinese import competition

A major shock to the global economy in the 21st century has been the dramatic rise of China. China's exports grew rapidly after it joined the WTO in 2001 and MFA binding quotas on its textiles and apparel were lifted in 2005. This shock has contributed significantly to the deepening of import competition in many developed economies not only because of its scale, but also because it has increased competition specifically from producers in a large country with lower (albeit growing) wages and productivity.

We compare the impact of import competition from China and from the rest of the world, $ChinaImpComp_{ikt}$ and $ROWImpComp_{ikt}$. We measure $ChinaImpComp_{ikt}$ with country $i$'s imports of sector $k$ goods from China in year $t$, net of sector $k$ imports used by $i$ in the production of $k$ products. We calculate $ROWImpComp_{ikt}$ as in the baseline, excluding China from the calculation. We correspondingly construct two new instruments, $ChinaSupply_{ikt}$ and $ROWSupply_{ikt}$, in place of $FSupply_{ikt}$. For example, $ChinaSupply_{ikt}$ 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 countries $i$ based on China's initial share in $i$'s imports of $k$ goods at time $t = 0$, $\frac{M_{China \to ik,t=0}}{M_{ik,t=0}}$.

$$ChinaImpComp_{ikt} = \ln \left[ \sum_{s \neq k} X_{China \to i,kst} \right], \quad ChinaSupply_{ikt} = \ln \left[ \frac{M_{China \to i,k,t=0}}{M_{ik,t=0}} XVA^{final}_{China,kt} \right] \tag{4.7}$$

We present the results in Panel C of Table 6. The findings for export demand remain qualitatively and quantitatively similar. Conditioning on both country-year and sector-year fixed effects, Chinese and

ROW import competition induce similar adjustments: They both stimulate aggregate productivity by raising average firm productivity while lowering the productivity covariance term. At the same time, the gains triggered by Chinese competition are about a third of the gains caused by competition from other countries of origin. Omitting the sector-year fixed effects leaves the results for $ROWImpComp_{ikt}$ unchanged, but $ChinaImpComp_{ikt}$ now exerts significant effects only on the covariance term.

#### 4.6.3 Skill and mark-up dispersion

While we have emphasized the role of heterogeneity in firm productivity, in practice firms may also differ in the skill of their labor force. If this arises because firms make endogenous hiring decisions based on their productivity, measured real value added per worker woudl rightly capture effective firm productivity. However, if skill dispersion across firms emerges because exogenous worker skill or firm-worker match quality are unobserved at the hiring stage, classical measurement error in the aggregate productivity terms may reduce estimate precision.

A separate concern is the potential mark-up heterogeneity across firms. The model in Section 2 shuts down variable mark-ups in the differentiated sector by assuming CES consumption and monopolistic competition, in order to focus on misallocation due to distortions to input costs. In a richer framework, endogenous mark-ups would become a separate source of misallocation if firms charge heterogeneous mark-ups and adjust them differentially in response to trade reforms. We would conceptually like to separate the two. Mark-up heterogeneity can also introduce classical measurement error in the aggregate productivity terms.

In Panels D and E of Table 6, we control respectively for skill and mark-up dispersion with the 90th-10th interpercentile ratio of the average wage and of the price-to-cost margin across firms within country-sector-years, the best available proxies in the data. The baseline results remain unchanged.

## 5 How Trade Affects Productivity: Mechanisms

Our analysis has identified the effects of export demand and import competition, which correspond to the effects of unilateral export and import liberalization in the model. We now argue that the empirical results are consistent with globalization shaping effective aggregate productivity by triggering reallocations across heterogeneous firms in the presence of resource misallocation.

We base this conclusion on three arguments. The first two rely on model-dependent inference, while the last one constitutes direct, model-independent evidence. First, the empirical findings can be rationalized only with numerical simulations for the case of misallocation. Second, the effect of trade on firm selection is not a sufficient statistic for its effect on measured aggregate productivity, counter to model predictions without distortions. Finally, the impact of trade depends on countries' institutional and market efficiency. Although the consequences of misallocation for the gains from trade are theoretically ambiguous, the fact that institutional frictions moderate these gains implies that misallocation plays a role. The sign of this moderating force (amplification or dampening) is moreover of policy interest.

### 5.1 Pattern of Trade Effects

The sign pattern for the estimated effects of $ExpDemand_{ikt}$ and $ImpComp_{ikt}$ on $\{AggProd_{ikt}, AvgProd_{ikt}, CovProd_{ik}$ is $\{+, +, +\}$ and $\{+, +, -\}$. This suggests that export access generates gains in effective aggregate productivity through the exit of effectively less productive firms and the reallocation of market share towards effectively more productive firms. While import competition induces similar cleansing along the extensive margin, it shifts market share towards firms with lower measured productivity along the intensive margin. Our extensive numerical exercises indicate that the model in Section 2 can only generate this pattern when there is resource misallocation across firms (see Table 1 and Figure 2). In particular, the empirical results are in line with the numerical simulation for the case of intra-sectoral misallocation across firms under fixed wages. By contrast, they could not be reconciled simply by inter-sectoral misallocation due to higher mark-ups in the differentiated sector compared to the homogeneous sector. This implies that the welfare gains from trade in Europe during the sample period are in principle ambiguous.

Consider first the case of no resource misallocation. Increased export demand lowers the productivity cut-off for exporting, such that the productivity cut-off for domestic production rises due to free entry, and aggregate productivity, $AggProd_{ikt}$, increases. By contrast, higher import competition has theoretically ambiguous effects because it intensifies competition both at home and abroad, with opposite effects on the domestic productivity cut-off. When home wages can adjust down, this cut-off rises and $AggProd_{ikt}$ goes up, while the converse occurs when wages are fixed. Importantly, the numerical exercises indicate that $AggProd_{ikt}$, $AvgProd_{ikt}$ and $CovProd_{ikt}$ always move in the same direction.

Consider next the case of resource misallocation. Now both export and import liberalization can have ambiguous effects on effective aggregate productivity, because the economy transitions from one distorted steady state to another. Numerical exercises show that export liberalization increases all three productivity terms, $\{AggProd_{ikt}, AvgProd_{ikt}, CovProd_{ikt}\}$, over a wide range of the parameter space. On the other hand, import liberalization can move these outcomes in different directions in different segments of the parameter space, and $AggProd_{ikt}$ and $AvgProd_{ikt}$ can both rise while $CovProd_{ikt}$ declines under fixed wages.

### 5.2 Firm Selection

We next evaluate the impact of trade exposure on firm selection at the bottom end of the measured productivity distribution. In the absence of misallocation, in the model globalization affects aggregate productivity $AggProd_{ikt}$ by (i) raising the first-best productivity cut-off $\varphi^*_{ii}$ and by (ii) reallocating resources across inframarginal firms. Moreover, the change in $\varphi^*_{ii}$ is a sufficient statistic for the change in $AvgProd_{ikt}$ and $AggProd_{ikt}$, but not for the change in $CovProd_{ikt}$. In the presence of misallocation, globalization still affects effective aggregate productivity via (i) and (ii), but also by (iii) changing the degree of misallocation by shifting resources across firms. As a result, the distorted productivity threshold $\underline{\varphi}^*_{ii}$ is no longer a sufficient statistic for $AvgProd_{ikt}$ or $AggProd_{ikt}$. This motivates us to exploit the information contained in the observed minimum productivity $\min Prod_{ikt}$ in the data: Controlling for $\min Prod_{ikt}$, any residual impact of trade on $\{AggProd_{ikt}, AvgProd_{ikt}\}$ would be consistent with mechanism (iii). A caveat is that the model may lose the sufficient statistic property with alternative functional form assumptions even in the absense of misallocation, such that we view the empirical findings as suggestive but not conclusive.

We find in Panel A of Table 7 that export demand and import competition both raise $\min Prod_{ikt}$ (Columns 1 and 5). We measure $\min Prod_{ikt}$ with the first percentile of log value added per worker across firms, in order to guard against outliers due to measurement error or idiosyncratic firm shocks. The estimates imply that the productivity threshold rises by 4%-6.3% and 1.5%-5% following a 20% expansion in foreign market access and import penetration, respectively.

We then expand IV specification (4.2) to include $\min Prod_{ikt}$. Higher $\min Prod_{ikt}$ is associated with higher measured aggregate and average productivity, but lower measured productivity-size covariance. However, controlling for $\min Prod_{ikt}$ leaves large residual effects of export demand and import competition on $AggProd_{ikt}$, as much as 69% and 38% of the baseline estimates (Column 2). These numbers stand at 52% and 46% when we further condition on sector-year fixed effects (Column 6). The point estimates for $\beta_{EX}$ and $\beta_{IM}$ are also reduced by only 48% and 57% in the regression for $AvgProd_{ikt}$ (Column 3). In the specification for $CovProd_{ikt}$, $\beta_{EX}$ increases by 20%, while $\beta_{IM}$ falls by 38% (Column 4). We have obtained similar results when controlling for a cubic polynomial in $\min Prod_{ikt}$. This more flexible approach allows for the mapping of $\min Prod_{ikt}$ to $AggProd_{ikt}$, $AvgProd_{ikt}$ and $CovProd_{ikt}$ to be unique but non-linear.

Through the lens of theory, these results suggest that the observed productivity effects of globalization cannot be fully attributed to the reallocation of activity across firms in a frictionless economy. While not conclusive, the results are instead consistent with the presence of distortions, whereby international trade influences effective aggregate productivity in part by changing the efficiency with which resources are allocated across firms.[38]

### 5.3 Imperfect Institutions and Market Frictions

In order to provide model-free evidence for the role of misallocation, we finally exploit the cross-country variation in the strength of institutions that govern the efficiency of factor and product markets. This approach rests on two premises. First, institutional imperfections constitute structural problems that generate an inefficient allocation of production inputs and market shares across firms. Institutional indicators thus identify primitives that microfound resource misallocation in theoretical frameworks. Of note, the model in Section 2 considers distortions to input costs that map to measures of labor and capital

[38] Our analysis abstracts away from the potential impact of globalization on productivity upgrading within firms. This effect and its consequences for $AggProd_{ikt}$, $AvgProd_{ikt}$ and $CovProd_{ikt}$ are in principle ambiguous. For example, higher export demand may increase expected profits and induce firms to upgrade productivity if there are economies of scale in innovation and adoption (e.g. Bustos 2011). Steeper import competition may discourage innovation by reducing domestic profits, but it may conversely incentivize incumbents to upgrade productivity in order to remain competitive (e.g. Bloom et al. 2015, Dhingra 2013). In Panel B of Table 7, we proxy the aggregate amount of productivity upgrading with log R&D expenditure by country-sector-year, $RD_{ikt}$. We find mixed effects of export demand and import competition on $RD_{ikt}$. Moreover, controlling for both $\min Prod_{ikt}$ and $RD_{ikt}$ in equation (4.2) leaves large residual productivity effects of trade.

market frictions, but its predictions would be qualitatively similar with revenue or profit distortions via sales or corporate taxes that map to measures of product market regulation.

Our second premise is that countries at different levels of institutional efficiency will respond differently to trade shocks if and only if misallocation is present and influences the trade-productivity nexus. Recall from Section 2 that trade expansion has theoretically ambiguous effects on aggregate productivity under misallocation, and these effects need not vary smoothly with the degree of misallocation. Showing that institutional frictions moderate the impact of trade is thus sufficient to establish a role for misallocation, while estimating the direction and magnitude of this moderating force is of independent policy relevance.

We therefore expand IV specification (4.2) to include interactions of export demand and import competition with country measures of institutional quality, $Institution_{it}$, whose level effect is subsumed by the country-year fixed effects. We instrument the main and interaction trade terms using the same instruments as before and their interactions with $Institution_{it}$.

We exploit five indicators, defined such that higher values signify more efficient and effective institutions. The first two are rule of law and corruption, from the *World Bank Governance Indicators* (Kaufmann et al. 2010). These are comprehensive indices respectively of general institutional capacity and scope for rent extraction for private gains, which arguably affect economic efficiency in both input and output markets. Rule of law has a mean of 1.11 and a standard deviation of 0.49 in the panel; the corresponding statistics for (inverse) corruption are 1.07 and 0.69.

The other three measures characterize institutional efficiency in specific markets. We quantify labor market flexibility with a 0-6 index that averages 21 indicators for firing and hiring costs, from the *OECD Employment Database* (mean 3.28, standard deviation 0.37). We proxy financial market development with a 0-12 index that captures the strength of creditor rights' protection necessary to support financial contracts, from the *World Bank Doing Business Report* (mean 5.86, standard deviation 1.79). Finally, we assess the (inverse) tightness of product market regulation with a 0-3 index that aggregates 18 measures for state control, barriers to entrepreneurship, and barriers to trade and investment, from the *OECD Market Regulation Database* (mean 1.17, standard deviation 0.25).

Table 8 reveals consistent patterns across all five institutional measures: Strong rule of law, low corruption, efficient factor and product markets amplify the productivity gains from import competition and dampen the productivity gains from export expansion. This is true for effective aggregate productivity, average productivity and productivity-size covariance. The interaction terms are highly statistically and economically significant for all but 2 out of 30 coefficient estimates.[39]

These results indicate the complex interactions between international trade and market frictions in shaping effective aggregate productivity. They also point to an asymmetry between positive and negative shocks to domestic firms. The evidence suggests that growth opportunities, such as greater export demand, can partly correct accumulated misallocation and boost effective productivity more when markets and institutions are less efficient. This may occur if the "truly" productive firms that start

[39] These findings are generally robust to adding sector-year fixed effects (Panel A of Appendix Table 4). The key aspect of labor market flexibility is the governance of regular individual contracts (Panel B of Appendix Table 4). The governance of collective regular contracts and temporary contracts play a much lesser role.

out with sub-optimal resources can more effectively scale up production than the "truly" less productive firms. By contrast, contractionary shocks, such as stiffer import competition, can engender more cleansing reallocation under more efficient markets and institutions, such that "truly" less productive firms downsize more.[40] There may also be less scope for distortionary policy interventions such as firm-specific subsidies in response to import-induced contraction than in response to export-induced expansion.

### 5.4 Misallocation Measures in the Literature

We conclude by examining the impact of international trade on several measures of resource misallocation that have been proposed in the literature. While micro-founded, these measures are valid under modeling assumptions that are difficult to validate empirically. Under certain assumptions, Hsieh-Klenow (2009) and Gopinath et al. (2017) show that the observed dispersion across firms in revenue-based total factor productivity (TFPR), marginal revenue product of capital (MRPK), and marginal revenue product of labor (MRPL) monotonically increases with misallocation in input and output markets. Under certain assumptions, Edmond et al. (2015) likewise find that the observed dispersion across firms in price-cost mark-ups (PCM) signals distortions in output markets.

There are several challenges in interpreting these indicators. First, measurement error in firm TFPR, MRPK, MRPL and PCM can inflate their observed dispersion. Second, TFPR, MRPK and MRPL are inferred from production function estimates, such that treating them as regression outcomes can complicate econometric inference. Third, the nature of production technology and market competition can affect these dispersion metrics even in the absence of resource misallocation. Bartelsman et al. (2013) and Foster et al. (2015, 2016) establish that TFPR, MRPK and MRPL dispersion signals resource misallocation under constant returns to scale and no shocks to firm demand or productivity. However, this is no longer the case if firms face increasing returns to scale or adjustment costs. Foster et al. (2008) show that TFPR, MRPK and MRPL dispersion implies misallocation of production inputs under constant mark-ups, but not under variable mark-ups. Dhingra-Morrow (2014) further demonstrate that market-share misallocation arises in product markets with variable mark-ups even when there are no distortions in factor markets.

Given prior empirical evidence of variable mark-ups, increasing returns to scale, and adjustment costs, it can thus be difficult to interpret the four dispersion measures. We nevertheless explore the effect of international trade on these dispersion outcomes in our data in Appendix Table 5. For each country, sector and year, CompNet reports the standard deviations of TFPR, MRPK and MRPL, as well as the 90th-10th interpercentile range for PCM. We generally find positive significant effects of import competition across the four $Dispersion_{ikt}$ metrics, but mixed results for export demand (see also DeLoecker and Warczinsky 2012 on PCM).

[40] Table 8 speaks to the differential effects of export and import shocks across economies at different levels of institutional and market efficiency. This is conceptually distinct from and thus not inconsistent with the baseline asymmetric effects of export and import shocks in Table 5, which capture average effects across countries.

# 6 Conclusion

We examine the impact of international trade on welfare and effective domestic aggregate productivity. Theoretically, we show that under allocative efficiency, bilateral and unilateral export liberalizations increase $W$ and $\tilde{\Phi}$, while unilateral import liberalization can either raise or reduce them. However, all three trade reforms have ambiguous effects in the presence of resource misallocation, and distortions can amplify, dampen or overturn the gains from trade.

Using unique new data on 14 European countries and 20 manufacturing industries during 1998-2011, we empirically establish that exogenous shocks to export demand and import competition generated large gains in effective domestic aggregate productivity in this sample. Trade operated by reallocating activity across heterogeneous firms in the presence of distortions, with asymmetric effects of export and import shocks: While both increased the minimum and average effective firm productivity, export expansion shifted activity towards firms with higher effective productivity and import penetration acted in reverse. In addition, efficient institutions, factor and product markets amplified the gains from import competition, but dampened 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 frictions in capital, labor and product markets. The analysis suggests that reallocation across firms is a key margin of adjustment, while alleviating market distortions can be important for realizing the full welfare gains from globalization. Our results also indicate that developed economies 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. The asymmetric effects of export and import shocks suggest that the impact of globalization may depend jointly on the nature of the shock and the drivers of misallocation. It would thus be valuable to assess the impact of specific frictions in capital, labor and product markets on firm selection and reallocation. It would also be important to explore how international trade affects technological innovation, adoption and cross-border transfer in the presence of resource misallocation. These constitute some steps towards understanding how to design trade policy and how to coordinate trade and structural reforms that remove institutional and market frictions in order to improve welfare.

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## Table 1. Numerical Simulation: Gains from Trade

This table reports numerical and estimation results for the impact of reducing bilateral trade costs, unilateral export costs or unilateral import costs by 20%. Panels A-C show the change in welfare, aggregate productivity, average firm productivity and the covariance of firms' productivity and employment share in different economic environments. In Panels A and B, there is no resource misallocation, and productivity is Pareto or Log-Normal distributed. In Panel C, there is misallocation, and productivity and distortions are joint Log-Normal with $\sigma_\eta$=0.15 and $\rho(\varphi,\eta)$={-0.4,0,0.4}. All other parameter values are as discussed in the text. Panel D reports the estimated effect of increasing export demand or import competition by 20% based on the baseline IV results in Table 5.

| | Bilateral Liberalization | | | | Export Liberalization | | | | Import Liberalization | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Welfare | Agg Prod | Avg Prod | Cov Term | Welfare | Agg Prod | Avg Prod | Cov Term | Welfare | Agg Prod | Avg Prod | Cov Term |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) |
| **Panel A. No Misallocation (Pareto)** | | | | | | | | | | | | |
| Flexible *w* | 4.76% | 4.76% | 3.52% | 1.23% | 1.67% | 1.67% | 1.23% | 0.43% | 2.52% | 2.52% | 1.87% | 0.65% |
| Fixed *w* | 3.31% | 4.76% | 3.52% | 1.23% | 4.96% | 7.16% | 5.32% | 1.83% | -0.85% | -1.21% | -0.91% | -0.31% |
| **Panel B. No Misallocation (Log-Normal)** | | | | | | | | | | | | |
| Flexible *w* | 3.92% | 3.50% | 2.75% | 0.75% | 1.39% | 1.22% | 0.96% | 0.26% | 1.95% | 1.72% | 1.35% | 0.37% |
| Fixed *w* | 2.73% | 3.50% | 2.75% | 0.75% | 3.77% | 4.88% | 3.83% | 1.05% | -0.49% | -0.60% | -0.48% | -0.12% |
| **Panel C. Misallocation (Joint Log-Normal)** | | | | | | | | | | | | |
| Flexible *w* | | | | | | | | | | | | |
| $\rho = -0.4$ | 3.92% | 3.49% | 2.65% | 0.84% | 1.40% | 1.22% | 0.92% | 0.30% | 1.96% | 1.72% | 1.30% | 0.42% |
| $\rho = 0$ | 3.87% | 3.47% | 2.80% | 0.67% | 1.37% | 1.21% | 0.98% | 0.22% | 1.93% | 1.70% | 1.38% | 0.32% |
| $\rho = 0.4$ | 3.85% | 3.47% | 2.94% | 0.53% | 1.35% | 1.20% | 1.04% | 0.16% | 1.91% | 1.70% | 1.46% | 0.24% |
| Fixed *w* | | | | | | | | | | | | |
| $\rho = -0.4$ | -1.68% | -0.05% | -0.16% | 0.11% | 2.32% | 2.26% | 1.77% | 0.49% | -3.27% | -1.55% | -1.37% | -0.18% |
| $\rho = 0$ | 2.70% | 3.48% | 2.81% | 0.67% | 2.62% | 4.46% | 3.54% | 0.91% | 0.58% | -0.21% | -0.13% | -0.08% |
| $\rho = 0.4$ | 0.92% | 7.71% | 6.42% | 1.29% | 0.15% | 8.47% | 7.11% | 1.36% | 1.38% | 0.03% | 0.11% | -0.09% |
| **Panel D. Data** | | | | | | | | | | | | |
| Estimated Effects (ctry-year FE) | | | | | | 7.96% | 5.90% | 2.06% | | 1.36% | 1.80% | -0.42% |
| Estimated Effects (ctry-year & sector-year FE) | | | | | | 7.34% | 4.52% | 2.82% | | 10.04% | 11.70% | -1.66% |

## Table 2: Summary Statistics

This table summarizes the variation in aggregate economic activity, aggregate productivity, international trade activity, and institutional and market frictions across countries, sectors and years in the 1998-2011 panel. All variables are defined in the text. The unit of observation is indicated in the panel heading.

| | N | Mean | St Dev |
|---|---|---|---|
| **Panel A. Country-Sector-Year Level** | | | |
| ln Output | 2,811 | 8.09 | 1.77 |
| ln Value Added | 2,811 | 13.51 | 2.03 |
| ln Employment | 2,811 | 10.21 | 1.35 |
| ln Exports | 2,811 | 7.65 | 1.74 |
| ln (Imports - Own-Sector Imp Inputs) | 2,811 | 6.41 | 1.97 |
| ln Aggregate Productivity | 2,811 | 3.21 | 1.13 |
| ln Average Productivity | 2,811 | 2.98 | 1.19 |
| Covariance Term | 2,811 | 0.23 | 0.22 |
| Δ ln Aggregate Productivity, Δ = 1 year | 2,548 | 0.04 | 0.10 |
| Δ ln Average Productivity, Δ = 1 year | 2,548 | 0.03 | 0.09 |
| Δ Covariance Term, Δ = 1 year | 2,548 | 0.01 | 0.08 |
| Δ ln Aggregate Productivity, Δ = 3 years | 2,073 | 0.11 | 0.19 |
| Δ ln Average Productivity, Δ = 3 years | 2,073 | 0.09 | 0.17 |
| Δ Covariance Term, Δ = 3 years | 2,073 | 0.02 | 0.12 |
| Δ ln Aggregate Productivity, Δ = 5 years | 1,587 | 0.18 | 0.25 |
| Δ ln Average Productivity, Δ = 5 years | 1,587 | 0.16 | 0.22 |
| Δ Covariance Term, Δ = 5 years | 1,587 | 0.02 | 0.14 |
| **Panel B. Country(-Year) Level** | | | |
| Rule of Law | 144 | 1.11 | 0.49 |
| (Inverse) Corruption | 144 | 1.07 | 0.69 |
| Labor Market Flexibility | 130 | 3.28 | 0.37 |
| Creditor Rights Protection | 14 | 5.86 | 1.79 |
| (Inverse) Product Market Regulation | 13 | 1.17 | 0.25 |

## Table 3. Trade and Aggregate Performance: OLS Correlation

This table examines the relationship between aggregate economic activity, aggregate productivity and trade exposure at the country-sector-year level. The outcome variable is indicated in the column heading and described in the text. All columns include country-year pair fixed effects, and control for the log number of firms by country-sector-year, the average log number of firms across countries by sector-year, and the average log employment across countries by sector-year. Standard errors clustered by sector-year in parentheses. ***, **, * significant at 1%, 5%, 10%.

| | Economic Activity | | | Aggregate Productivity | | |
|---|---|---|---|---|---|---|
| Dep Variable: | ln Output (ikt) | ln Value Added (ikt) | ln Employ-ment (ikt) | ln Agg Prod (ikt) | ln Avg Prod (ikt) | Cov Term (ikt) |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| **Exp Dem (ikt)** | **0.403*** ** | **0.380*** ** | **0.243*** ** | **0.125*** ** | **0.080*** ** | **0.045*** ** |
| | **(0.029)** | **(0.022)** | **(0.014)** | **(0.016)** | **(0.016)** | **(0.007)** |
| **Imp Comp (ikt)** | **-0.139*** ** | **0.041*** ** | **-0.066*** ** | **0.106*** ** | **0.124*** ** | **-0.019*** ** |
| | **(0.015)** | **(0.015)** | **(0.006)** | **(0.013)** | **(0.013)** | **(0.005)** |
| ln N Firms (ikt) | 0.552*** | 0.573*** | 0.736*** | -0.161*** | -0.122*** | -0.039*** |
| | (0.023) | (0.023) | (0.019) | (0.020) | (0.018) | (0.007) |
| Avg ln N Firms (kt) | -0.969*** | -0.710*** | -0.727*** | 0.023 | 0.100*** | -0.077*** |
| | (0.032) | (0.033) | (0.023) | (0.033) | (0.033) | (0.010) |
| Avg ln Employment (kt) | 1.285*** | 0.653*** | 0.858*** | -0.182*** | -0.245*** | 0.063*** |
| | (0.065) | (0.045) | (0.028) | (0.040) | (0.041) | (0.020) |
| N | 2,811 | 2,811 | 2,811 | 2,811 | 2,811 | 2,811 |
| R2 | 0.927 | 0.928 | 0.949 | 0.849 | 0.868 | 0.519 |
| Country*Year FE | Y | Y | Y | Y | Y | Y |

## Table 4. Instrumenting Export Demand and Import Competition: IV First Stage

This table presents the baseline IV first stage. It examines the impact of foreign supply, foreign demand and import tariffs on export and import activity at the country-sector-year level. The outcome variable is indicated in the column heading and described in the text. All columns include country-year pair fixed effects and the full set of controls in Table 3. Columns 2 and 5 (3 and 6) also include sector (sector-year pair) fixed effects. Standard errors clustered by sector-year in parentheses. ***, **, * significant at 1%, 5%, 10%.

| Dep Variable: | Exp Dem (ikt) | | | Imp Comp (ikt) | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| **Foreign Demand (ikt)** | **0.638*** ** | **0.458*** ** | **0.443*** ** | **-0.002** | **-0.007** | **-0.036** |
| | **(0.034)** | **(0.056)** | **(0.062)** | **(0.022)** | **(0.027)** | **(0.030)** |
| **Foreign Supply (ikt)** | **0.087*** ** | **0.139** ** | **0.140* ** | **0.868*** ** | **0.422*** ** | **0.345*** ** |
| | **(0.015)** | **(0.066)** | **(0.081)** | **(0.007)** | **(0.027)** | **(0.031)** |
| **Import Tariff (ikt)** | **-4.693*** ** | **0.307** | **0.662** | **-2.802*** ** | **-0.986** ** | **-1.332*** ** |
| | **(0.847)** | **(0.669)** | **(0.816)** | **(0.507)** | **(0.407)** | **(0.437)** |
| ln N Firms (ikt) | 0.555*** | 0.564*** | 0.569*** | 0.036** | 0.008 | 0.007 |
| | (0.034) | (0.032) | (0.032) | (0.018) | (0.016) | (0.016) |
| Avg ln N Firms (kt) | -0.741*** | -0.539*** | | -0.112*** | 0.110* | |
| | (0.033) | (0.134) | | (0.025) | (0.062) | |
| Avg ln Employment (kt) | 0.344*** | 0.490*** | | 0.113*** | -0.042 | |
| | (0.065) | (0.089) | | (0.042) | (0.055) | |
| N | 2,777 | 2,777 | 2,777 | 2,777 | 2,777 | 2,777 |
| R2 | 0.889 | 0.921 | 0.924 | 0.974 | 0.985 | 0.986 |
| Country*Year FE | Y | Y | Y | Y | Y | Y |
| Sector FE | N | Y | N | N | Y | N |
| Sector*Year FE | N | N | Y | N | N | Y |

## Table 5. Impact of Trade on Aggregate Productivity: IV Second Stage

This table presents the baseline IV second stage. It examines the impact of instrumented export demand and import competition on aggregate productivity at the country-sector-year level. The outcome variable is indicated in the column heading and described in the text. All columns include country-year pair fixed effects and the full set of controls in Table 3. Columns 4-6 (7-9) also include sector (sector-year pair) fixed effects. Standard errors clustered by sector-year in parentheses. ***, **, * significant at 1%, 5%, 10%.

| Dep Variable: | ln Agg Prod (ikt) | ln Avg Prod (ikt) | Cov Term (ikt) | ln Agg Prod (ikt) | ln Avg Prod (ikt) | Cov Term (ikt) | ln Agg Prod (ikt) | ln Avg Prod (ikt) | Cov Term (ikt) |
|---|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| **^Exp Dem (ikt)** | **0.398*** ** | **0.295*** ** | **0.103*** ** | **0.300*** ** | **0.197** ** | **0.103** ** | **0.367*** ** | **0.226** ** | **0.141*** ** |
| | **(0.039)** | **(0.039)** | **(0.014)** | **(0.097)** | **(0.085)** | **(0.045)** | **(0.109)** | **(0.098)** | **(0.050)** |
| **^Imp Comp (ikt)** | **0.068*** ** | **0.090*** ** | **-0.021*** ** | **0.294** ** | **0.296** ** | **-0.002** | **0.502*** ** | **0.585*** ** | **-0.083** |
| | **(0.014)** | **(0.014)** | **(0.005)** | **(0.131)** | **(0.118)** | **(0.042)** | **(0.185)** | **(0.166)** | **(0.059)** |
| ln N Firms (ikt) | -0.321*** | -0.248*** | -0.073*** | -0.257*** | -0.185*** | -0.072** | -0.292*** | -0.196*** | -0.097*** |
| | (0.029) | (0.027) | (0.012) | (0.062) | (0.054) | (0.029) | (0.067) | (0.061) | (0.032) |
| Avg ln N Firms (kt) | 0.327*** | 0.334*** | -0.007 | 0.061 | 0.030 | 0.031 | | | |
| | (0.046) | (0.046) | (0.019) | (0.127) | (0.123) | (0.052) | | | |
| Avg ln Employment (kt) | -0.461*** | -0.458*** | -0.003 | 0.054 | 0.021 | 0.033 | | | |
| | (0.054) | (0.055) | (0.027) | (0.128) | (0.125) | (0.052) | | | |
| N | 2,777 | 2,777 | 2,777 | 2,777 | 2,777 | 2,777 | 2,777 | 2,777 | 2,777 |
| R2 | 0.820 | 0.852 | 0.485 | 0.869 | 0.897 | 0.635 | 0.856 | 0.887 | 0.649 |
| Ctry*Year FE, Controls | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| Sector FE | N | N | N | Y | Y | Y | N | N | N |
| Sector*Year FE | N | N | N | N | N | N | Y | Y | Y |

## Table 6. Additional Results

This table provides additional evidence on the impact of export demand and import competition on aggregate productivity at the country-sector-year level, based on Columns 1-3 and 7-9 in Table 5. Panel A weights observations at the country-sector level by the initial share of a sector in manufacturing employment. Panel B weights observations at the country-year level by the share of manufacturing in total employment. Panel C distinguishes between import competition from China vs. Rest Of the World. Panels D-E control for skill and mark-up dispersion across firms with the 90th-10th inter-percentile ratio in firm-level wages and price-to-cost margins. Standard errors clustered by sector-year in parentheses. ***, **, * significant at 1%, 5%, 10%.

| Dep Variable: | ln Agg Prod (ikt) | ln Avg Prod (ikt) | Cov Term (ikt) | ln Agg Prod (ikt) | ln Avg Prod (ikt) | Cov Term (ikt) |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| **Panel A. Country-Sector Weights: Initial Share of Manuf Employment, L (ikt=0) / $L^M$ (it=0)** | | | | | | |
| ^Exp Dem (ikt) | 0.427*** | 0.360*** | 0.067*** | 0.467*** | 0.359*** | 0.108*** |
| | (0.039) | (0.036) | (0.011) | (0.102) | (0.090) | (0.039) |
| ^Imp Comp (ikt) | 0.075*** | 0.092*** | -0.017*** | 0.498*** | 0.494*** | 0.004 |
| | (0.015) | (0.014) | (0.005) | (0.151) | (0.141) | (0.043) |
| **Panel B. Country-Year Weights: Manufacturing Share of Total Employment, $L^M$ (it) / L (it)** | | | | | | |
| ^Exp Dem (ikt) | 0.385*** | 0.288*** | 0.097*** | 0.436*** | 0.267*** | 0.168*** |
| | (0.037) | (0.036) | (0.013) | (0.112) | (0.101) | (0.052) |
| ^Imp Comp (ikt) | 0.069*** | 0.091*** | -0.022*** | 0.703*** | 0.811*** | -0.108* |
| | (0.014) | (0.014) | (0.005) | (0.193) | (0.175) | (0.063) |
| **Panel C. Import Competition from China vs. ROW** | | | | | | |
| ^Exp Dem (ikt) | 0.371*** | 0.290*** | 0.082*** | 0.337*** | 0.200** | 0.137*** |
| | (0.038) | (0.038) | (0.013) | (0.104) | (0.093) | (0.047) |
| ^Imp Comp ROW (ikt) | 0.082*** | 0.086*** | -0.004 | 0.398** | 0.484*** | -0.086 |
| | (0.015) | (0.015) | (0.006) | (0.182) | (0.163) | (0.067) |
| ^Imp Comp China (ikt) | -0.015 | 0.005 | -0.019*** | 0.136** | 0.141*** | -0.005 |
| | (0.014) | (0.014) | (0.004) | (0.058) | (0.051) | (0.023) |
| **Panel D. Skill Dispersion across Firms** | | | | | | |
| ^Exp Dem (ikt) | 0.394*** | 0.291*** | 0.103*** | 0.364*** | 0.224** | 0.140*** |
| | (0.039) | (0.038) | (0.014) | (0.109) | (0.099) | (0.050) |
| ^Imp Comp (ikt) | 0.066*** | 0.088*** | -0.022*** | 0.501*** | 0.584*** | -0.083 |
| | (0.014) | (0.014) | (0.005) | (0.184) | (0.165) | (0.059) |
| 90-10 Wage Ratio (ikt) | -0.001** | -0.001** | -0.000 | -0.001** | -0.001* | -0.000*** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| **Panel E. Mark-Up Dispersion across Firms** | | | | | | |
| ^Exp Dem (ikt) | 0.397*** | 0.294*** | 0.103*** | 0.367*** | 0.226** | 0.141*** |
| | (0.039) | (0.039) | (0.014) | (0.109) | (0.098) | (0.050) |
| ^Imp Comp (ikt) | 0.068*** | 0.090*** | -0.022*** | 0.509*** | 0.591*** | -0.082 |
| | (0.014) | (0.014) | (0.005) | (0.184) | (0.165) | (0.059) |
| 90-10 PCM Ratio (ikt) | -0.000 | -0.000 | -0.000 | -0.000* | -0.000 | -0.000 |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| Ctry*Year FE, Controls | Y | Y | Y | Y | Y | Y |
| Sector*Year FE | N | N | N | Y | Y | Y |

## Table 7. Mechanisms: Selection and Innovation

This table examines the contribution of firm selection to the effects of export demand and import competition on aggregate productivity at the country-sector-year level. The outcome variable is indicated in the column heading and described in the text. All columns include country-year pair fixed effects and the full set of controls in Table 3. Columns 5-8 also include sector-year pair fixed effects. Standard errors clustered by sector-year in parentheses. ***, **, * significant at 1%, 5%, 10%.

**Panel A. Firm Selection**

| Dep Variable: | ln min Prod (ikt) | ln Agg Prod (ikt) | ln Avg Prod (ikt) | Cov Term (ikt) | ln min Prod (ikt) | ln Agg Prod (ikt) | ln Avg Prod (ikt) | Cov Term (ikt) |
|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| **^Exp Dem (ikt)** | **0.198*** ** | **0.275*** ** | **0.152*** ** | **0.124*** ** | **0.314*** ** | **0.190*** ** | **0.023** | **0.166*** ** |
| | **(0.040)** | **(0.027)** | **(0.020)** | **(0.013)** | **(0.108)** | **(0.072)** | **(0.053)** | **(0.049)** |
| **^Imp Comp (ikt)** | **0.073*** ** | **0.026*** ** | **0.039*** ** | **-0.013** ** | **0.249** | **0.230* ** | **0.324*** ** | **-0.095** |
| | **(0.015)** | **(0.010)** | **(0.007)** | **(0.005)** | **(0.173)** | **(0.123)** | **(0.099)** | **(0.059)** |
| ln min Prod (ikt) | | 0.642*** | 0.733*** | -0.091*** | | 0.653*** | 0.676*** | -0.023** |
| | | (0.025) | (0.018) | (0.011) | | (0.024) | (0.021) | (0.009) |
| N | 2,750 | 2,750 | 2,750 | 2,750 | 2,750 | 2,750 | 2,750 | 2,750 |
| R2 | 0.911 | 0.913 | 0.948 | 0.473 | 0.930 | 0.938 | 0.959 | 0.619 |
| Ctry*Year FE, Controls | Y | Y | Y | Y | Y | Y | Y | Y |
| Sector*Year FE | N | N | N | N | Y | Y | Y | Y |

**Panel B. Firm Selection & Innovation**

| Dep Variable: | ln R&D (ikt) | ln Agg Prod (ikt) | ln Avg Prod (ikt) | Cov Term (ikt) | ln R&D (ikt) | ln Agg Prod (ikt) | ln Avg Prod (ikt) | Cov Term (ikt) |
|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| **^Exp Dem (ikt)** | **0.103** | **0.282*** ** | **0.154*** ** | **0.129*** ** | **0.370** | **0.237*** ** | **0.055** | **0.182*** ** |
| | **(0.115)** | **(0.027)** | **(0.019)** | **(0.012)** | **(0.448)** | **(0.083)** | **(0.057)** | **(0.052)** |
| **^Imp Comp (ikt)** | **0.164*** ** | **0.016* ** | **0.038*** ** | **-0.022*** ** | **-3.680*** ** | **0.190** | **0.241** ** | **-0.051** |
| | **(0.046)** | **(0.009)** | **(0.007)** | **(0.004)** | **(0.527)** | **(0.135)** | **(0.105)** | **(0.068)** |
| ln min Prod (ikt) | | 0.657*** | 0.736*** | -0.079*** | | 0.654*** | 0.676*** | -0.022** |
| | | (0.022) | (0.016) | (0.009) | | (0.024) | (0.020) | (0.009) |
| ln R&D (ikt) | | -0.000 | -0.018*** | 0.017*** | | -0.018 | -0.031*** | 0.012** |
| | | (0.008) | (0.006) | (0.003) | | (0.012) | (0.010) | (0.006) |
| N | 2,777 | 2,750 | 2,750 | 2,750 | 2,777 | 2,750 | 2,750 | 2,750 |
| R2 | 0.999 | 0.915 | 0.949 | 0.501 | 0.999 | 0.936 | 0.961 | 0.599 |
| Ctry*Year FE, Controls | Y | Y | Y | Y | Y | Y | Y | Y |
| Sector*Year FE | N | N | N | N | Y | Y | Y | Y |

## Table 8. Mechanisms: Imperfect Institutions and Market Frictions

This table examines the role of institutional efficiency in moderating the impact of export demand and import competition on aggregate productivity at the country-sector-year level. The outcome variable and the measure of institutional efficiency are indicated in the column heading and described in the text. All columns include country-year pair fixed effects and the full set of controls in Table 3. Standard errors clustered by sector-year in parentheses. ***, **, * significant at 1%, 5%, 10%.

| Institution Measure: | Rule of Law | | | (Inverse) Corruption | | | Labor Market Flexibility | | | Creditor Rights Protection | | | (Inverse) Product Market Regulation | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dep. Variable: | ln Agg Prod (ikt) | ln Avg Prod (ikt) | Cov Term (ikt) | ln Agg Prod (ikt) | ln Avg Prod (ikt) | Cov Term (ikt) | ln Agg Prod (ikt) | ln Avg Prod (ikt) | Cov Term (ikt) | ln Agg Prod (ikt) | ln Avg Prod (ikt) | Cov Term (ikt) | ln Agg Prod (ikt) | ln Avg Prod (ikt) | Cov Term (ikt) |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) | (15) |
| ^Exp Dem (ikt) | 1.066*** | 0.862*** | 0.204*** | 0.850*** | 0.670*** | 0.180*** | 1.121*** | 0.763*** | 0.358*** | 0.718*** | 0.511*** | 0.207*** | 1.314*** | 1.047*** | 0.267*** |
| | (0.126) | (0.111) | (0.037) | (0.096) | (0.085) | (0.031) | (0.261) | (0.238) | (0.063) | (0.158) | (0.147) | (0.040) | (0.172) | (0.155) | (0.045) |
| ^Imp Comp (ikt) | -0.113** | -0.053 | -0.060*** | -0.063* | -0.013 | -0.050*** | -0.202** | -0.102 | -0.100*** | -0.108* | -0.063 | -0.045*** | -0.045 | 0.033 | -0.078*** |
| | (0.050) | (0.044) | (0.012) | (0.038) | (0.034) | (0.010) | (0.096) | (0.089) | (0.027) | (0.061) | (0.055) | (0.015) | (0.061) | (0.055) | (0.016) |
| **^Exp Dem (ikt) x** | **-0.476*** | **-0.405*** | **-0.070*** | **-0.302*** | **-0.252*** | **-0.050*** | **-0.218*** | **-0.143** | **-0.075*** | **-0.048** | **-0.033*** | **-0.015*** | **-0.769*** | **-0.636*** | **-0.133*** |
| **Institution (it)** | **(0.067)** | **(0.059)** | **(0.017)** | **(0.042)** | **(0.036)** | **(0.012)** | **(0.069)** | **(0.063)** | **(0.016)** | **(0.019)** | **(0.017)** | **(0.005)** | **(0.130)** | **(0.118)** | **(0.032)** |
| **^Imp Comp (ikt) x** | **0.136*** | **0.106*** | **0.030*** | **0.095*** | **0.074*** | **0.021*** | **0.083*** | **0.060** | **0.024*** | **0.028*** | **0.025*** | **0.003** | **0.085*** | **0.039** | **0.046*** |
| **Institution (it)** | **(0.031)** | **(0.028)** | **(0.006)** | **(0.020)** | **(0.018)** | **(0.004)** | **(0.027)** | **(0.026)** | **(0.008)** | **(0.009)** | **(0.008)** | **(0.002)** | **(0.046)** | **(0.043)** | **(0.013)** |
| N | 2,777 | 2,777 | 2,777 | 2,777 | 2,777 | 2,777 | 2,777 | 2,777 | 2,777 | 2,777 | 2,777 | 2,777 | 2,777 | 2,777 | 2,777 |
| R2 | 0.792 | 0.835 | 0.459 | 0.797 | 0.839 | 0.460 | 0.747 | 0.802 | 0.447 | 0.811 | 0.848 | 0.463 | 0.825 | 0.858 | 0.398 |
| Ctry*Year FE, Controls | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |

## Appendix Table 1. Summary Statistics

This table provides summary statistics for the variation in aggregate productivity (CompNet) and trade activity (WIOD) across country-sector-year triplets in the 1998-2011 panel, as well as for the variation in institutional and market efficiency (World Justice Project, OECD, World Bank) across country-years in the 1998-2011 panel.

**Panel A. Country-Sector-Year Level**

| | Years | # Sector-Years | Avg # Firms per Sector-Year | ln Aggregate Productivity | | ln Average Productivity | | Covariance Term | | ln Exports | ln (Imports - Own-Sector Imp Inputs) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Mean | St Dev | Mean | St Dev | Mean | St Dev | | |
| AUSTRIA | 2000-2011 | 178 | 68 | 4.29 | 0.53 | 4.23 | 0.52 | 0.06 | 0.09 | 8.06 | 6.67 |
| BELGIUM | 1998-2010 | 254 | 709 | 4.07 | 0.56 | 3.87 | 0.48 | 0.20 | 0.17 | 8.26 | 6.92 |
| ESTONIA | 1998-2011 | 157 | 218 | 1.96 | 0.58 | 1.63 | 0.60 | 0.33 | 0.22 | 4.93 | 3.70 |
| FINLAND | 1999-2011 | 233 | 573 | 4.06 | 0.56 | 3.88 | 0.52 | 0.18 | 0.20 | 7.10 | 5.65 |
| FRANCE | 1998-2009 | 231 | 3,559 | 4.03 | 0.47 | 3.85 | 0.44 | 0.19 | 0.15 | 9.14 | 8.05 |
| GERMANY | 1998-2011 | 274 | 721 | 4.50 | 0.40 | 4.39 | 0.38 | 0.11 | 0.09 | 9.91 | 8.62 |
| HUNGARY | 2003-2011 | 164 | 1,484 | 1.58 | 0.64 | 1.06 | 0.55 | 0.53 | 0.31 | 6.88 | 5.62 |
| ITALY | 2001-2011 | 218 | 4,356 | 3.53 | 0.43 | 3.25 | 0.44 | 0.28 | 0.09 | 9.17 | 7.75 |
| LITHUANIA | 2000-2011 | 179 | 263 | 1.86 | 0.61 | 1.38 | 0.58 | 0.48 | 0.23 | 5.01 | 4.17 |
| POLAND | 2005-2011 | 128 | 709 | 2.30 | 0.80 | 2.12 | 0.79 | 0.18 | 0.15 | 8.12 | 6.65 |
| PORTUGAL | 2006-2011 | 110 | 1,637 | 2.76 | 0.63 | 2.48 | 0.59 | 0.28 | 0.12 | 7.14 | 6.18 |
| SLOVAKIA | 2001-2011 | 182 | 109 | 2.11 | 0.63 | 1.97 | 0.57 | 0.14 | 0.20 | 6.60 | 5.26 |
| SLOVENIA | 1998-2011 | 232 | 216 | 2.30 | 0.58 | 2.20 | 0.54 | 0.10 | 0.17 | 6.06 | 4.74 |
| SPAIN | 1998-2011 | 271 | 3,192 | 3.46 | 0.44 | 3.15 | 0.38 | 0.31 | 0.15 | 8.39 | 7.42 |
| Mean (across countries) | | 201 | 1,272 | 3.06 | 0.56 | 2.82 | 0.53 | 0.24 | 0.17 | 7.48 | 6.24 |
| St Dev (across countries) | | 52 | 1,416 | 1.03 | 0.11 | 1.12 | 0.11 | 0.14 | 0.06 | 1.51 | 1.47 |

## Appendix Table 1. Summary Statistics (cont,)

This table provides summary statistics for the variation in aggregate productivity (CompNet) and trade activity (WIOD) across country-sector-year triplets in the 1998-2011 panel, as well as for the variation in institutional and market efficiency (World Justice Project, OECD, World Bank) across country-years in the 1998-2011 panel.

**Panel B. Country-Year Level**

| | Years | Rule of Law | | Corruption | | Labor Market Flexibility | | Creditor Rights Protection | | Product Market Regulation | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Mean | St Dev | Mean | St Dev | Mean | St Dev | Mean | St Dev | Mean | St Dev |
| AUSTRIA | 2000-2011 | 1.86 | 0.05 | 1.92 | 0.22 | 3.31 | 0.12 | 6.00 | 0.00 | 1.39 | 0.00 |
| BELGIUM | 1998-2010 | 1.29 | 0.06 | 1.37 | 0.08 | 3.18 | 0.04 | 5.00 | 0.00 | 1.18 | 0.00 |
| ESTONIA | 1998-2011 | 0.94 | 0.23 | 0.83 | 0.14 | 3.71 | 0.20 | 6.25 | 0.00 | 1.63 | 0.00 |
| FINLAND | 1999-2011 | 1.94 | 0.03 | 2.41 | 0.13 | 3.92 | 0.07 | 8.00 | 0.00 | 1.49 | 0.00 |
| FRANCE | 1998-2009 | 1.39 | 0.08 | 1.37 | 0.06 | 3.32 | 0.05 | 4.38 | 0.00 | 1.11 | 0.00 |
| GERMANY | 1998-2011 | 1.65 | 0.06 | 1.84 | 0.14 | 3.05 | 0.00 | 7.50 | 0.00 | 1.19 | 0.00 |
| HUNGARY | 2003-2011 | 0.85 | 0.08 | 0.48 | 0.15 | 3.60 | 0.00 | 7.00 | 0.00 | 1.03 | 0.00 |
| ITALY | 2001-2011 | 0.48 | 0.13 | 0.31 | 0.19 | 2.85 | 0.00 | 3.00 | 0.00 | 1.23 | 0.00 |
| LITHUANIA | 2000-2011 | 0.59 | 0.17 | 0.17 | 0.11 | | | 5.00 | 0.00 | | |
| POLAND | 2005-2011 | 0.52 | 0.15 | 0.32 | 0.12 | 3.59 | 0.00 | 8.38 | 0.00 | 0.61 | 0.00 |
| PORTUGAL | 2006-2011 | 1.01 | 0.04 | 1.01 | 0.05 | 2.28 | 0.22 | 3.00 | 0.00 | 1.01 | 0.00 |
| SLOVAKIA | 2001-2011 | 0.47 | 0.11 | 0.28 | 0.16 | 3.28 | 0.10 | 8.00 | 0.00 | 1.11 | 0.00 |
| SLOVENIA | 1998-2011 | 0.98 | 0.10 | 0.94 | 0.15 | 3.15 | 0.02 | 4.50 | 0.00 | 1.11 | 0.00 |
| SPAIN | 1998-2011 | 1.19 | 0.09 | 1.19 | 0.16 | 3.25 | 0.03 | 6.00 | 0.00 | 1.07 | 0.00 |
| Mean (across countries) | | 1.08 | 0.10 | 1.03 | 0.13 | 3.27 | 0.06 | 5.86 | 0.00 | 1.17 | 0.00 |
| St Dev (across countries) | | 0.50 | 0.05 | 0.70 | 0.05 | 0.41 | 0.08 | 1.79 | 0.00 | 0.25 | 0.00 |

## Appendix Table 2. Trade and Aggregate Productivity: OLS First Differences

This table examines the relationship between aggregate productivity and trade exposure at the country-sector-year level. The outcome variable is indicated in the column heading and described in the text. All left- and right-hand side variables are first differences over rolling 1-year, 3-year or 5-year overlapping periods. All columns include year fixed effects and the full set of controls in Table 3. Standard errors clustered by sector-year in parentheses. ***, **, * significant at 1%, 5%, 10%.

| | Δ = 1 year | | | Δ = 3 years | | | Δ = 5 years | | |
|---|---|---|---|---|---|---|---|---|---|
| | Δ ln Agg Prod (ikt) | Δ ln Avg Prod (ikt) | Δ Cov Term (ikt) | Δ ln Agg Prod (ikt) | Δ ln Avg Prod (ikt) | Δ Cov Term (ikt) | Δ ln Agg Prod (ikt) | Δ ln Avg Prod (ikt) | Δ Cov Term (ikt) |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| **Δ Exp Dem (ikt)** | **0.116*** ** | **0.034** | **0.082*** ** | **0.142*** ** | **0.053* ** | **0.089*** ** | **0.162*** ** | **0.088*** ** | **0.074*** ** |
| | **(0.028)** | **(0.025)** | **(0.027)** | **(0.027)** | **(0.027)** | **(0.018)** | **(0.032)** | **(0.031)** | **(0.019)** |
| **Δ Imp Comp (ikt)** | **0.083*** ** | **0.102*** ** | **-0.019** | **0.062** ** | **0.102*** ** | **-0.040** ** | **0.078*** ** | **0.108*** ** | **-0.030* ** |
| | **(0.021)** | **(0.022)** | **(0.019)** | **(0.025)** | **(0.024)** | **(0.017)** | **(0.030)** | **(0.027)** | **(0.016)** |
| N | 2,546 | 2,546 | 2,546 | 2,073 | 2,073 | 2,073 | 1,587 | 1,587 | 1,587 |
| R2 | 0.114 | 0.115 | 0.022 | 0.101 | 0.117 | 0.044 | 0.096 | 0.094 | 0.035 |
| Year FE, Controls | Y | Y | Y | Y | Y | Y | Y | Y | Y |

## Appendix Table 3. Sensitivity Analysis

This table examines the stability of the impact of export demand and import competition on aggregate productivity at the country-sector-year level, based on Columns 1-3 and 7-9 in Table 5. Panels A-B consider only one dimension of trade exposure at a time. Panel C lags trade exposure by 1 year. Panel D measures import competition with the ratio of imports to domestic turnover. Panel E winsorizes productivity, trade, and foreign demand and supply instruments at the top and bottom 1 percentile. Standard errors clustered by sector-year in parentheses. ***, **, * significant at

| Dep Variable: | ln Agg Prod (ikt) | ln Avg Prod (ikt) | Cov Term (ikt) | ln Agg Prod (ikt) | ln Avg Prod (ikt) | Cov Term (ikt) |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| **Panel A. Only Export Demand** | | | | | | |
| ^Exp Dem (ikt) | 0.461*** | 0.350*** | 0.111*** | 0.417*** | 0.304*** | 0.114** |
| | (0.039) | (0.041) | (0.018) | (0.112) | (0.097) | (0.047) |
| **Panel B. Only Import Competition** | | | | | | |
| ^Imp Comp (ikt) | 0.148*** | 0.149*** | -0.001 | 0.730*** | 0.728*** | 0.001 |
| | (0.013) | (0.015) | (0.005) | (0.150) | (0.142) | (0.050) |
| **Panel C. Lagged Trade Exposure** | | | | | | |
| ^Exp Dem (ikt-1) | 0.395*** | 0.292*** | 0.103*** | 0.297*** | 0.179* | 0.118** |
| | (0.041) | (0.041) | (0.014) | (0.102) | (0.092) | (0.049) |
| ^Imp Comp (ikt-1) | 0.069*** | 0.091*** | -0.022*** | 0.500*** | 0.569*** | -0.069 |
| | (0.015) | (0.014) | (0.006) | (0.180) | (0.163) | (0.062) |
| **Panel D. Import Competition Ratio** | | | | | | |
| ^Exp Dem (ikt) | 0.433*** | 0.329*** | 0.104*** | 0.465*** | 0.345*** | 0.121** |
| | (0.038) | (0.038) | (0.013) | (0.140) | (0.124) | (0.058) |
| ^Imp Comp Ratio (ikt) | 0.101*** | 0.144*** | -0.043*** | 0.153*** | 0.181*** | -0.028 |
| | (0.020) | (0.020) | (0.010) | (0.053) | (0.047) | (0.024) |
| **Panel E. Winsorizing Outliers** | | | | | | |
| ^Exp Dem (ikt) | 0.393*** | 0.301*** | 0.092*** | 0.206* | 0.078 | 0.127* |
| | (0.039) | (0.039) | (0.014) | (0.120) | (0.122) | (0.067) |
| ^Imp Comp (ikt) | 0.073*** | 0.094*** | -0.021*** | 0.637*** | 0.792*** | -0.154* |
| | (0.014) | (0.014) | (0.006) | (0.245) | (0.236) | (0.087) |
| Ctry*Year FE, Controls | Y | Y | Y | Y | Y | Y |
| Sector*Year FE | N | N | N | Y | Y | Y |

## Appendix Table 4. Imperfect Institutions and Market Frictions: Extensions

This table examines the stability of the role of institutional efficiency in moderating the impact of export demand and import competition on aggregate productivity at the country-sector-year level. Compared to Table 8, Panel A adds sector-year pair fixed effects, and Panel B considers different aspects of labor market flexibility. Standard errors clustered by sector-year in parentheses. ***, **, * significant at 1%, 5%,

**Panel A. Sector-Year Pair FE**

| Institution Measure: | Rule of Law | | | (Inverse) Corruption | | | Labor Market Flexibility | | | Creditor Rights Protection | | | (Inverse) Product Market Regulation | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ln Agg Prod (ikt) | ln Avg Prod (ikt) | Cov Term (ikt) | ln Agg Prod (ikt) | ln Avg Prod (ikt) | Cov Term (ikt) | ln Agg Prod (ikt) | ln Avg Prod (ikt) | Cov Term (ikt) | ln Agg Prod (ikt) | ln Avg Prod (ikt) | Cov Term (ikt) | ln Agg Prod (ikt) | ln Avg Prod (ikt) | Cov Term (ikt) |
| ^Exp Dem (ikt) | 1.902*** | 1.558*** | 0.343** | 1.609*** | 1.243*** | 0.366** | -0.530* | -1.364*** | 0.835*** | 0.905* | 0.142 | 0.762*** | 1.097*** | 0.910*** | 0.187*** |
| | (0.429) | (0.359) | (0.152) | (0.411) | (0.327) | (0.156) | (0.319) | (0.296) | (0.287) | (0.516) | (0.340) | (0.293) | (0.222) | (0.220) | (0.065) |
| ^Imp Comp (ikt) | -0.873** | -0.712** | -0.161 | -0.859** | -0.655** | -0.204* | 0.369** | 0.491*** | -0.122 | 0.179 | 0.416** | -0.237* | 0.602*** | 0.701*** | -0.099* |
| | (0.353) | (0.307) | (0.104) | (0.374) | (0.313) | (0.121) | (0.159) | (0.166) | (0.101) | (0.242) | (0.170) | (0.139) | (0.148) | (0.157) | (0.055) |
| **^Exp Dem (ikt) x** | **-0.754*** ** | **-0.653*** ** | **-0.101** ** | **-0.510*** ** | **-0.422*** ** | **-0.088** ** | **0.129** | **0.310*** ** | **-0.180*** ** | **-0.068** | **-0.009** | **-0.059** ** | **-0.683*** ** | **-0.602*** ** | **-0.082*** ** |
| **Institution (it)** | **(0.148)** | **(0.125)** | **(0.050)** | **(0.109)** | **(0.087)** | **(0.040)** | **(0.081)** | **(0.072)** | **(0.064)** | **(0.045)** | **(0.030)** | **(0.024)** | **(0.135)** | **(0.131)** | **(0.031)** |
| **^Imp Comp (ikt) x** | **0.177*** ** | **0.138*** ** | **0.039*** ** | **0.140*** ** | **0.107*** ** | **0.033*** ** | **-0.031** | **-0.090*** ** | **0.059*** ** | **0.039** ** | **0.017** | **0.022** ** | **0.085** | **0.066** | **0.018** |
| **Institution (it)** | **(0.048)** | **(0.042)** | **(0.011)** | **(0.038)** | **(0.031)** | **(0.010)** | **(0.029)** | **(0.028)** | **(0.022)** | **(0.019)** | **(0.013)** | **(0.010)** | **(0.061)** | **(0.060)** | **(0.017)** |
| N | 2,777 | 2,777 | 2,777 | 2,777 | 2,777 | 2,777 | 2,777 | 2,777 | 2,777 | 2,777 | 2,777 | 2,777 | 2,777 | 2,777 | 2,777 |
| R2 | 0.727 | 0.808 | 0.549 | 0.731 | 0.821 | 0.487 | 0.896 | 0.907 | 0.431 | 0.840 | 0.904 | 0.086 | 0.856 | 0.876 | 0.642 |
| Ctry*Year FE, Controls | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| Sector*Year FE | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |

**Panel B. Sub-Components of Labor Market Flexibility**

| LMF Component: | Baseline: Regular Contracts (Individual & Collective) | | | Individual Regular Contracts | | | Collective Regular Contracts (Additional Provisions) | | | Temporary Employment Contracts | | | Synthetic Indicator (Regular & Temporary Contracts) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ln Agg Prod (ikt) | ln Avg Prod (ikt) | Cov Term (ikt) | ln Agg Prod (ikt) | ln Avg Prod (ikt) | Cov Term (ikt) | ln Agg Prod (ikt) | ln Avg Prod (ikt) | Cov Term (ikt) | ln Agg Prod (ikt) | ln Avg Prod (ikt) | Cov Term (ikt) | ln Agg Prod (ikt) | ln Avg Prod (ikt) | Cov Term (ikt) |
| ^Exp Dem (ikt) | 1.121*** | 0.763*** | 0.358*** | 0.611*** | 0.482*** | 0.129*** | 0.376*** | 0.204** | 0.172*** | 0.336 | 0.069 | 0.267*** | 0.276 | 0.028 | 0.248*** |
| | (0.261) | (0.238) | (0.063) | (0.072) | (0.067) | (0.022) | (0.095) | (0.093) | (0.027) | (0.275) | (0.233) | (0.073) | (0.223) | (0.187) | (0.063) |
| ^Imp Comp (ikt) | -0.202** | -0.102 | -0.100*** | -0.122*** | -0.081*** | -0.042*** | -0.019 | 0.022 | -0.040** | 0.220*** | 0.270*** | -0.050*** | 0.225*** | 0.275*** | -0.050*** |
| | (0.096) | (0.089) | (0.027) | (0.033) | (0.031) | (0.010) | (0.057) | (0.055) | (0.016) | (0.059) | (0.051) | (0.018) | (0.053) | (0.046) | (0.017) |
| **^Exp Dem (ikt) x** | **-0.218*** ** | **-0.143** ** | **-0.075*** ** | **-0.089*** ** | **-0.077*** ** | **-0.012** ** | **0.000** | **0.017** | **-0.017** ** | **0.014** | **0.060** | **-0.046** ** | **0.031** | **0.071** | **-0.041** ** |
| **Institution (it)** | **(0.069)** | **(0.063)** | **(0.016)** | **(0.016)** | **(0.015)** | **(0.005)** | **(0.017)** | **(0.017)** | **(0.007)** | **(0.071)** | **(0.059)** | **(0.019)** | **(0.056)** | **(0.047)** | **(0.016)** |
| **^Imp Comp (ikt) x** | **0.083*** ** | **0.060** ** | **0.024*** ** | **0.077*** ** | **0.068*** ** | **0.009** ** | **0.025* ** | **0.020** | **0.005** | **-0.040*** ** | **-0.048*** ** | **0.008* ** | **-0.042*** ** | **-0.050*** ** | **0.008* ** |
| **Institution (it)** | **(0.027)** | **(0.026)** | **(0.008)** | **(0.010)** | **(0.010)** | **(0.003)** | **(0.013)** | **(0.013)** | **(0.004)** | **(0.015)** | **(0.013)** | **(0.005)** | **(0.013)** | **(0.012)** | **(0.005)** |
| N | 2,777 | 2,777 | 2,777 | 2,777 | 2,777 | 2,777 | 2,777 | 2,777 | 2,777 | 2,777 | 2,777 | 2,777 | 2,777 | 2,777 | 2,777 |
| R2 | 0.747 | 0.802 | 0.447 | 0.758 | 0.809 | 0.463 | 0.752 | 0.805 | 0.455 | 0.748 | 0.802 | 0.456 | 0.748 | 0.802 | 0.457 |
| Ctry*Year FE, Controls | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |

## Appendix Table 5. Trade and MRPK, MRPL, TFPR, Markup 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, or the 90th-10th interpercentile range of the price-cost mark-up as indicated in the column heading. All columns include country-year pair fixed effects and the full set of controls in Table 3. Columns 5-8 also include sector-year pair fixed effects. Standard errors clustered by sector-year in parentheses. ***, **, * significant at 1%, 5%, 10%.

| Dep Variable: | MRPK St Dev | MRPL St Dev | TFPR St Dev | PCM p90 / p10 | MRPK St Dev | MRPL St Dev | TFPR St Dev | PCM p90 / p10 |
|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| **^Exp Dem (ikt)** | **-0.203*** ** | **0.272*** ** | **0.297*** ** | **0.407*** ** | **0.425*** ** | **0.059** | **0.125** | **-0.738** |
| | **(0.069)** | **(0.038)** | **(0.035)** | **(0.138)** | **(0.145)** | **(0.082)** | **(0.155)** | **(0.527)** |
| **^Imp Comp (ikt)** | **0.193*** ** | **0.095*** ** | **0.059*** ** | **-0.031** | **0.408* ** | **0.483*** ** | **0.981*** ** | **2.077*** ** |
| | **(0.026)** | **(0.012)** | **(0.013)** | **(0.050)** | **(0.229)** | **(0.131)** | **(0.248)** | **(0.707)** |
| N | 2,777 | 2,777 | 2,382 | 2,775 | 2,777 | 2,777 | 2,382 | 2,775 |
| R2 | 0.552 | 0.810 | 0.784 | 0.661 | 0.703 | 0.872 | 0.792 | 0.731 |
| Ctry*Year FE, Controls | Y | Y | Y | Y | Y | Y | Y | Y |
| Sector*Year FE | N | N | N | N | Y | Y | Y | Y |

## Figure 1. Numerical Simulation: Welfare and Measured Aggregate Productivity

This figure illustrates the relationship between aggregate welfare, measured aggregate productivity, and the misallocation parameters in numerical model simulations. In each figure, the productivity-distortion correlation $\rho(\varphi,\eta)$ varies along the x-axis and the standard deviation of distortions $\sigma_\eta$ varies along the y-axis. Figures A, B, C and D plot welfare, aggregate productivity, average productivity and the productivity-size covariance on the z-axis. All other parameter values are described in the text.

**Figure 1A. Welfare**

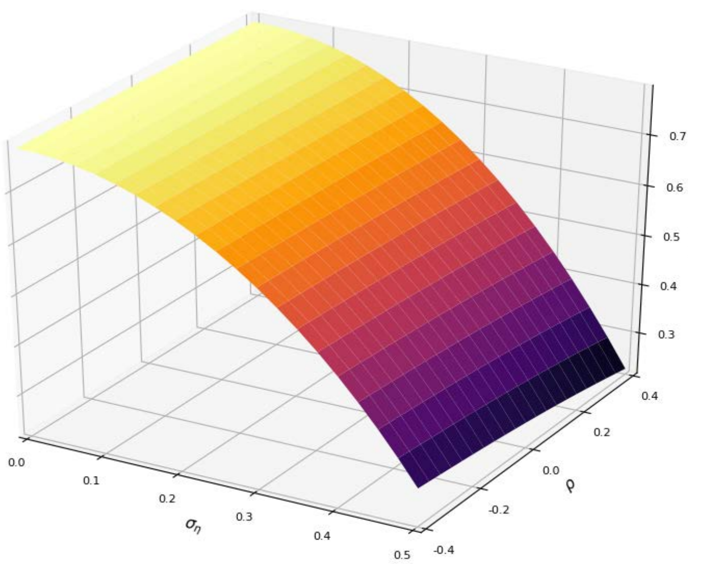



**Figure 1B. (log) Aggregate Productivity**

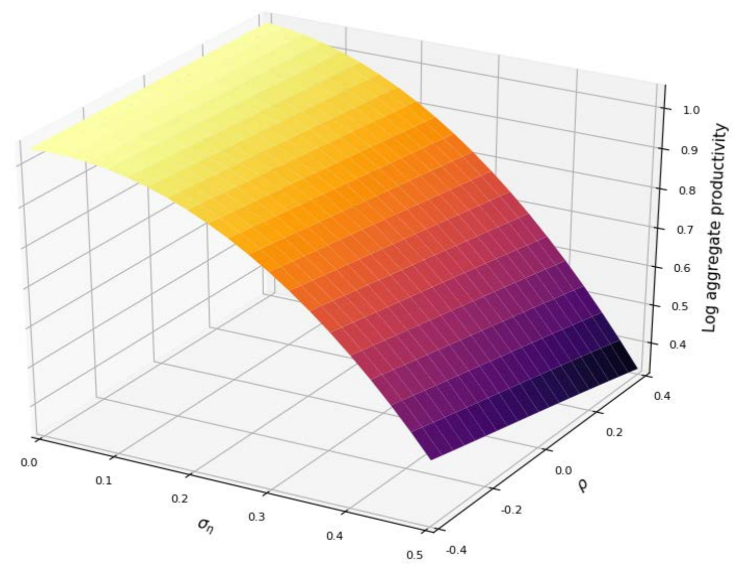



**Figure 1C. (log) Average Productivity**

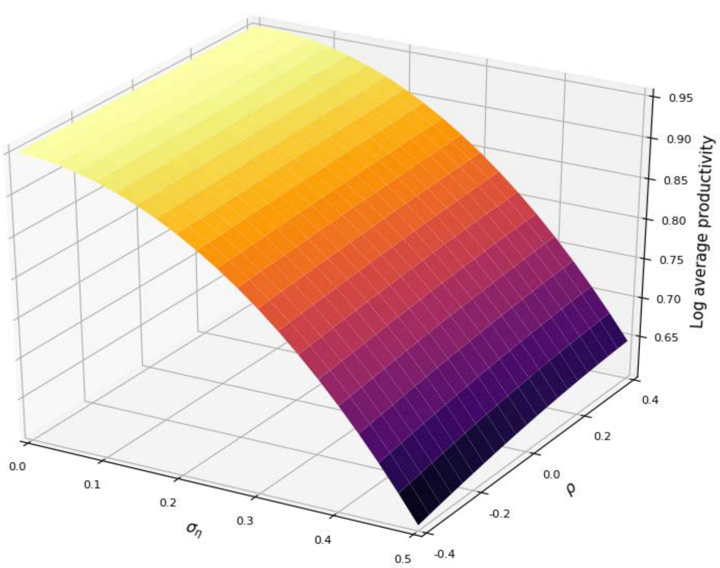
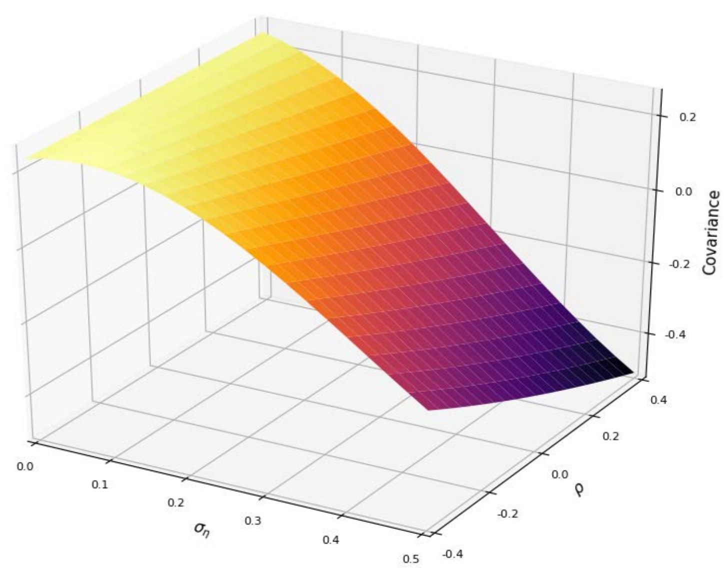



**Figure 1D. (log) Productivity-Size Covariance**

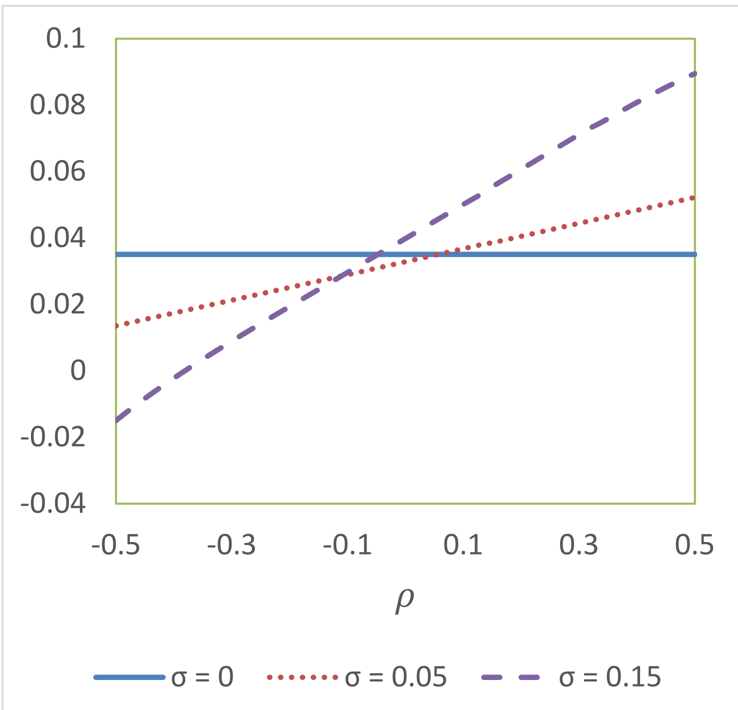


## Figure 2. Numerical Simulation: Trade Liberalization

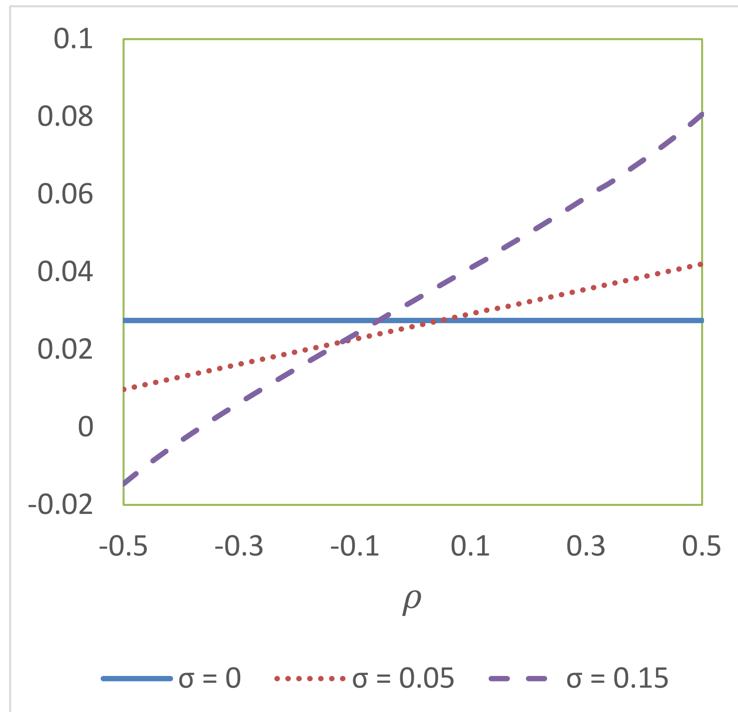
This figure displays numerical simulations for the productivity impact of reducing by 20% bilateral trade costs (Figure A) or unilateral export or import costs (Figure B-C). Each line shows how the predicted change in aggregate productivity, average productivity and the productivity-size covariance on the y-axis varies with the productivity-distortion correlation ρ(φ,η) on the x-axis. Different lines correspond to the case of no misallocation (standard deviation of distortions $\sigma_\eta$=0) and two cases of misallocation ($\sigma_\eta$={0.05,0.15}). All other parameter values are described in the text.

**Figure 2A. Bilateral Trade Liberalization**

**(log) Aggregate Productivity**




**(log) Average Productivity**




**Productivity-Size Covariance**

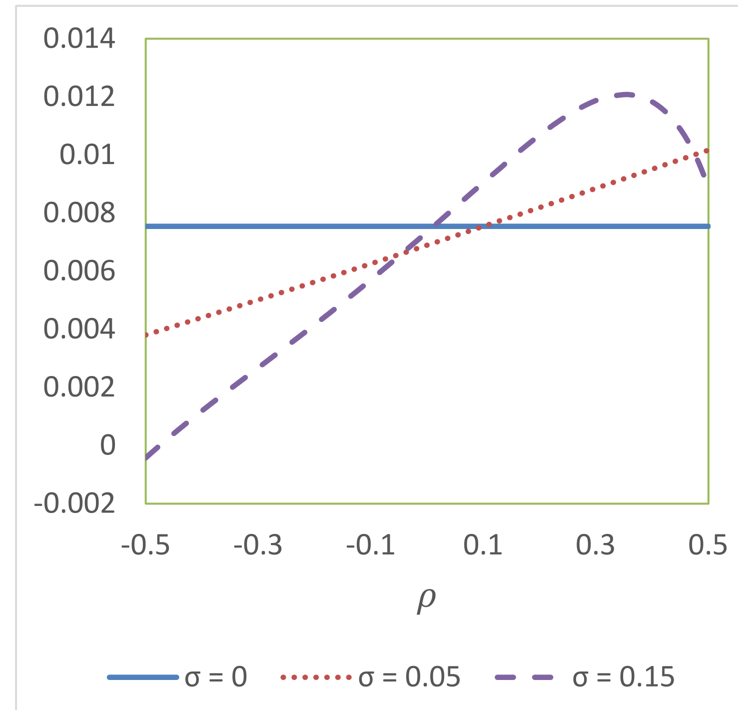


**Figure 2. Numerical Simulation: Trade Liberalization (cont.)**

This figure displays numerical simulations for the productivity impact of reducing by 20% bilateral trade costs (Figure A) or unilateral export or import costs (Figure B-C). Each line shows how the predicted change in aggregate productivity, average productivity and the productivity-size covariance on the y-axis varies with the productivity-distortion correlation ρ(φ,η) on the x-axis. Different lines correspond to the case of no misallocation (standard deviation of distortions $\sigma_\eta$=0) and two cases of misallocation ($\sigma_\eta$={0.05,0.15}). All other parameter values are described in the text.

**Figure 2B. Unilateral Export Liberalization**

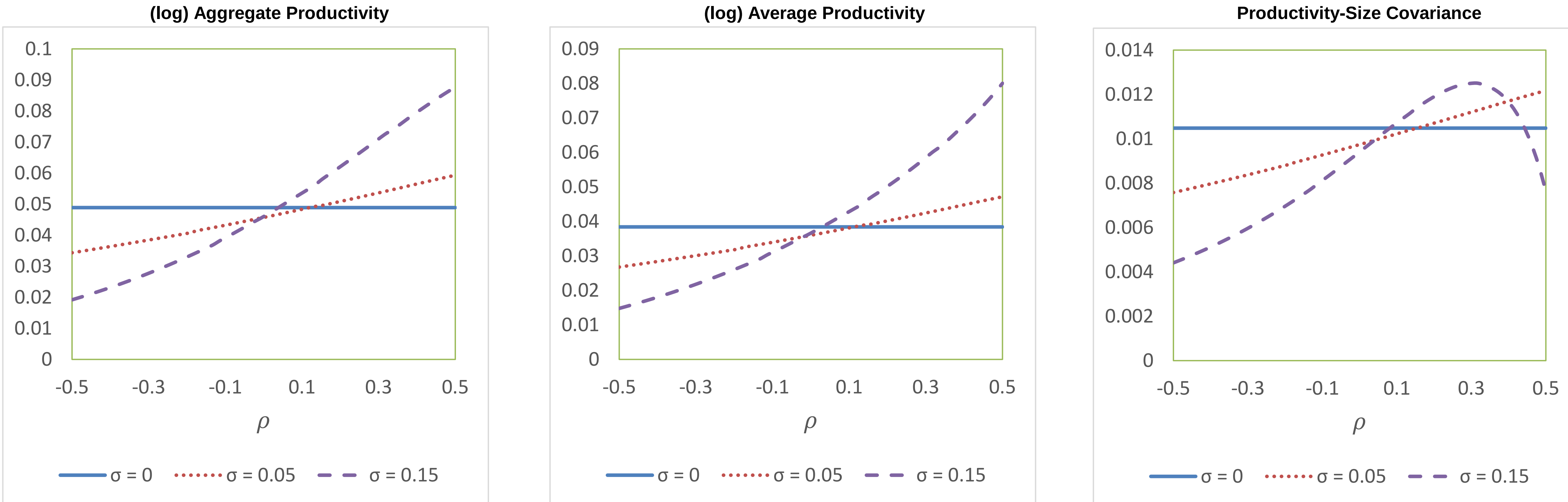
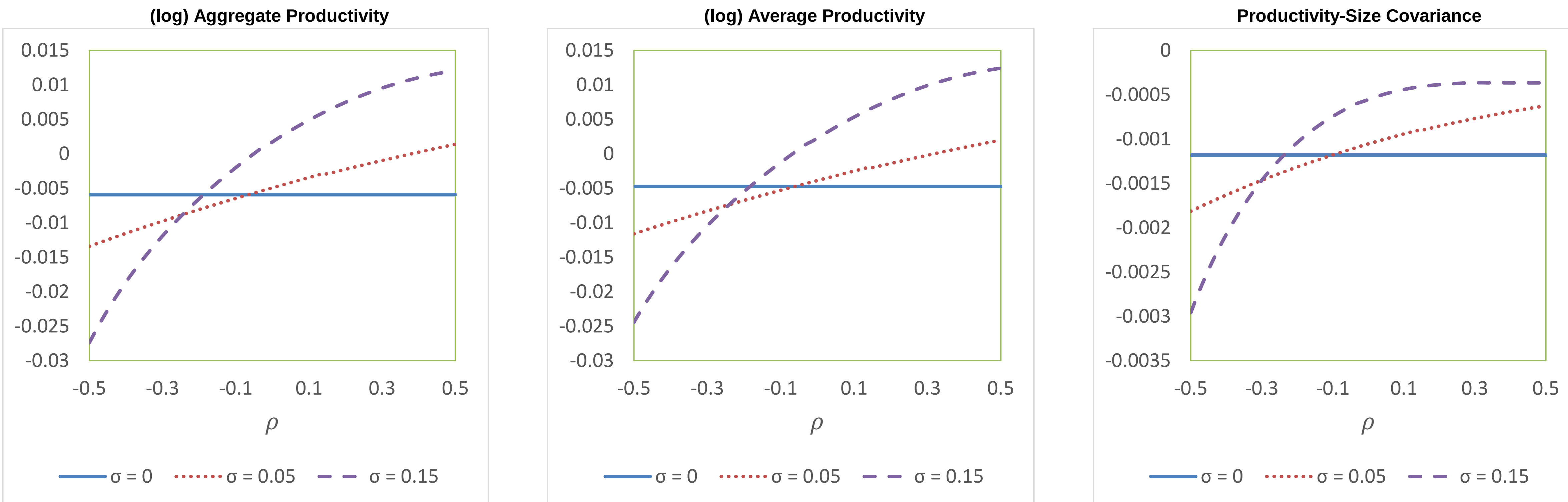


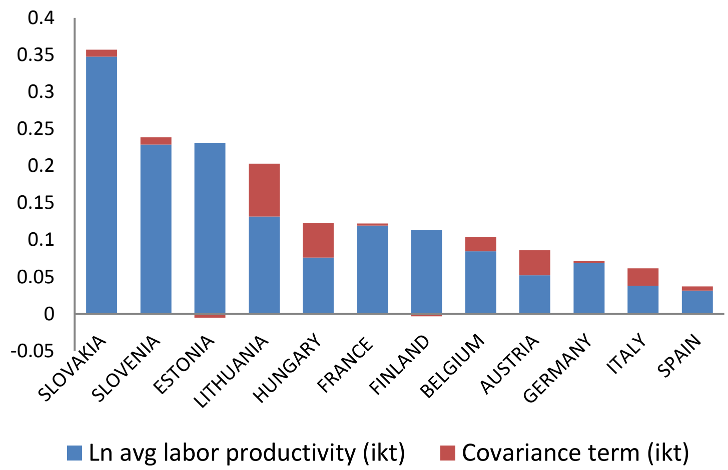

**Figure 2C. Unilateral Import Liberalization**



## Figure 3. Sources of Productivity Growth

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

### Figure 3A. Growth 2003-2007




### Figure 3B. Growth 2008-2011

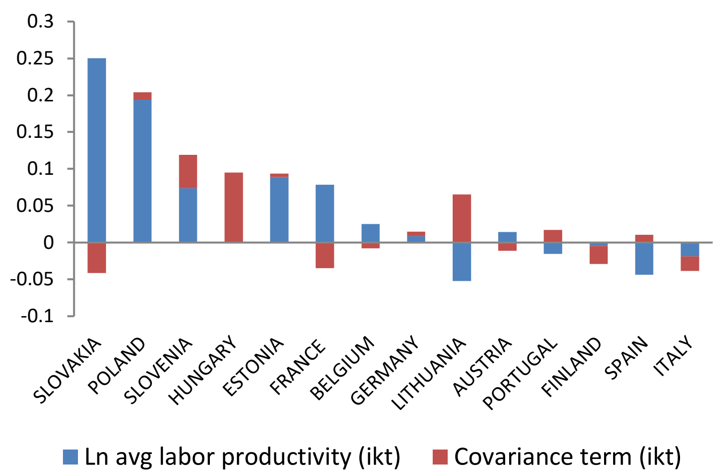


**Figure 4. Trade Exposure Over Time**

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 A covers all countries, while Figures B and C distinguish between EU-15 countries and new EU member states.

**Figure 4A. All Countries**

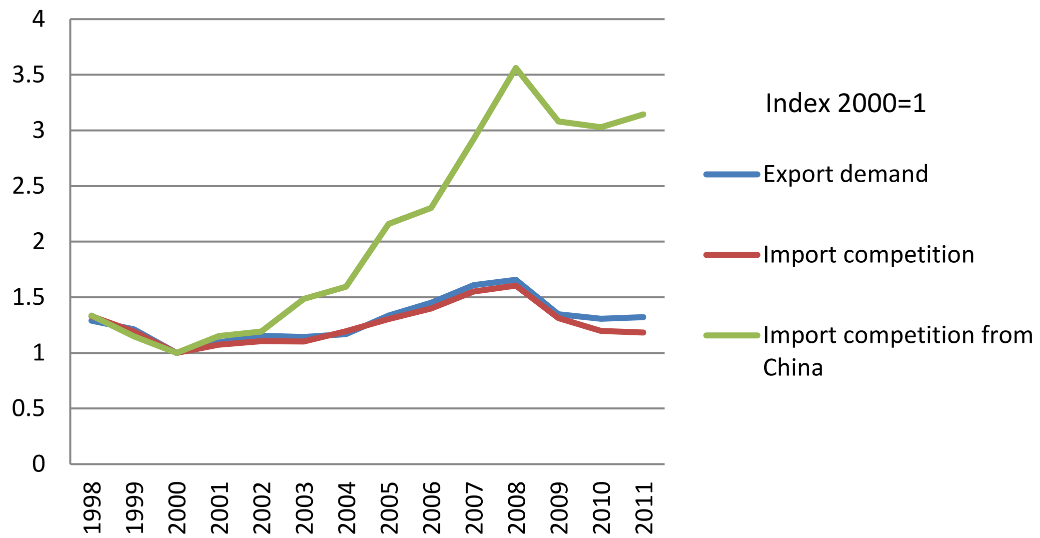



**Figure 4B. New Member States**

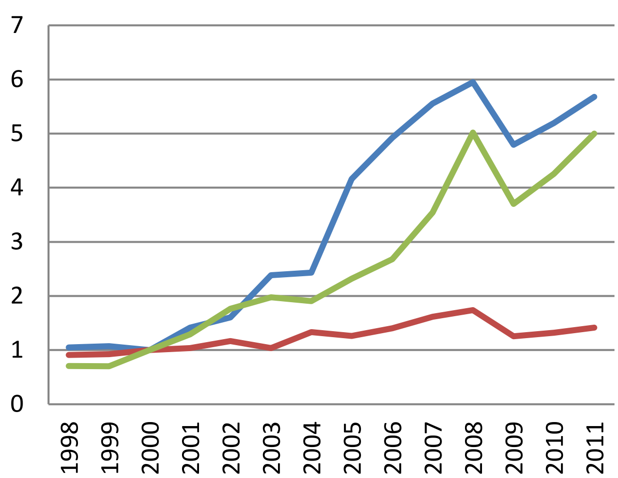



**Figure 4C. EU-15 Countries**

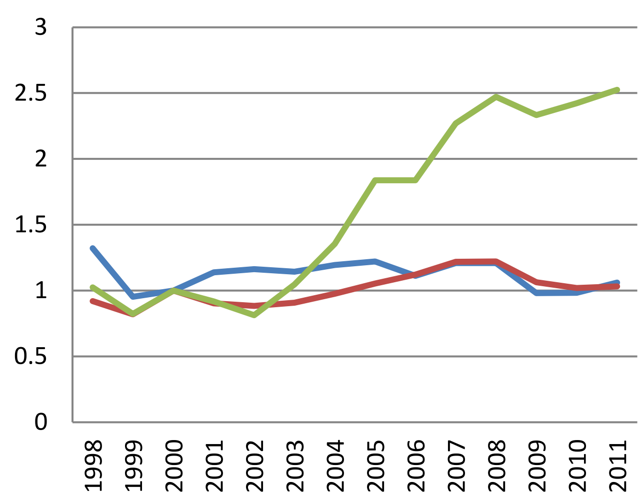
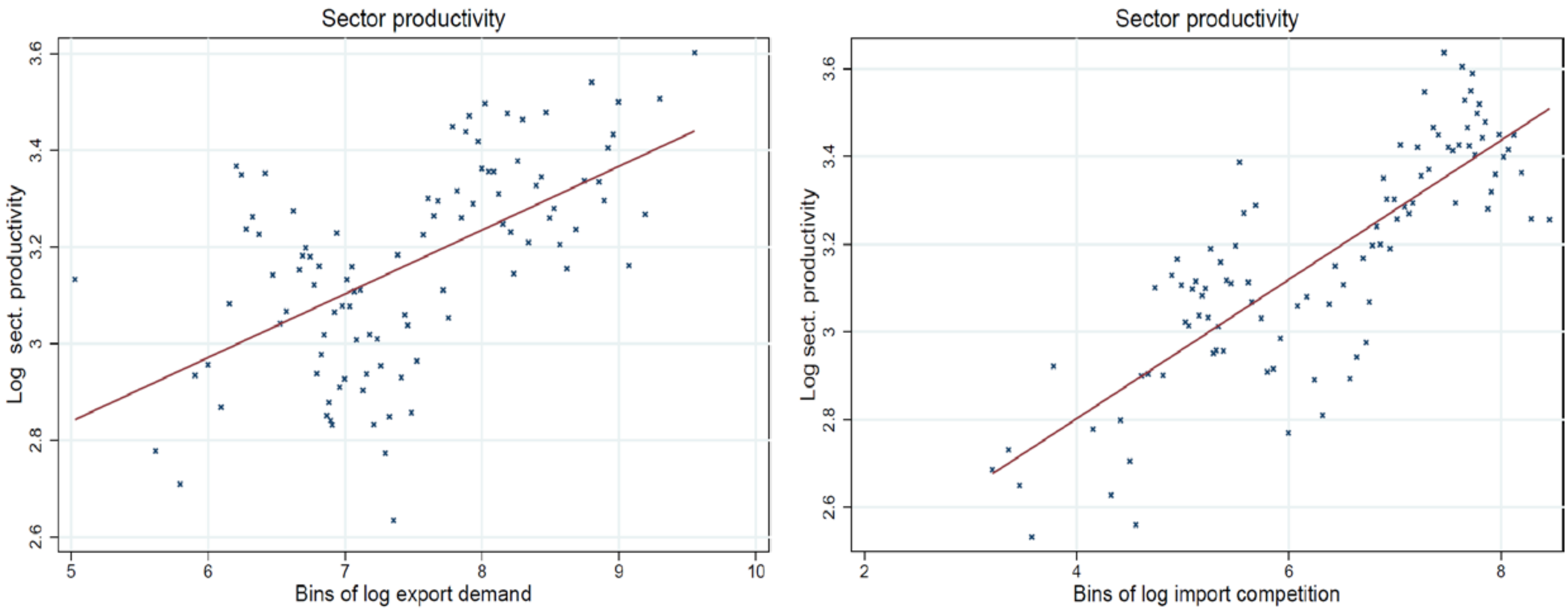


**Figure 5. Trade Exposure and Aggregate Productivity**

These bin scatters display the raw correlation of aggregate productivity with export and import activity across 100 bins in the panel. Each point represents average values across country-sector-year triplets within a percentile bin, after demeaning by country-year fixed



# Trade, Productivity and (Mis)allocation: Appendix

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**Abstract**

This Appendix complements Section 2 Theoretical Framework in the main paper. It provides a more detailed exposition of the model and formal proofs for all lemmas and propositions, but moves quickly over standard theoretical features discussed in the main paper.

Appendix Section 1 corresponds to Sections 2.1 and 2.2 in the paper. It introduces three model set-ups (efficient allocation and flexible wages, efficient allocation and fixed wages, and resource misallocation), derives firms' optimal behavior, describes the general equilibrium, and proves Lemma 1. Appendix Section 2 corresponds to Section 2.3 in the paper. It develops a mapping between theoretical concepts and empirical measures of productivity and welfare, and proves Lemma 2. Appendix Section 3 corresponds to Section 2.4 in the paper. It examines the impact of trade liberalization, and proves Propositions 1-3.

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# 1 Theoretical Framework: Three Model Set-ups

This section characterizes firm behavior and the general equilibrium in three versions of a heterogeneous-firm trade model with two countries.

The first subsection considers a single-sector model with optimal resource allocation, in which trade balance holds at the equilibrium and wages adjust in response to trade shocks. This set-up has been analyzed by Melitz (2003), Arkolakis et al (2012), and Demidova and Rodriguez-Clare (2013), among others.

The second subsection examines a two-sector model with optimal resource allocation, in which one sector produces a freely-traded, constant-returns-to-scale homogeneous good that fixes the wage.[1] This environment has been studied by Chaney (2008) and Demidova (2008).

The third subsection presents a model with resource misallocation, where firm-specific "wedges" lead firms to deviate from the socially optimal levels of production and exporting. This approach to modeling misallocation in the macro literature follows Hsieh and Klenow (2009) and Bartelsman et al (2013).

## 1.1 Efficient allocation and flexible wages

### 1.1.1 Set up and firm behavior

Country $j$ has a mass $L_j$ of consumers with CES preferences and utility

$$U_j = Q_j \equiv \left[ \int_{z \in \Omega_j} q_j(z)^{\alpha} \, dz \right]^{1/\alpha} \tag{1.1}$$

where $\Omega_j$ is the set of varieties available in country $j$, $q_j(z)$ is the quantity of variety $z$ consumed there, and $\sigma \equiv 1/(1-\alpha) > 1$ is the elasticity of substitution across varieties.

Country $i$ has a mass of firms $M_i$ that use labor to produce horizontally differentiated varieties. Entrepreneurs have to pay a sunk cost $w_i f_i^E$ to draw productivity $\varphi > 0$ from the Pareto distribution:

$$G_i(\varphi) = 1 - \left( \frac{\varphi_i^m}{\varphi} \right)^{\theta}, \quad \theta > \sigma - 1, \quad \varphi_i^m > 0. \tag{1.2}$$

A firm in country $i$ with productivity $\varphi$ needs to use $l_{ij}(q;\varphi)$ units of domestic labor to produce and deliver $q$ units to market $j$, where

$$l_{ij}(q;\varphi) = f_{ij} + \frac{\tau_{ij} q}{\varphi}. \tag{1.3}$$

Here, $f_{ij} > 0$ represents the fixed overhead cost associated with sales to market $j$ in units of labor, and $\tau_{ij} \geq 1$ represents the iceberg cost associated with delivery from $i$ to $j$, with the normalization $\tau_{ii} = 1$. Each consumer provides a unit of labor inelastically.

The market is characterized by monopolistic competition with free entry. Firms' profit maximization problem can be separately solved for each destination. Profits from sales to market $j$ are

$$\pi_{ij}(\varphi) = \max_{p,q} \; pq - w_i l_{ij}(q;\varphi) \tag{1.4}$$

[1] Since mark-ups will be 0 in the homogenous-good sector and positive in the differentiated-good sector, there is in principle a sub-optimal allocation of market shares across sectors. We abstract away from this dimension of misallocation to focus on distortions in the allocation of productive resources across heterogeneous firms in the differentiated sector.

where $q_j(z) = E_j P_j^{\sigma-1} p_j(z)^{-\sigma}$ is demand by country $j$ consumers, $E_j$ is aggregate expenditure in country $j$, $P_j \equiv \left[\int_{z\in\Omega_i} p_i(z)^{1-\sigma}\, dz\right]^{1/(1-\sigma)}$ is the consumer price index in country $j$, and $w_i$ is the wage rate in country $i$. Firms' profit-maximizing quantity, price, revenues, costs and profits are then:

$$
\begin{aligned}
q_{ij}(\varphi) &= E_j P_j^{\sigma-1}\left(\frac{\alpha\varphi}{w_i\tau_{ij}}\right)^{\sigma}, \\
p_{ij}(\varphi) &= \frac{w_i\tau_{ij}}{\alpha\varphi}, \\
r_{ij}(\varphi) &\equiv p_{ij}(\varphi)q_{ij}(\varphi) = E_j P_j^{\sigma-1}\left(\frac{\alpha\varphi}{w_i\tau_{ij}}\right)^{\sigma-1}, \\
c_{ij}(\varphi) &\equiv w_i l_{ij}(q_{ij}(\varphi);\varphi) = \alpha r_{ij}(\varphi) + w_i f_{ij}, \\
\pi_{ij}(\varphi) &= \frac{r_{ij}(\varphi)}{\sigma} - w_i f_{ij}.
\end{aligned}
$$

Since profits are monotonically increasing in productivity, firms in country $i$ sell in market $j$ only if their productivity exceeds a certain threshold but not if $\pi_{ij}(\varphi) < 0$.

### 1.1.2 Equilibrium

Define the equilibrium as the set of cutoff productivity levels $\{\varphi_{ij}^*\}$, mass of firms $\{M_i\}$, wages $\{w_i\}$, price indices $\{P_i\}$, and expenditures $\{E_i\}$ that satisfy a system of equilibirum conditions for the zero-profit productivity cut-off, labor market clearing, free entry, price index, and income-expenditure balance.

The zero profit condition states that a firm with productivity $\varphi$ in country $i$ serves market $j$ if and only if $\varphi \geq \varphi_{ij}^*$, where $\pi_{ij}(\varphi_{ij}^*) = 0$. This condition implies that:

$$\varphi_{ij}^* = \left(\frac{\sigma w_i f_{ij}}{E_j}\right)^{\frac{1}{\sigma-1}}\left(\frac{w_i\tau_{ij}}{\alpha P_j}\right). \tag{1.5}$$

The free entry condition requires that ex ante expected profits from entry equal the cost of entry, that is $\sum_j \mathbf{E}_i\left[\pi_{ij}(\varphi)\mathbf{I}(\varphi \geq \varphi_{ij}^*)\right] = w_i f_i^E$, where $\mathbf{E}_i[\cdot]$ is the expectation operator and $\mathbf{I}(\cdot)$ is the indicator function. Under Pareto distributed productivity, this condition can be expressed as:

$$f_i^E = \frac{\sigma-1}{\theta-(\sigma-1)}(\varphi_i^m)^{\theta}\sum_j f_{ij}(\varphi_{ij}^*)^{-\theta}. \tag{1.6}$$

Labor market clearing requires that total labor supplied $L_i$ equal total labor employed in entry and production, $M_i f_i^E + M_i\left(\sum_j \mathbf{E}_i\left[l_{ij}(\varphi)\mathbf{I}(\varphi \geq \varphi_{ij}^*)\right]\right)$. Under Pareto, this condition simplifies to:

$$L_i = \frac{\sigma\theta}{\theta-(\sigma-1)}M_i(\varphi_i^m)^{\theta}\sum_j f_{ij}(\varphi_{ij}^*)^{-\theta} = \frac{\sigma\theta}{\sigma-1}M_i f_i^E, \tag{1.7}$$

where the second equality holds under the free entry condition (1.6). In particular, the mass of entrants in each country is invariant to trade costs:

$$M_i = \left(\frac{\sigma-1}{\sigma\theta}\right)\frac{L_i}{f_i^E}. \tag{1.8}$$

Since all firms with productivity $\varphi$ charge the same price to a given destination, the consumer price index can be expressed in terms of $p_{ij}(\varphi)$ rather than $p_j(z)$. That is, $P_j^{1-\sigma} = \sum_i M_i \mathbf{E}\left[p_{ij}(\varphi)^{1-\sigma}\mathbf{I}(\varphi \geq \varphi_{ij}^*)\right]$. Under Pareto, this becomes:

$$P_j^{1-\sigma} = \frac{\theta}{\theta - (\sigma - 1)} \sum_i M_i \left(\frac{w_i \tau_{ij}}{\alpha}\right)^{1-\sigma} (\varphi_{ij}^*)^{\sigma-1-\theta}(\varphi_i^m)^{\theta}. \tag{1.9}$$

Finally, the income-expenditure balance requires that aggregate consumer expenditure equal aggregate earnings in each country:

$$E_j = P_j Q_j = w_j L_j. \tag{1.10}$$

Note that this condition implies balanced international trade. To see this, let $X_{ij}$ denote aggregate sales from $i$ to $j$. Then $X_{ij} = \frac{\sigma\theta}{\theta-(\sigma-1)} M_i w_i f_{ij} \left(\frac{\varphi_i^m}{\varphi_{ij}^*}\right)^{\theta}$, so that $\sum_j X_{ij} = \frac{\sigma\theta}{\theta-(\sigma-1)} M_i w_i (\varphi_i^m)^{\theta} \sum_j f_{ij}(\varphi_{ij}^*)^{-\theta} = w_i L_i = E_i$, where the second equality follows from (1.7) and the last equality follows from (1.10). Since aggregate expenditure satisfies $E_j = \sum_i X_{ij}$, trade balance will hold for each country $k$:

$$\sum_j X_{kj} = \sum_i X_{ik}. \tag{1.11}$$

The model does not guarantee $\varphi_{ii}^* \leq \varphi_{ij}^*$ for all possible parameters. To be consistent with the empirical evidence of selection into exporting, we restrict the parameter space so that $\varphi_{ii}^* \leq \varphi_{ij}^*$ holds. This requires fixed and variable export cost to be sufficiently high.

### 1.1.3 Welfare

Define welfare as real consumption per capita:

$$W_i \equiv \frac{Q_i}{L_i} = \frac{E_i}{P_i L_i} = \frac{w_i}{P_i} = \alpha \left(\frac{L_i}{\sigma f_{ii}}\right)^{\frac{1}{\sigma-1}} \varphi_{ii}^*, \tag{1.12}$$

where the first equality follows from the CES aggregation $E_i = Q_i P_i$, the second equality follows from the income-expenditure balance (1.10), and the last equality follows from the zero-profit condition (1.5).

A direct implication of (1.12) will be that any trade cost shock that increases the domestic productivity cut-off $\varphi_{ii}^*$ will improve aggregate welfare. Likewise, any trade shock that reduces the expenditure share on domestic varieties will increase welfare, as ACR (2012) have shown. Since trade balance holds within the single differentiated-good sector, this will occur both due to trade shocks that increase the share of exports in total domestic production and due to trade shocks that increase the share of imports in total domestic consumption.[2]

[2] Let $\lambda_k$ denote country $k$'s expenditure share on domestic goods, which under balanced trade is equal to the share of the domestic market in domestic firms' total sales:

$$\lambda_k = \frac{X_{kk}}{\sum_i X_{ik}} = \frac{X_{kk}}{\sum_j X_{kj}} = \frac{\sigma - 1}{\theta - (\sigma - 1)} \frac{f_{kk}}{f_k^E} \left(\frac{\varphi_k^m}{\varphi_{kk}^*}\right)^{\theta}.$$

Hence,

$$d \log W_k = -\frac{1}{\theta} d \log \lambda_k.$$

In other words, any foreign supply or demand shock and any trade cost shock that increases the export sales share (which, under the model assumptions, must also increase the import consumption share) will improve welfare.

## 1.2 Efficient allocation and fixed wages

In the single-sector model, a unilateral reduction in export costs has the same effects as a unilateral reduction in import costs due to the equilibrium condition (1.11) that trade be balanced in the differentiated-good sector. One way to allow for asymmetric effects is to relax the balanced trade condition by introducing multiple sectors.

We introduce an "outside" sector that produces freely traded homogeneous goods. A unilateral export liberalization in the differentiated sector can and will now have opposite effects to a unilateral import liberalization. Intuitively, when the home country export cost goes down, home exports more. This increases competition in the foreign country, discouraging entry by foreign firms and reducing foreign's exports to home. The resulting imbalance between home's imports and exports of differentited goods can be maintained as the foreign country can specialize in the outside sector.

### 1.2.1 Set up and firm behavior

Country $j$ has a mass $L_j$ of consumers with nested utility:

$$U_j = H_j^{1-\beta} Q_j^{\beta},$$

where $H_j$ is the quantity of the homogeneous good consumed and $Q_j$ is as in (1.1). A unit of labor produces $w_i$ units of the homogeneous good in country $i$, which is freely traded and chosen as the numeraire. The labor market is competitive and labor is mobile across sectors, so the wage in country $i$ is $w_i$. The aggregate price index is now $P_i = P_{iQ}^{\beta}$, where $P_{iQ}$ is the differentiated-good sector price index.

The market for differentiated goods is characterized by monopolistic competition with production and trade technology as before. The firm's profit maximization problem therefore delivers the same first-best solution as above, adjusted for the share of aggregate expenditure $\beta E_j$ and the price index $P_{iQ}$ relevant for the differentiated sector:

$$\begin{aligned}
q_{ij}(\varphi) &= \beta E_j P_{jQ}^{\sigma-1} \left(\frac{\alpha\varphi}{w_i \tau_{ij}}\right)^{\sigma}, \\
p_{ij}(\varphi) &= \frac{w_i \tau_{ij}}{\alpha\varphi}, \\
r_{ij}(\varphi) &\equiv p_{ij}(\varphi) q_{ij}(\varphi) = \beta E_j \left(P_{jQ}\right)^{\sigma-1} \left(\frac{\alpha\varphi}{w_i \tau_{ij}}\right)^{\sigma-1}, \\
c_{ij}(\varphi) &\equiv w_i l_{ij}(q_{ij}(\varphi);\varphi) = \alpha r_{ij}(\varphi) + w_i f_{ij}, \\
\pi_{ij}(\varphi) &= \frac{r_{ij}(\varphi)}{\sigma} - w_i f_{ij}.
\end{aligned}$$

### 1.2.2 Equilibrium

The equilibrium cutoffs $\{\varphi_{ij}^*\}$, mass of firms $\{M_i\}$, price indices $\{P_i, P_{iQ}\}$, and aggregate expenditures $\{E_i\}$ are determined by the conditions above for zero cut-off profits (1.5), free entry (1.6), and income-expenditure balance (1.10), along with a modified expression for the price index:

$$P_{jQ}^{1-\sigma} = \frac{\theta}{\theta-(\sigma-1)} \sum_i M_i \left(\frac{w_i \tau_{ij}}{\alpha}\right)^{1-\sigma} (\varphi_{ij}^*)^{\sigma-1-\theta} (\varphi_i^m)^{\theta}, \tag{1.13}$$

Note that the earlier labor market clearing condition (1.7) no longer binds and is therefore excluded from the current equilibrium. In other words, the quantity of labor demanded by the differentiated goods sector (the right-hand side of (1.7)) is strictly less than the quantity of labor available, $L_i$. The residual labor is used in the production of the homogeneous good.

The equilibrium conditions here assume imperfect specialization. Under sufficiently strong asymmetry, one country may completely specialize in the differentiated goods sector. In that case the mass of firms in the other country will be zero, and the specialized country's cutoffs and mass of firms will be determined by the free entry condition and consumers' budget constraint.

### 1.2.3 Welfare

Aggregate welfare can be expressed as:

$$W_i \equiv \frac{U_i}{L_i} = (1-\beta)^{1-\beta}\beta^{\beta}\frac{w_i}{P_{iQ}^{\beta}} = ((1-\beta)w_i)^{1-\beta}\left(\alpha\beta\left(\frac{L_i}{\sigma f_{ii}}\right)^{\frac{1}{\sigma-1}}\varphi_{ii}^{*}\right)^{\beta}. \tag{1.14}$$

Thus $\varphi_{ii}^{*}$ is still a sufficient statistic for welfare, and aggregate welfare increases with the domestic productivity cut-off. Unlike the case of the single-sector model above, however, trade balance no longer holds within the differentiated-good sector. As a result, trade shocks that increase the share of exports in total domestic production will increase welfare, but the same need not hold for the share of imports in domestic consumption.[3]

[3] The share of home sales in domestic firms' total sales is still given by:

$$\lambda_k^X \equiv \frac{X_{kk}}{\sum_j X_{kj}} = \frac{\sigma-1}{\theta-(\sigma-1)}\frac{f_{kk}}{f_k^E}\left(\frac{\varphi_k^m}{\varphi_{kk}}\right)^{\theta},$$

so that $d\log W_k = -\frac{\beta}{\theta}d\log\lambda_k^X$. However, the trade balance condition no longer holds within the differentiated sector, such that the share of domestic goods in total domestic consumption is $\lambda_k^M \equiv \frac{X_{kk}}{\sum_i X_{ik}} \neq \lambda_k^X$.

In the case of two countries, one can show that

$$\varphi_{11} = \left(\frac{a_{22}\tilde{f}_1^E - a_{12}\tilde{f}_2^E}{a_{11}a_{22} - a_{12}a_{21}}\right)^{-\frac{1}{\theta}}. \tag{1.15}$$

Therefore, a unilateral import liberalization in country 1 that reduces $f_{21}$ or $\tau_{21}$ and thus increases $a_{21}$ will decrease $\varphi_{11}$ and depress welfare in country 1. On the other hand, a unilateral export liberalization in country 1 that increases $a_{12}$ will raise $\varphi_{11}$ and welfare in country 1, as expected.

This result can be understood as a delocation effect. In the two-country case, the mass of entrants in country 1 is:

$$M_1 = \frac{\tilde{a}_{22}\tilde{\varphi}_{11}^{\theta} - \tilde{a}_{12}\tilde{\varphi}_{22}^{\theta}}{\tilde{a}_{11}\tilde{a}_{22} - \tilde{a}_{12}\tilde{a}_{21}}.$$

A fall in import trade costs — which increases $\tilde{a}_{21}$, decreases $\tilde{\varphi}_{11}$, and increases $\tilde{\varphi}_{22}$ — will reduce $M_1$. This loss of domestic varieties outweighs the gain from foreign varieties and associated price changes, leading to a net decline in welfare.

More generally, one can show that:

$$\lambda_k^M = \frac{\sigma\theta}{\theta-(\sigma-1)}\frac{f_{kk}}{L_k}M_k\left(\frac{\varphi_k^m}{\varphi_{kk}}\right)^{\theta}.$$

Hence, any shock that simultaneously increases the import share in consumption $\lambda_k^M$ and decreases the mass of domestic entrants $M_k$ will necessarily decrease the domestic cutoff $\varphi_{kk}$ and subsequently welfare.

## 1.3 Resource misallocation

We now introduce resource misallocation in the standard heterogeneous-firm trade model. We consider the case of an outside sector to allow unilateral export and import liberalizations to have asymmetric effects. The equilibrium of the single-sector alternative can be obtained by adjusting the conditions below analogously to the adjustments between Sections 1.1 and 1.2 above.

We introduce firm-specific "wedges" that generate deviations from the socially optimal resource allocation across firms. We refer to these wedges as subsidies, but they capture the net effect of all possible factors that cause a firm to deviate from the first-best levels of production and exporting. Consequently, some firms become larger than optimal while others remain smaller than optimal.

### 1.3.1 Set up

After paying a sunk entry cost of $w_i f_i^E$, each entrant receives two draws, productivity $\varphi > 0$ and production subsidy/tax $\eta > 0$, from a joint distribution $H_i(\varphi, \eta)$. For comparability with the no-misallocation models, we assume $\underline{\varphi}$ is Pareto distributed with scale parameter $\underline{\varphi}_i^m$ and shape parameter $\theta$, which will imply that the observed distribution of firm sales follows Pareto.

Firms' production technology is still characterized by its productivity through (1.3). The subsidy $\eta$ affects only the production cost conditional on the amount of labor used, so that the cost to the firm associated with manufacturing $q$ units is:

$$c_{ij}(q; \varphi, \eta) = w_i \left( f_{ij} + \frac{\tau_{ij} q}{\eta \varphi} \right).$$

This differs from the pre-subsidy cost, i.e. the wage payments received by workers:

$$c'_{ij}(q; \varphi, \eta) = w_i \left( f_{ij} + \frac{\tau_{ij} q}{\varphi} \right).$$

The profits of a firm with productivity $\varphi$ and subsidy $\eta$ in destination market $j$ are therefore:

$$\pi_{ij}(\varphi, \eta) = \max_{p,q} \quad pq - c_{ij}(q; \varphi, \eta). \tag{1.16}$$

Firms' profit-maximizing quantity, price, revenues, costs and profits are then:

$$\begin{aligned}
q_{ij}(\varphi, \eta) &= \beta E_j P_{jQ}^{\sigma-1} \left( \frac{\alpha \varphi \eta}{w_i \tau_{ij}} \right)^{\sigma}, \\
p_{ij}(\varphi, \eta) &= \frac{w_i \tau_{ij}}{\alpha \varphi \eta}, \\
r_{ij}(\varphi, \eta) &\equiv p_{ij}(\varphi, \eta) q_{ij}(\varphi, \eta) = \beta E_j P_{jQ}^{\sigma-1} \left( \frac{w_i \tau_{ij}}{\alpha} \right)^{1-\sigma} (\varphi \eta)^{\sigma-1}, \\
c_{ij}(\varphi, \eta) &\equiv c_{ij}(q_{ij}(\varphi, \eta); \varphi, \eta) = \alpha \eta r_{ij}(\varphi, \eta) + w_i f_{ij}, \\
c'_{ij}(\varphi, \eta) &\equiv c'_{ij}(q_{ij}(\varphi, \eta); \varphi, \eta) = \alpha r_{ij}(\varphi, \eta) + w_i f_{ij}, \\
\pi_{ij}(\varphi, \eta) &= \frac{r_{ij}(\varphi, \eta)}{\sigma} - w_i f_{ij}.
\end{aligned}$$

### 1.3.2 Equilibrium

Define the distorted productivity of a firm as $\underline{\varphi} \equiv \varphi\eta$. Note that firm profits depend on firm characteristics $(\varphi, \eta)$ through and only through distorted productivity $\underline{\varphi}$. In addition, profits are monotonically increasing in $\underline{\varphi}$. This implies that there exists a unique $\underline{\varphi}^*_{ij}$ defined by $\pi_{ij}(\underline{\varphi}^*_{ij}) = 0$, such that all firms with $\underline{\varphi} > \underline{\varphi}^*_{ij}$ can profitably sell to market $j$:

$$\underline{\varphi}^*_{ij} = \left(\frac{\sigma w_i f_{ij}}{\beta E_j}\right)^{\frac{1}{\sigma-1}} \left(\frac{w_i \tau_{ij}}{\alpha P_{jQ}}\right). \tag{1.17}$$

The free entry condition implies that ex ante expected profits equal the sunk cost of entry:

$$f_i^E = \frac{\sigma - 1}{\theta - (\sigma - 1)} \left(\underline{\varphi}_i^m\right)^\theta \sum_j f_{ij} \left(\underline{\varphi}^*_{ij}\right)^{-\theta}. \tag{1.18}$$

Note that (1.17) is equivalent to (1.5) and (1.18) is equivalent to (1.6), with productivity $\varphi$ in the no-misallocation case replaced by distorted productivity $\underline{\varphi}$ in the misallocation case.

The consumer budget constraint, however, is substantially different. Assume that subsidies to firms producing in country $i$ are covered by lump-sum taxation of consumers in $i$. Aggregate income in country $i$ is then total labor income less the aggregate cost of all subsidies:

$$E_i = w_i L_i - T_i \tag{1.19}$$

where

$$T_i \equiv C_i' - C_i = \sum_j M_i w_i f_{ij} (\sigma - 1) \iint_{\varphi\eta \geq \underline{\varphi}^*_{ij}} (\eta - 1) \left(\frac{\varphi\eta}{\underline{\varphi}^*_{ij}}\right)^{\sigma-1} dH_i(\varphi, \eta). \tag{1.20}$$

The equilibrium cut-off profitability levels $\{\underline{\varphi}^*_{ij}\}$ and the mass of firms $\{M_i\}$ are characterized by equations (1.17), (1.18), and (1.19).

### 1.3.3 Welfare

The welfare of country $i$ can be expressed as:

$$W_i = (1-\beta)^{1-\beta} \beta^\beta \frac{E_i}{P_i L_i} = (1-\beta)^{1-\beta} \beta^\beta \left(\frac{w_i}{P_i}\right) \chi_i = ((1-\beta) w_i)^{1-\beta} \left(\alpha\beta \left(\frac{L_i}{\sigma f_{ii}}\right)^{\frac{1}{\sigma-1}} \underline{\varphi}^*_{ii}\right)^\beta \chi_i^{\frac{\beta + (\sigma-1)}{\sigma-1}}, \tag{1.21}$$

where the share of disposable income available to consumers is:

$$\chi_i \equiv \frac{w_i L_i - T_i}{w_i L_i}.$$

From (1.20), the aggregate tax $T_i$ and hence $\chi_i$ depend on the joint distribution of $(\varphi, \eta)$, and cannot be determined from the marginal distribution of $\underline{\varphi}$ alone. The aggregate tax $T_i$ may either increase or decrease in response to a rise in $\underline{\varphi}^*_{ii}$ even when $\underline{\varphi}$ follows Pareto, depending on the joint distribution of $(\varphi, \eta)$. Moreover, a potential increase in $T_i$ can be sufficiently high such that welfare can fall in response to a rise in $\underline{\varphi}^*_{ii}$. This stands in sharp contrast to the no-misallocation model.

### 1.4 Proof of Lemma 1

Equations (1.12), (1.14) and (1.21) imply that aggregate welfare is proportional to the productivity cut-off for domestic production in the absence of misallocation and to the profitability cut-off and the share of disposable income in the presence of misallocation:

$$W_i \propto \left\{ \begin{array}{ll} \left(\frac{L_i}{\sigma f_{ii}}\right)^{\frac{\beta}{\sigma-1}} (\varphi_{ii}^*)^\beta & \text{without misallocation} \\ \left(\frac{L_i}{\sigma f_{ii}}\right)^{\frac{\beta}{\sigma-1}} (\chi_i)^{\frac{\beta+\sigma-1}{\sigma-1}} (\underline{\varphi}_{ii}^*)^\beta & \text{with misallocation} \end{array} \right\}. \tag{1.22}$$

The proves Lemma 1 as stated in the paper:

**Lemma 1** *Without misallocation, welfare increases with the domestic productivity cut-off,* $\frac{dW_i}{d\varphi_{ii}^*} > 0$*. With misallocation, welfare increases with the distorted domestic productivity cut-off (holding* $\chi_i$ *fixed),* $\frac{\partial W_i}{\partial \underline{\varphi}_{ii}^*} > 0$*, and with the share of disposable income in gross income (holding* $\underline{\varphi}_{ii}^*$ *fixed),* $\frac{\partial W_i}{\partial \chi_i} > 0$*.*

## 2 From Theory to Empirics

We now consider the relationship between the theoretical concepts of welfare, firm productivity, and aggregate productivity and their empirical counterparts that can be measured in the data. For the case of real value added per worker, we establish that the measured aggregate productivity of domestic firms is proportional to welfare in the absence of misallocation, but not in the presence of misallocation.

### 2.1 Theoretical and measured firm productivity

In Section 2.3 of the paper, we introduce real value added per worker $\Phi_i(\varphi)$ as the empirical counterpart to firm productivity in the model $\varphi$. Observed value added corresponds to total firm revenues from domestic sales and any exports, $r_i(\varphi) = \sum_j r_{ij}(\varphi)\mathbf{I}(\varphi \geq \varphi_{ij}^*)$. Observed employment represents the total amount of labor that a firm hires to produce for home and abroad, $l_i(\varphi) = \sum_j l_{ij}(\varphi)\mathbf{I}(\varphi \geq \varphi_{ij}^*)$. Denoting labor used towards fixed overhead and export costs as $f_i(\varphi) = \sum_j f_{ij}\mathbf{I}(\varphi \geq \varphi_{ij}^*)$ and normalizing by the consumer price index in the differentiated industry $P_{iQ} = P_i^{1/\beta}$, measured firm productivity is given by:

$$\Phi_i(\varphi) = \frac{r_i(\varphi)}{P_i^{1/\beta} l_i(\varphi)} = \frac{w_i}{\alpha P_i^{1/\beta}} \left[1 - \frac{f_i(\varphi)}{l_i(\varphi)}\right]. \tag{2.1}$$

In Section 2.3 of the paper, we claim that measured productivity $\Phi_i(\varphi)$ is monotonically increasing in theoretical productivity $\varphi$ conditional on export status, i.e. $\Phi_i'(\varphi|\varphi < \varphi_{ij}^*) > 0$ and $\Phi_i'(\varphi|\varphi \geq \varphi_{ij}^*) > 0$. From equation (2.1), it is sufficient to show that $l_{ii}(\varphi)$ and $l_{ii}(\varphi) + l_{ij}(\varphi)$ are increasing in $\varphi$. The latter follows from the firm's maximization problem since $l_{ii}(\varphi) = f_{ii} + \beta E_i P_{iQ}^{\sigma-1} \left(\frac{\alpha}{w_i}\right)^\sigma \varphi^{\sigma-1}$ and $l_{ii}(\varphi) + l_{ij}(\varphi) = (f_{ii} + f_{ij}) + \beta \left(E_i P_{iQ}^{\sigma-1} + E_j P_{jQ}^{\sigma-1} \tau_{ij}^{1-\sigma}\right) \varphi^{\sigma-1}$, both of which are increasing in $\varphi$.

In the case of misallocation, there is an analogous relationship between theoretical and observed distorted productivity, $\underline{\varphi} = \varphi\eta$ and $\underline{\Phi}_i(\varphi, \eta)$. Now measured firm productivity is monotonically increasing in distorted productivity conditional on export status.

$$\underline{\Phi}_i(\varphi,\eta) = \frac{r_i(\varphi,\eta)}{P_i^{1/\beta} l_i(\varphi,\eta)} = \frac{w_i}{\alpha P_i^{1/\beta}\eta}\left[1 - \frac{f_i(\varphi,\eta)}{l_i(\varphi,\eta)}\right]. \tag{2.2}$$

## 2.2 Theoretical and measured aggregate productivity

In Section 2.3 of the paper, we define measured aggregate productivity in the differentiated-good sector:

$$\tilde{\Phi}_i = \begin{cases} \int_{\varphi_{ii}^*}^{\infty} \theta_i(\varphi)\Phi_i(\varphi)\,\frac{dG_i(\varphi)}{1-G_i(\varphi_{ii}^*)} & \text{without misallocation} \\ \int_{\underline{\varphi}_{ii}^*}^{\infty} \theta_i(\varphi,\eta)\Phi_i(\varphi,\eta)\,\frac{dG_i(\varphi,\eta)}{1-G_i(\underline{\varphi}_{ii}^*)} & \text{with misallocation} \end{cases}, \tag{2.3}$$

where $\theta_i(\varphi) = l_i(\varphi)/\left[\int_{\varphi_{ii}^*}^{\infty} l_i(\varphi)\,\frac{dG_i(\varphi)}{1-G_i(\varphi_{ii}^*)}\right]$ and $\theta_i(\varphi,\eta) = l_i(\varphi,\eta)/\left[\int_{\underline{\varphi}_{ii}^*}^{\infty} l_i(\varphi,\eta)\,\frac{dG_i(\varphi,\eta)}{1-G_i(\underline{\varphi}_{ii}^*)}\right]$ are a firm's share of aggregate employment.[4]

In Section 2.3, we claim that $\tilde{\Phi}_i$ can be expressed as:

$$\tilde{\Phi}_i = \begin{cases} \frac{\sigma\theta}{\sigma\theta-(\sigma-1)}\frac{w_i}{P_i^{1/\beta}} & \text{without misallocation} \\ \frac{\sigma\theta}{(\sigma-1)\theta\tilde{\eta}_i+\theta-(\sigma-1)}\frac{w_i}{P_i^{1/\beta}} & \text{with misallocation} \end{cases}, \tag{2.4}$$

$$\text{where } \tilde{\eta}_i = \frac{\sum_j \mathbf{E}_i\left[\eta r_{ij}(\varphi,\eta)\mathbf{I}(\varphi\eta \geq \underline{\varphi}_{ij}^*)\right]}{\sum_j \mathbf{E}_i\left[r_{ij}(\varphi,\eta)\mathbf{I}(\varphi\eta \geq \underline{\varphi}_{ij}^*)\right]}. \tag{2.5}$$

In the case of misallocation, aggregate productivity is adjusted for the inefficient allocation of productive resources across firms. The scaling factor $\tilde{\eta}_i$ represents the size-weighted average distortion $\eta$ to true firm productivity $\varphi$. When there is no misallocation, $\eta = 1$ for all firms and $\tilde{\eta}_i = 1$ drops out.

Since the expression for $\tilde{\Phi}_i$ without misallocation follows directly from that with misallocation, we derive it explicitly for the case of misallocation. The derivation for the case without misallocation is equivalent after replacing $\varphi$ with $\varphi\eta$.

From the definitions of $\Phi_i(\cdot)$ and $\theta_i(\cdot)$, aggregate productivity can be written as:

$$\tilde{\Phi}_i = \frac{\sum_j \mathbf{E}_i\left[r_{ij}(\varphi,\eta)\mathbf{I}(\varphi\eta \geq \underline{\varphi}_{ij}^*)\right]}{\sum_j \mathbf{E}_i\left[w_i l_{ij}(\varphi,\eta)\mathbf{I}(\varphi\eta \geq \underline{\varphi}_{ij}^*)\right]}\frac{w_i}{P_i^{1/\beta}}.$$

Since $r_{ij}(\varphi,\eta) = \left(\frac{\varphi\eta}{\underline{\varphi}_{ij}^*}\right)^{\sigma-1}\sigma w_i f_{ij}$, $w_i l_{ij}(\varphi,\eta) = \frac{\sigma-1}{\sigma}\eta r_{ij}(\varphi,\eta) + f_{ij}$, and $\varphi\eta$ is distributed Pareto with parameters $\varphi_i^m$ and $\theta > \sigma - 1$, the ex-ante expected average sales and wagebill can be expressed as:

$$\sum_j \mathbf{E}_i\left[r_{ij}(\varphi,\eta)\mathbf{I}(\varphi\eta \geq \underline{\varphi}_{ij}^*)\right] = \frac{\sigma\theta}{\theta-(\sigma-1)}\sum_j w_i f_{ij}\mathbf{E}_i\left[\mathbf{I}(\varphi\eta \geq \underline{\varphi}_{ij}^*)\right]$$

and

$$\begin{aligned}\sum_j \mathbf{E}_i\left[w_i l_{ij}(\varphi,\eta)\mathbf{I}(\varphi\eta \geq \underline{\varphi}_{ij}^*)\right] &= \frac{\sigma-1}{\sigma}\tilde{\eta}_i\sum_j \mathbf{E}_i\left[r_{ij}(\varphi,\eta)\mathbf{I}(\varphi\eta \geq \underline{\varphi}_{ij}^*)\right] + \sum_j w_i f_{ij}\mathbf{E}_i\left[\mathbf{I}(\varphi\eta \geq \underline{\varphi}_{ij}^*)\right] \\ &= \frac{(\sigma-1)\theta\tilde{\eta}_i+\theta-(\sigma-1)}{\sigma\theta}\sum_j \mathbf{E}_i\left[r_{ij}(\varphi,\eta)\mathbf{I}(\varphi\eta \geq \underline{\varphi}_{ij}^*)\right].\end{aligned}$$

[4]In the data, the firm weights are defined such that they sum to 1 across firms. Here, $\theta_i(\varphi)$ and $\theta_i(\varphi,\eta)$ are defined such that they average 1 across firms. This ensures that the residual in the OP decomposition is the covariance of firms' measured productivity and employment share.

Rearranging delivers expression (2.4) for aggregate measured productivity $\tilde{\Phi}_i$.

### 2.3 Proof of Lemma 2

Lemma 2 in the paper states:

**Lemma 2** *Without misallocation, measured aggregate productivity increases with the domestic productivity cut-off,* $\frac{d\tilde{\Phi}_i}{d\varphi^*_{ii}} > 0$. *With misallocation, this relationship becomes ambiguous,* $\frac{d\tilde{\Phi}_i}{d\varphi^*_{ii}} \gtreqless 0$.

This lemma follows directly from Lemma 1 and equations (1.22) and (2.4).

## 3 Trade Liberalization

In this section, we examine the effects of trade liberalization on welfare and aggregate measured productivity in the three model scenarios introduced above. Both import and export liberalization improve a country's welfare and aggregate productivity in a one-sector frictionless economy. In a two-sector frictionless economy by contrast, bilateral and export liberalizations increase welfare and aggregate productivity, while unilateral import liberalization acts in reverse due to a delocation effect. In the presence of resource misallocation, all three types of trade liberalization have ambiguous effects.

### 3.1 Efficient allocation and flexible wages: Proof of Proposition 1

Section 2.4.1 in the paper examines the impact of trade liberalization in the case of efficient resource allocation and no outside sector ($\beta = 1$). Its results are summarized by the following proposition:

**Proposition 1** *Under no misallocation and flexible wages ($\beta = 1$), bilateral and unilateral trade liberalizations (i.e. reduction in $\tau_{ij}$, $\tau_{ji}$, or both $\tau_{ij}$ and $\tau_{ji}$) increase welfare $W_i$ and measured aggregate productivity $\tilde{\Phi}_i$, but have ambiguous effects on average productivity $\overline{\Phi}_i$ and covariance $\ddot{\Phi}_i$.*

**Proof.** The proof of this proposition builds on an intermediate result summarized in the following lemma:

**Appendix Lemma 1** *Under no misallocation and flexible wages ($\beta = 1$), a reduction in the export cost $\tau_{12}$ or in the import cost $\tau_{21}$ increases the domestic productivity cut-off $\varphi^*_{11}$.*

Equilibrium conditions (2.11), (2.12), (2.13), and (2.14) in the paper can be expressed in terms of the model parameters and endogenous variables $\{\varphi^*_{11}, \varphi^*_{12}, \varphi^*_{21}, \varphi^*_{22}, M_1, M_2, w_1, w_2\}$ with the following system of equations:

$$\left(\frac{\varphi_{21}^*}{\varphi_{11}^*}\right)^{\sigma-1} = \tau_{21}^{\sigma-1}\frac{f_{21}}{f_{11}}\left(\frac{w_2}{w_1}\right)^{\sigma}, \tag{3.1}$$

$$\left(\frac{\varphi_{12}^*}{\varphi_{22}^*}\right)^{\sigma-1} = \tau_{12}^{\sigma-1}\frac{f_{12}}{f_{22}}\left(\frac{w_1}{w_2}\right)^{\sigma}, \tag{3.2}$$

$$L_1 = \frac{\sigma\theta}{\sigma-1}M_1 f_1^E, \tag{3.3}$$

$$L_2 = \frac{\sigma\theta}{\sigma-1}M_2 f_2^E, \tag{3.4}$$

$$f_1^E = \frac{\sigma-1}{\theta-(\sigma-1)}(\varphi_1^m)^\theta\left(f_{11}(\varphi_{11}^*)^{-\theta} + f_{12}(\varphi_{12}^*)^{-\theta}\right), \tag{3.5}$$

$$f_2^E = \frac{\sigma-1}{\theta-(\sigma-1)}(\varphi_2^m)^\theta\left(f_{21}(\varphi_{21}^*)^{-\theta} + f_{22}(\varphi_{22}^*)^{-\theta}\right), \tag{3.6}$$

$$M_1 w_1 f_{12}(\varphi_1^m)^\theta(\varphi_{12}^*)^{-\theta} = M_2 w_2 f_{21}(\varphi_2^m)^\theta(\varphi_{21}^*)^{-\theta}. \tag{3.7}$$

Let country 2's labor be the numeraire, such that $w_2 = 1$. The mass of entrants can be determined directly from the labor market clearing conditions (3.3) and (3.4). From the free entry conditions (3.5) and (3.6), $\varphi_{ii}$ can be expressed as a function of $\varphi_{ij}$, denoted $\varphi_{ii} = h_{ii}(\varphi_{ij})$. From the zero cut-off profit conditions (3.1) and (3.2), $\varphi_{ij}$ can in turn be written as a function of $\varphi_{jj}$ and $w_1$, denoted $\varphi_{ij} = k_{ij}(\varphi_{jj}, w_1)$. Thus the system can be reduced to two equations, (3.2) and (3.7), in two unknowns, $\varphi_{12}^*$ and $w_1$.

Equation (3.2) implies a positive relationship between $\varphi_{12}^*$ and $w_1$:

$$\left(\frac{d\varphi_{12}^*}{dw_1}\right) = \frac{\frac{\partial h_{12}}{\partial w_1} + \frac{\partial h_{12}}{\partial \varphi_{22}^*}\frac{\partial k_{22}}{\partial \varphi_{21}^*}\frac{\partial h_{21}}{\partial w_1}}{1 - \frac{\partial h_{12}}{\partial \varphi_{22}^*}\frac{\partial k_{22}}{\partial \varphi_{21}^*}\frac{\partial h_{21}}{\partial \varphi_{11}^*}\frac{\partial k_{11}}{\partial \varphi_{12}^*}} = \frac{\frac{\sigma}{\sigma-1}\frac{\varphi_{12}^*}{w_1}\left(1 + \frac{f_{21}}{f_{22}}\left(\frac{\varphi_{21}^*}{\varphi_{22}^*}\right)^{-\theta}\right)}{1 - (\tau_{12}\tau_{21})^{1-\sigma}\left(\frac{\varphi_{12}^*\varphi_{21}^*}{\varphi_{11}^*\varphi_{22}^*}\right)^{(\sigma-1)-\theta}} > 0.$$

On the other hand, equation (3.7) implies a negative relationship between $\varphi_{12}^*$ and $w_1$.

Rearranging this equation gives:

$$w_1 = \left(\frac{L_2 f_{21} f_1^E \varphi_2^m}{L_1 f_{12} f_2^E \varphi_1^m}\right)\left(\frac{\varphi_{21}^*}{\varphi_{12}^*}\right)^{-\theta}.$$

Substituting for $w_1$ using (3.1) and rearranging,

$$(\varphi_{21}^*)^{\frac{\sigma-1}{\sigma}-\theta} = \left(\frac{L_1 f_{12} f_2^E \varphi_1^m}{L_2 f_{21} f_1^E \varphi_2^m}\right)\tau_{21}^{\frac{\sigma-1}{\sigma}}\left(\frac{f_{21}}{f_{11}}\right)^{\frac{1}{\sigma}}(\varphi_{11}^*)^{\frac{\sigma-1}{\sigma}}(\varphi_{12}^*)^{-\theta}.$$

The left hand side of this equation is decreasing in $\varphi_{21}^*$ because $\theta > \sigma - 1$ and $\sigma > 1$ by assumption. The right hand side is decreasing in $\varphi_{12}^*$, since the free entry condition (3.5) implies that $\varphi_{11}^*$ and $\varphi_{12}^*$ move in opposite directions. Therefore, $\varphi_{12}^*$ and $\varphi_{21}^*$ move in the same direction. Condition (3.1) then implies that $w_1$ and $\varphi_{12}^*$ move in opposite directions: If $w_1$ rises, $\varphi_{21}^*/\varphi_{11}^*$ must fall. Since $\varphi_{11}^*$ and $\varphi_{12}^*$ move in opposite directions but $\varphi_{12}^*$ and $\varphi_{21}^*$ move in the same direction, this can only occur when $\varphi_{21}^*$ and $\varphi_{12}^*$ decrease while $\varphi_{11}^*$ increases.

Therefore, equations (3.2) and (3.7) determine the unique equilibrium $(\varphi_{12}^{*}, w_1)$, as illustrated in Appendix Figure 1.

We next examine the impact of trade liberalization by showing that a reduction in the bilateral trade cost $\tau_{21}$ decreases $\varphi_{12}^{*}$. From the perspective of country 1, this corresponds to an import liberalization. Recall from the free entry condition (3.5) that the productivity cut-offs for production and for exporting, $\varphi_{11}^{*}$ and $\varphi_{12}^{*}$, move in opposite directions. An import reform that reduces the export cut-off $\varphi_{12}^{*}$ would thus increase productivity cut-off $\varphi_{11}^{*}$.

From the perspective of country 2, a fall in $\tau_{21}$ corresponds to an export liberalization. If $\varphi_{12}^{*}$ decreases in response, so would $\varphi_{21}^{*}$, since $\varphi_{12}^{*}$ and $\varphi_{21}^{*}$ move in the same direction as argued above. Given the free entry condition (3.6), an export reform would then raise productivity cut-off $\varphi_{22}^{*}$.

We illustrate the effect of a reduction in $\tau_{21}$ in Appendix Figure 1. This trade cost shock shifts both curves downward. To see this, consider first the curve associated with (3.2). Holding $\varphi_{12}^{*}$ fixed, free entry (3.5) implies that $\varphi_{11}^{*}$ would also be fixed. From equations (3.1) and (3.2), it follows that $\varphi_{12}^{*}\varphi_{21}^{*} = \tau_{12}\tau_{21}\left(\frac{f_{12}f_{21}}{f_{11}f_{22}}\right)^{\frac{1}{\sigma-1}}\varphi_{11}^{*}\varphi_{22}^{*}$. So if $\tau_{21}$ falls, $\varphi_{22}^{*}$ must increase and $\varphi_{21}^{*}$ must decrease. From equation (3.2), $w_1$ would then fall.

Consider next the curve associated with (3.7). Holding $w_1^{*}$ fixed, we now show that $\varphi_{12}^{*}$ would decrease if $\tau_{21}$ falls. Since $\varphi_{12}^{*}$ and $\varphi_{21}^{*}$ move in the same direction, it is sufficient to show that $\varphi_{21}^{*}$ must fall. By way of contradiction, suppose $\varphi_{21}^{*}$ were to increase. Then (3.1) implies that $\varphi_{11}^{*}$ would rise as well. In turn, (3.5) implies that $\varphi_{12}^{*}$ would decrease. But then $\varphi_{21}^{*}$ would have to fall as well, contradicting the initial assumption.

Since both curves shift down with a reduction in $\tau_{21}$, the wage $w_1$ must fall. One can further establish that $\varphi_{12}^{*}$ must also fall. Suppose by way of contradiction that $\varphi_{12}^{*}$ were to rise. Then from (3.2), $\varphi_{22}^{*}$ would have to increase, and from (3.6) $\varphi_{21}^{*}$ would in turn have to fall. This would, however, violate the result above that $\varphi_{12}^{*}$ and $\varphi_{21}^{*}$ must move in the same direction.

This completes the proof of Appendix Lemma 1.■

Equation (2.20) in the paper shows that welfare $W_i$ is proportional to the domestic productivity cut-off $\varphi_{ii}^{*}$, where the scaling constant is invariant to trade costs. Equations (2.20) and (2.25) in the paper imply that measured aggregate productivity $\tilde{\Phi}_i$ is proportional to welfare, where the scaling constant is a function of $\theta$ and $\sigma$ alone. The resutls for $W_i$ and $\tilde{\Phi}_i$ in Proposition 1 therefore follow directly from Appendix Lemma 1.

Unlike $W_i$ and $\tilde{\Phi}_i$, average productivity $\overline{\Phi}_i$ and covariance $\ddot{\Phi}_i$ do not have closed-form analytical solutions in terms of trade costs or productivity cut-offs. However, numerical exercises indicate that they can either rise or fall in response to each trade reform considered at different segments of the parameter space. This supports the ambiguous predictions in Proposition 1. ■

### 3.2 Efficient allocation and fixed wages: Proof of Proposition 2

Section 2.4.1 in the paper examines the impact of trade liberalization in the case of efficient resource allocation and an outside sector ($\beta < 1$). Its results are summarized by the following proposition:

**Proposition 2** *Under no misallocation and fixed wages ($\beta < 1$), bilateral and unilateral export liberalizations (i.e. reduction in $\tau_{ij}$ or both $\tau_{ij}$ and $\tau_{ji}$) increase welfare $W_i$ and measured aggregate productivity $\tilde{\Phi}_i$, but have ambiguous effects on average productivity $\overline{\Phi}_i$ and covariance $\ddot{\Phi}_i$. Unilateral import liberalization (i.e. reduction in $\tau_{ji}$) reduces $W_i$ and $\tilde{\Phi}_i$, but has ambiguous effects on $\overline{\Phi}_i$ and $\ddot{\Phi}_i$.*

**Proof.** The proof of this proposition builds on an intermediate result summarized in the following lemma:

**Appendix Lemma 2** *Under no misallocation and fixed wages ($\beta < 1$), a reduction in the export cost $\tau_{12}$ or in bilateral trade costs $\tau_{12}$ and $\tau_{21}$ increases the domestic productivity cut-off $\varphi_{11}^*$, while a reduction in the import cost $\tau_{21}$ decreases $\varphi_{11}^*$.*

Since wages are fixed, the productivity cut-offs can be determined from the zero cut-off profits and free entry conditions (1.5) and (1.6) alone. Conditions (1.5) for $\varphi_{jj}^*$ and $\varphi_{ij}^*$ imply:

$$\frac{\varphi_{ij}^*}{\varphi_{jj}^*} = d_{ij}, \quad d_{ij} \equiv \left(\frac{w_i f_{ij}}{w_j f_{jj}}\right)^{\frac{1}{\sigma-1}} \left(\frac{w_i \tau_{ij}}{w_j \tau_{jj}}\right),$$

while condition (1.6) can be expressed as:

$$\tilde{f}_i^E = \sum_j a_{ij} (\varphi_{jj}^*)^{-\theta}, \quad \text{where} \qquad \tilde{f}_i^E \equiv \frac{\theta - (\sigma-1)}{\sigma-1} f_i^E (\varphi_i^m)^{-\theta} \quad \text{and} \quad a_{ij} \equiv f_{ij} d_{ij}^{-\theta}.$$

Note that $a_{ij}$ measures trade opennness in that it is decreasing in $f_{ij}$ and $\tau_{ij}$.

The equilibrium domestic productivity cut-offs can be determined from:

$$\varphi_d^{-\theta} = A^{-1} \tilde{f}^E,$$

where $\varphi_d^{-\theta}$ is the vector of $(\varphi_{ii}^*)^{-\theta}$, $A$ is the square matrix of $a_{ij}$, and $\tilde{f}^E$ is the vector of $\tilde{f}_i^E$. We assume $A$ is nonsingular to ensure the existence of a unique equilibrium.

Explicitly solving for $\varphi_{11}^*$ yields:

$$\varphi_{11}^* = \left(\frac{a_{22}\tilde{f}_1^E - a_{12}\tilde{f}_2^E}{a_{11}a_{22} - a_{12}a_{21}}\right)^{-\frac{1}{\theta}}. \tag{3.8}$$

Clearly, a unilateral import liberalization in country 1 that reduces $\tau_{21}$ and thus increases $a_{21}$ will decrease the domestic productivity cut-off $\varphi_{11}^*$.

Conversely, a unilateral export liberalization in country 1 that reduces $\tau_{12}$ and thus increases $a_{12}$ will likewise raise $\varphi_{11}^*$. Taking the derivative of $\varphi_{11}^*$ with respect to $a_{12}$ gives:

$$\frac{d\varphi_{11}^*}{da_{12}} = \frac{a_{22}}{\theta} \frac{(\varphi_{11}^*)^{-\frac{1}{\theta}-1} (\varphi_{22}^*)^{-\theta}}{a_{11}a_{22} - a_{12}a_{21}} > 0. \tag{3.9}$$

Finally, a bilateral trade liberalization between two symmetric countries ($\varphi_{11}^* = \varphi_{22}^*, a_{11} = a_{22} = a_d, a_{12} = a_{21} = a_t$) would raise the productivity cut-offs in both countries. To see this, note that a bilateral reduction in $\tau_{12} = \tau_{12} = \tau$ would lower the export cut-offs in both countries, and thereby raise the domestic production cut-offs due to free entry. Formally, the cut-off expression simplifies to:

$$\varphi_{11}^* = \left( \frac{\tilde{f}_1^E}{a_d + a_t} \right)^{-\frac{1}{\theta}}, \tag{3.10}$$

which is clearly increasing in $a_t$ and hence decreasing in $\tau$.■

Equation (2.20) in the paper shows that welfare $W_i$ is proportional to the domestic productivity cut-off $\varphi_{ii}^*$, where the scaling constant is invariant to trade costs. Equation (2.25) in the paper shows that aggregate measured productivity $\tilde{\Phi}_i$ is proportional to $P_i^{-1/\beta}$. Since welfare is proportional to $1/P_i$, aggregate productivity must move in the same direction as welfare in response to trade liberalization. The resutls for $W_i$ and $\tilde{\Phi}_i$ in Proposition 2 therefore follow directly from Appendix Lemma 2. As in Proposition 1, the ambiguous predictions for average productivity $\overline{\Phi}_i$ and covariance $\ddot{\Phi}_i$ in Proposition 2 are based on their varying response to trade reforms in numerical simulations with different parameter values. ■

## 3.3 Resource misallocation: Proof of Proposition 3

Section 2.4.2 in the paper examines the impact of trade liberalization in the case of resource misallocation. Its results are summarized by the following proposition:

**Proposition 3** *Under resource misallocation, bilateral and unilateral trade liberalization (i.e. reductions in $\tau_{ij}$, $\tau_{ji}$, or both $\tau_{ij}$ and $\tau_{ji}$) have ambiguous effects on welfare $W_i$, measured aggregate productivity $\tilde{\Phi}_i$, average productivity $\overline{\Phi}_i$, and covariance $\ddot{\Phi}_i$.*

**Proof.** To prove this proposition, it is sufficient to show that there exists some joint distribution $H_i(\varphi, \eta)$ and model parameters such that a given trade cost shock can either increase or reduce welfare $W_i$ and aggregate productivity $\tilde{\Phi}_i$.

Note from equation (1.21) that welfare $W_i$ depends on trade costs $\tau_{ij}$ and $\tau_{ji}$ only through their effect on the distorted productivity cut-off for domestic production $\underline{\varphi}_{ii}^*$ and the share of disposable income $\chi_i$; this is implicitly equivalent to the effects on the two cut-offs for domestic production and exporting, $\underline{\varphi}_{ii}^*$ and $\underline{\varphi}_{ij}^*$.

Consider the following $H_i(\varphi, \eta)$ special case. Firms first draw distorted productivity $\underline{\varphi}$ from the Pareto distribution (1.2). Then firms with $\underline{\varphi} \in [\phi - \varepsilon, \phi]$ are assigned $\eta = \bar{\eta} > 1$, while all other firms are assigned $\eta = 1$. True firm productivity is given by $\varphi = \frac{\underline{\varphi}}{\eta}$.

The total lump-sum tax on consumers can be expressed as the sum of the subsidies provided for the domestic and export sales of subsidized firms, $T_i = \sum_j T_{ij}$, where:

$$T_{ij} \equiv \frac{\theta(\sigma - 1)}{\theta - (\sigma - 1)} M_i w_i (\varphi_i^m)^\theta f_{ij} (\bar{\eta} - 1) \left( (\phi - \varepsilon)^{-(\theta - (\sigma - 1))} - \phi^{-(\theta - (\sigma - 1))} \right) (\underline{\varphi}_{ij}^*)^{-(\sigma - 1)} > 0.$$

Consider two scenarios. Assume first that other model paramaters and initial trade costs are such that $\underline{\varphi}_{ii}^1 < \phi - \varepsilon < \phi < \underline{\varphi}_{ij}^1$. Then only some domestic producers but no exporters would be subsidized, and $T_i^1 = T_{ii}^1$. Suppose that a trade cost shock pushes down the export cut-off and consequently raises the production cut-off, such that $\underline{\varphi}_{ii}^2 < \underline{\varphi}_{ij}^2 < \phi - \varepsilon$ after the shock. Now some exporters would receive subsidies, and $T_i^2 = T_{ii}^2 + T_{ij}^2$. This shows that a marginal reduction in $\underline{\varphi}_{ij}^*$ from $\phi$ to $\phi - \varepsilon$ can generate a discrete rise in $T_i$ when $\bar{\eta}$ is sufficiently large relative to $\varepsilon$. The concurrent change in $\underline{\varphi}_{ii}^*$ and $M_1$, however, would be continuous. Therefore, such a trade shock would trigger a discrete drop in $\chi_i$ but a marginal rise in $\underline{\varphi}_{ii}^*$, leading to a fall in aggregate welfare $W_i$.

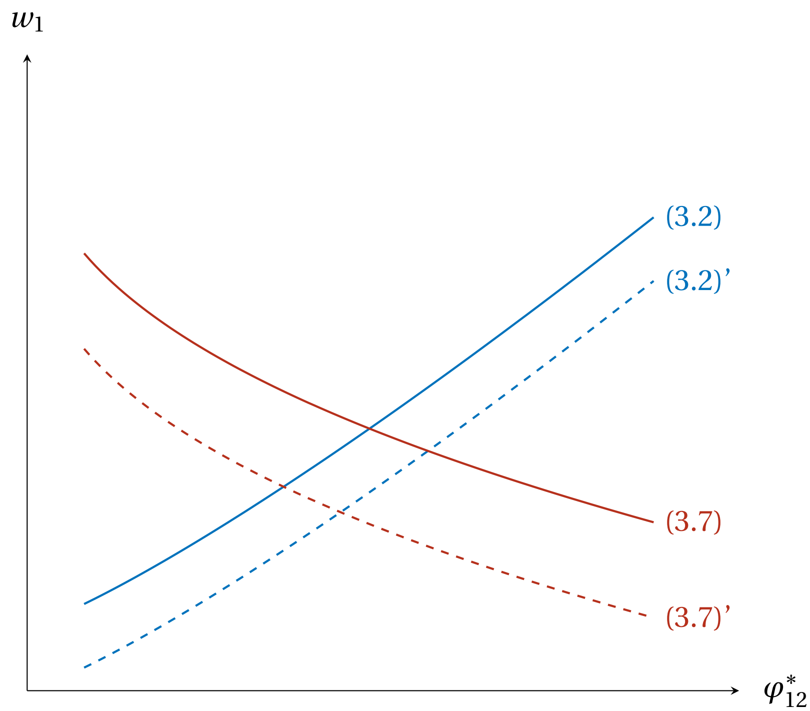
Intuitively, this sample economy subsidizes a small set of firms, that become larger than socially optimal while all other firms remain smaller than optimal due to general equilibrium forces. Trade liberalization can exacerbate this misallocation when it allows firms that are already too large to become even larger by accessing the foreign market, while firms that are already too small become even smaller or exit. This loss due to increased misallocation can outweigh the benefits of trade liberalization and reduce overall welfare.

Assume next that model parameters and initial trade costs are such that $\underline{\varphi}_{ii}^1 < \phi - \varepsilon < \phi < \underline{\varphi}_{ij}^1$. Suppose that a trade cost shock pushes down the export cut-off and consequently raises the production cut-off, such that $\underline{\varphi}_{ii}^2 < \phi - \varepsilon < \phi < \underline{\varphi}_{ij}^2$ continues to hold after the shock. Now a subset of domestic producers and no exporters would receive subsidies both before and after the shock, and the total value of these subsidies would moreover fall as producers contract domestic sales, $T_i^2 = T_{ii}^2 < T_i^1 = T_{ii}^1$. Now a marginal reduction in $\underline{\varphi}_{ij}^*$ would generate a marginal fall in $T_i$ and a marginal rise in $\underline{\varphi}_{ii}^*$. Such a trade shock would thus increase aggregate welfare $W_i$.

A similar argument applies to aggregate productivity $\tilde{\Phi}_i$. The effects of trade cost shocks $\tilde{\Phi}_i$ can be assessed based on equation (2.4). In the first scenario above for example, the sales-weighted average subsidy rate $\tilde{\eta}_i$ would increase discretely when the export cut-off $\underline{\varphi}_{ij}^*$ falls below $\phi - \varepsilon$. The consumer price index $P_i$, however, would decrease continuously in $\underline{\varphi}_{ii}^*$. Therefore, $\tilde{\Phi}_i$ would fall if $\bar{\eta}$ is sufficiently large. Conversely, $\tilde{\Phi}$ would rise in the latter scenario.

As in the absence of misallocation, average productivity $\overline{\Phi}_i$ and covariance $\ddot{\Phi}_i$ under misallocation do not receive closed-form analytical solutions in terms of trade costs or productivity cut-offs. Unlike the case of efficient allocation, the effects of trade reforms on $W_i$ and $\tilde{\Phi}_i$ are ambiguous with distortions. It is thus less surprising that numerical exercises reveal ambiguous effects of trade reforms on $\overline{\Phi}_i$ and $\ddot{\Phi}_i$as well. ■

Figure 1: Equilibrium export cutoff and wage ($\beta = 1$)




**Note:** The diagram illustrates the relationship between country 1's wage $w_1$ and export cutoff $\varphi^*_{12}$ as given by zero cutoff profit condition (3.2) and the balanced trade condition (3.7). The equilibrium level of $(w_1, \varphi^*_{12})$ is determined at the intersection of the two curves. The dashed lines show the shift in the relationships due to a reduction in import cost $\tau_{21}$, which reduces the equilibrium wage $w_1$ and the export cutoff $\varphi^*_{12}$.