ISSN 2042-2695

CENTRE *for* ECONOMIC PERFORMANCE

CEP Discussion Paper No 1668

January 2020

Trade, Productivity and (Mis)allocation

Antoine Berthou
John Jong-Hyun Chung
Kalina Manova
Charlotte Sandoz Dit Bragard

LSE THE LONDON SCHOOL OF ECONOMICS AND POLITICAL SCIENCE

UKRI Economic and Social Research Council

Abstract
We examine the gains from globalization in the presence of firm heterogeneity and potential resource misallocation. We show theoretically that without distortions, bilateral and export liberalizations increase aggregate welfare and productivity, while import liberalization has ambiguous effects. Resource misallocation can either amplify, dampen or reverse the gains from trade. Using model-consistent measures and unique new data on 14 European countries and 20 industries in 1998-2011, we empirically establish that exogenous shocks to export demand and import competition both generate large aggregate productivity gains. Guided by theory, we provide evidence consistent with these effects operating through reallocations across firms in the presence of distortions: (i) Both export and import expansion increase average firm productivity, but the former also shifts activity towards more productive firms, while the latter acts in reverse. (ii) Both export and import exposure raise the productivity threshold for survival, but this cut-off is not a sufficient statistic for aggregate productivity. (iii) Efficient institutions, factor and product markets amplify the gains from import competition but dampen those from export access.

Key words: international trade, export demand, import competition, productivity, allocative efficiency, misallocation
JEL Codes: F10; F14; F43; F62; O24; O40; O47

This paper was produced as part of the Centre's Trade Programme. The Centre for Economic Performance is financed by the Economic and Social Research Council.

We thank Treb Allen, Cagatay Bircan, Shang-Tai Hsieh, Jan De Loecker, Marc Melitz, and Daniel Xu for their valuable feedback. Thanks also to audiences at various seminars and at NBER ITI, NBER IFM, NBER MP, IMF, Bank of Mexico, Bank of England, 2015 ECB CompNet Conference on Enhancing Competitiveness and Fostering Sustainable Growth, 2015 RIEF Annual Conference, 2015 DEGIT Annual Conference, 2015 ETSG Annual Conference, 2016 CEPR Workshop on Understanding the Micro Channels Affecting Growth, 2016 PSE Workshop on Chinese Firms in a Globalized World, 2016 SMYE Annual Conference, 2016 ECB-CBRT Conference, 2017 AEA Annual Meeting, 2017 CEBRA Workshop, 2017 Bank of England London Financial Intermediation Workshop. The views expressed are those of the authors and do not necessarily reflect official positions of the European Central Bank or Banque de France.

Antoine Berthou, Banque de France and CEPII. John Jong-Hyun Chung, Auburn Universillty. Kalina Manova, UCL, CEPR and Centre for Economic Performance, London School of Economics. Charlotte Sandoz Dit Bragard, IMF.

Published by
Centre for Economic Performance
London School of Economics and Political Science
Houghton Street
London WC2A 2AE

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. In particular, heterogeneous-firm models emphasize the importance of firm selection and reallocation across firms in mediating these gains (e.g. Melitz 2003, Lileeva and Trefler 2010). At the same time, 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). However, how such frictions modify the gains from trade remains poorly understood.

This paper investigates the gains from globalization in the presence of firm heterogeneity and potential resource misallocation. We first show theoretically that without distortions, bilateral and export liberalizations increase aggregate welfare and productivity, while import liberalization has ambiguous effects. Resource misallocation can either amplify, dampen or reverse the gains from trade. Using model-consistent measures and unique new data on 14 European countries and 20 industries in 1998-2011, we then empirically establish that exogenous shocks to export demand and import competition both generate large aggregate productivity gains. Guided by theory, we provide evidence consistent with these effects operating through reallocations across firms in the presence of distortions. First, we decompose the aggregate productivity gains. Both export and import expansion increase average firm productivity, but the former also shifts activity towards more productive firms, while the latter acts in reverse. Second, both export and import exposure raise the productivity threshold for survival, but this cut-off is not a sufficient statistic for aggregate productivity. Finally, efficient institutions, factor and product markets amplify the gains from import competition but dampen those from export access.

Our first contribution is theoretical. We examine the impact of trade liberalization and resource misallocation in a standard heterogeneous-firm trade model, and numerically evaluate its predictions. In the absence of misallocation, reductions in bilateral trade costs or unilateral export costs unambiguously raise aggregate productivity and welfare, as in Melitz (2003) and Melitz and Redding (2014). On the extensive margin, such reforms raise the productivity cut-off above which domestic firms can operate. On the intensive margin, they shift activity from less towards more productive firms. By contrast, unilateral import reforms have ambiguous consequences because they increase market competitiveness both in the

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

liberalizing country and in its trade partner, with opposing effects on the productivity cut-off at home. This results in welfare and productivity gains when wages are flexible and Metzler-paradox losses when wages are fixed, as in Demidova and Rodriguez-Clare (2013) and Bagwell and Lee (2016).

Under resource misallocation, the impact of both bilateral and unilateral trade liberalization on aggregate productivity and welfare becomes ambiguous. Moreover, it is not monotonic in the degree of misallocation, such that distortions may amplify, dampen or reverse the gains from trade. In the model, firms receive two exogenous draws, productivity φ and distortion η. 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 that is based on distorted productivity $\underline{\varphi} = \varphi\eta$ rather than true productivity φ. This misallocation arises only due to institutional imperfections that cause frictions in the market for input factors (or equivalently, for output products), and is not driven by variable mark-ups as in Dhingra and Morrow (2014). Globalization has ambiguous effects because distorted economies operate in a second-best world and trade reforms can worsen or improve allocative efficiency.

Our second contribution is methodological. We demonstrate how key theoretical concepts map to empirically observable variables and how theoretical mechanisms can be assessed with available data. Firm productivity measured by real value-added per worker is monotonic in theoretical firm productivity inclusive of any distortions, conditional on export status. However, welfare is generally not monotonic in measured aggregate productivity, defined as the employment-weighted average productivity of domestic firms. The two are proportional under flexible wages, Pareto-distributed productivity, and no misallocation. They also co-move in a wide segment of the parameter space away from this special case, but only when there are no distortions.

We decompose measured aggregate productivity into the unweighted average firm productivity and the covariance of firms' productivity and employment share, as in Olley and Pakes (1996). The OP covariance is not a sufficient statistic for either the parameters governing the distribution of η or the state-dependent level of allocative efficiency. Numerical simulations indicate that the OP decomposition is nevertheless informative: Trade reforms can move the two OP productivity components in opposite directions only under misallocation.

Our third contribution is empirical. We assess the effect of international trade on aggregate productivity and the mechanisms through which it operates, using new data assembled by the Competitive Research Network of the ECB for 14 European countries and 20 manufacturing industries in 1998-2011. These data are unique in capturing not only aggregate outcomes, but also various moments of the underlying distribution across firms. This makes it possible to implement the OP decomposition in a large cross-country, cross-sector panel for the first time.

Our baseline measures of export access and import competition are gross exports and gross imports (less own-sector imported inputs) by country and sector, from the World Input-Output Database. We establish causality with an IV strategy that exploits variation in the initial composition of countries' trade baskets and WIOD data on 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.

We find that export access and import penetration both significantly increase measured aggregate productivity. The estimates imply that a 20% rise in export demand and import competition would generate productivity gains of 7.6%-8.2% and 1%-10% respectively. We perform three exercises to uncover the mechanisms driving these effects. The results indicate that firm heterogeneity and resource misallocation jointly determine the gains from trade. Moreover, distorted economies adjust asymmetrically to positive shocks to domestic firms such as stronger export demand and negative shocks such as tougher import competition.

First, the OP decomposition reveals that export growth both raises average firm productivity (61-77%) and reallocates activity towards more productive firms (23-39%). By contrast, the gains from import competition stem entirely from higher average firm productivity (117-136%) and are partly offset by a shift in activity towards less productive firms (- 17-36%). Through the lens of the model, these patterns can only be rationalized with trade inducing reallocations across firms in the presence of distortions.

Second, both export and import exposure increase the minimum productivity among active firms, consistent with trade improving firm selection by triggering exit from the left tail of the distribution. However, the productivity threshold is not a sufficient statistic for the effect of trade on aggregate productivity, counter to model predictions for the case of no misallocation.

Finally, efficient institutions, factor and product markets amplify the productivity gains from import competition and dampen 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. This direct, assumption-free evidence suggests that misallocation does moderate the impact of globalization, and informs the theoretically ambiguous sign of this moderating force.

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 the importance of reallocations across heterogeneous firms for the realization of welfare and productivity gains from globalization (e.g. Arkolakis et al. 2012, Melitz and Redding 2014). Prior empirical work has studied episodes of unilateral trade reforms with micro-level data for a single country. For example, Bernard et al. (2006) show that following a decline in trade barriers in the U.S., 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.[2] To the best of our

[2] 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). Separately, Alfaro and Chen (2017) conclude that greater competition from multinational firms fosters productivity-enhancing

knowledge, we provide the first causal cross-country evidence for high- and middle-income countries that at the same time informs the firm dimension and compares export and import access.

Our work also adds to a large literature on the implications of resource misallocation for aggregate growth and productivity. A key finding is that frictions in input and output markets distort the allocation of production resources across firms, lower aggregate productivity, and contribute to the large variation in aggregate productivity across countries (e.g. Restuccia and Rogerson 2008, Hsieh and Klenow 2009, Bartelsman et al. 2013, Hopenhayn 2014, Gopinath et al. 2015, Foster et al. 2008, Foster et al. 2016, Baqee and Farhi 2019). Since different micro-foundations for misallocation have different implications for measured cross-firm dispersion in productivity and marginal products of capital and labor, quantifying misallocation in the data poses challenges. We demonstrate how these insights extend to and generate rich additional effects in an open economy, general-equilibrium trade model. We do not aim to develop new misallocation measures, but instead study observed aggregate productivity inclusive of any distortions, as the policy-relevant concept of effective productivity. We characterize the disconnect between welfare and measured aggregate productivity, theoretically analyze the gains from trade with and without misallocation, and verify that the empirical evidence is consistent with model predictions for the case of misallocation.[3]

Most directly, we contribute to vibrant research on the impact of institutional and market frictions for international trade. This body of work departs from the traditional assumption in international economics that resources are efficiently and instantaneously reallocated across firms. Credit constraints have been shown to disrupt export entry, various dimensions of import and export activity at the firm level, and aggregate trade flows (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, Cuñat and Melitz 2012, Tombe 2015, Ruggieri 2018).

We extend this research by turning to the fundamental question of how resource misallocation affects the gains from trade. Our analysis implies that welfare results from workhorse quantifiable gravity trade models (Costinot and Rodriguez-Clare 2014, Donaldson 2015) no longer apply in the presence of distortions due to weak institutions. This is consistent with the literature on trade reforms in developing countries (Atkin and Khandelwal 2019) and work on the implications of intersectoral and interregional misallocation with and without input-output linkages for the gains from trade (Swiecki 2017, Caliendo et al. 2017, Hornbeck and Rotemberg 2019).

Our work relates to several studies that also focus on firm-level distortions. Bai et al. (2019) theoretically examine how firm-specific taxes and subsidies on input suppliers can distort the operations of final producers. Their quantitative exercise with Chinese manufacturing data implies that this misallocation results in TFP losses and lowers welfare gains following trade liberalization. Sandoz (2018) establishes that access to cheaper imported inputs fosters aggregate productivity growth by improving resource allocative efficiency, and offers evidence for France. Bajgar (2016) shows that the gains from trade tend to

reallocations of activity among domestic firms.

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

increase with revenue distortions to domestic sales only, to fall with distortions to exports only, and to become ambiguous with both distortions. Chung (2018) demonstrates how revenue subsidies and taxes that may differ for domestic and export sales influence the observed dispersion in firm productivity and the gains from trade, and provides evidence for China. 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.[4] Even without frictions in input and output markets, variable mark-ups that are absent from our framework entail market share misallocation across firms and limit the pro-competitive gains from trade (Epifani and Gancia 2011, Edmond et al. 2015, Dhingra and Morrow 2016, Feenstra and Weinstein 2017, Arkolakis et al. 2019).

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 impact of international trade on aggregate welfare and productivity in a general-equilibrium model with firm heterogeneity in productivity as in Melitz (2003) and Chaney (2008) and potential resource misallocation as in Hsieh and Klenow (2009) and Bartelsman et al (2013). Our goal is threefold. First, we highlight that in the absence of misallocation, bilateral and unilateral export liberalizations always raise aggregate welfare and productivity, while unilateral import liberalization can have ambiguous effects. Second, we show that all three types of globalization have ambiguous consequences in the presence of misallocation. Third, we characterize the relationship between welfare and aggregate productivity in the model and aggregate productivity measures in the data to provide a bridge between theory and empirics. We relegate detailed proofs to Appendix A.

2.1 Set Up

Economic environment: Consider a world with two potentially asymmetric countries $i = 1, 2$ and free firm entry into production.[5] In each country, a measure L_i of consumers inelastically supply a unit of labor, and aggregate expenditure is E_i. A representative consumer derives utility U_i from consuming

[4] 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).

[5] 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.

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 βE_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 β 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 that they can sell at home and potentially export. 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 such that τ_{ij} units of a good need to be shipped for 1 unit to arrive, where $\tau_{ii} = 1$ and $\tau_{ij} > 1$ if $i \neq j$. We allow for $\tau_{ij} \neq \tau_{ji}$, and analyze symmetric and asymmetric reductions in τ_{ij} to assess the impact of different trade reforms.

Firm productivity and resource misallocation: In the absence of misallocation, firms in country i draw productivity φ upon entry from a known Pareto distribution $G_i(\varphi) = 1 - (\varphi_i^m/\varphi)^{\theta}$, where $\theta > \sigma - 1$ and $\varphi_i^m > 0$.[6] This fixes firms' constant marginal cost to w_i/φ. Under resource misallocation on the other hand, firms draw both productivity φ and distortion η from a known joint distribution $H_i(\varphi, \eta)$. Firms' marginal cost is now determined by their *distorted productivity* $\underline{\varphi} = \varphi\eta$ and equals $w_i/\underline{\varphi} = w_i/(\varphi\eta)$. 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 θ.

Conceptually, η 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 markets or from generally weak contractual institutions that support inefficient practices like corruption and nepotism.[7] Distortions η 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 $\eta < 1$.

Modeling misallocation in this way has several appealing features. First, it permits a transparent comparison of firm and economy-wide outcomes with and without misallocation. Under misallocation, firm selection, production and export activity depend on φ and η only through distorted productivity

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

[7] 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).

$\underline{\varphi} = \varphi\eta$, while optimal resource allocation in the first best depends on φ alone. Thus two parameters regulate the degree of misallocation: the dispersion of the distortion draw, σ_η, and the correlation between the distortion and productivity draws, $\rho(\varphi, \eta)$.[8] Misallocation occurs if and only if $\sigma_\eta > 0$, but its severity need not vary monotonically in the $\sigma_\eta - \rho(\varphi, \eta)$ space.[9]

Second, introducing distortions on the input side is qualitatively isomorphic to allowing for distortions in output markets, such as firm-specific sales taxes.[10] 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.

Within the differentiated sector, misallocation stems from the inefficient allocation of production resources and consequently market shares across firms. Since CES preferences and monopolistic competition will imply a constant mark-up $\mu = 1/\alpha > 1$, there is no additional misallocation due to variable mark-ups across firms as in Dhingra and Morrow (2016). When $\beta < 1$, however, there will also be mark-up driven misallocation across sectors: Because perfectly competitive producers of the CRS homogeneous good do not charge a mark-up, the differentiated sector will be "too small".

2.2 Economy Equilibrium

Firm behavior: Producers choose their price $p_{ij}(\varphi)$ and quantity $q_{ij}(\varphi)$ to maximize profits $\pi_{ij}(\varphi)$ separately in each market j. With no distortions, the optimal behavior of a firm with productivity φ is:

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

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

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

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

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 φ_{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 φ_{ii}^*, and exit otherwise. We assume as standard that the parameter space guarantees selection into exporting, $\varphi_{ij}^* > \varphi_{ii}^*$, for any $\tau_{ij} > 1$.

[8] For example, with imperfect credit markets, lenders may base loan decisions on a noisy signal of firm productivity, such that $0 < \rho(\varphi, \eta) < 1$. Alternatively, if more productive firms optimally hire more skilled workers, labor market frictions may be especially costly in the specialized market for skilled workers, such that $\rho(\varphi, \eta) < 0$.

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

[10] For example, one can specify the distortion on the revenue side such that firm profits equal $\pi_{ij}(\varphi, \eta) = \eta p_{ij}q_{ij} - w_i l_{ij}$. While profits will now be proportional to $\varphi\eta^{1/\alpha}$ instead of $\varphi\eta$, and firm selection along the extensive margin will be adjusted accordingly, the main intuitions and results in the baseline model with input distortions will remain valid.

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

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

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

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

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

While it would be socially optimal to allocate input factors and output sales based on true firm productivity φ, in the market equilibrium this allocation is instead pinned down by distorted productivity $\underline{\varphi}$. Along the intensive margin, firms with low (high) distortions η produce and earn 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:

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

General equilibrium: The general equilibrium is characterized by conditions that ensure free entry, labor market clearing, income-expenditure balance, and trade balance 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.[11]

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 τ_{ij} or τ_{ji}. Intuitively, any force that lowers φ_{ij}^* tends to increase expected export profits conditional on production. For free entry to continue to hold, φ_{ii}^* must therefore rise, such that the probability of survival conditional on entry falls and overall expected profits from entry remain unchanged.

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 $L_i = L_{iQ}$.

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

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. Consumers' utility maximization implies the following income-expenditure balance:[12]

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

Consider next the case of misallocation. The free entry and labor market clearing conditions are analogous to those above after replacing productivity φ with distorted productivity $\underline{\varphi} = \varphi\eta$. The income-expenditure balance, however, has to be amended. While firm (φ, η) 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 firm-specific taxes or 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 new equilibrium conditions become:

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

$$L_i = L_{iH} + L_{iQ} = L_{iH} + M_i f^E_i + \sum_j M_i \mathbf{E}_i \left[l_{ij}(\varphi,\eta) \mathbf{I}(\varphi\eta \geq \underline{\varphi}^*_{ij}) \right], \tag{2.16}$$

$$\beta(w_j L_j - T_j) = \beta E_j = \sum\nolimits_i M_i \mathbf{E}_i \left[r_{ij}(\varphi,\eta) \mathbf{I}(\varphi\eta \geq \underline{\varphi}^*_{ij}) \right], \tag{2.17}$$

$$T_i = \sum\nolimits_j M_i \mathbf{E}_i \left[[c'_{ij}(\varphi,\eta) - c_{ij}(\varphi,\eta)] \mathbf{I}(\varphi\eta \geq \underline{\varphi}^*_{ij}) \right]. \tag{2.18}$$

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, χ_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 $\chi_i < 1$; albeit less realistic, it is in principle possible that $\chi_i > 1$. Misallocation also affects the price index P_i through distortions to firm selection on the extensive margin and to firm prices and market shares on the intensive margin.

One can show that the real wage, and therefore also welfare, is a function of two equilibrium outcomes: the (distorted) productivity cut-off for production, φ^*_{ii} or $\underline{\varphi}^*_{ii}$, and the share of disposable income, χ_i:[13]

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

[12] 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: $\sum_i M_i \mathbf{E} \left[r_{ik}(\varphi) \mathbf{I}(\varphi \geq \varphi^*_{ik}) \right] = \sum_j M_j \mathbf{E} \left[r_{kj}(\varphi) \mathbf{I}(\varphi \geq \varphi^*_{kj}) \right]$.

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

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* χ_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),* $\frac{\partial W_i}{\partial \chi_i} > 0$.

With efficient resource allocation, a higher productivity cut-off φ_{ii}^* implies a shift in economic activity towards more productive firms, which tends to lower the aggregate price index and increase consumers' real income. With misallocation, distortions affect welfare through the reduction in disposable income χ_i and through the sub-optimal selection and size of active firms based on distorted productivity $\underline{\varphi}$ rather than true productivity φ. One direct implication of Lemma 1 is that welfare is proportional to the domestic productivity cut-off if and only if there are no allocative frictions. Another implication is that the welfare impact of trade liberalization depends on how a reduction in τ_{ij} affects φ_{ii}^*, $\underline{\varphi}_{ii}^*$, and χ_i.

Note that in the two-sector general equilibrium, welfare reflects both distortion-driven misallocation across firms within the differentiated sector and markup-driven misallocation across sectors, both of which are reflected in the economy-wide price index P_i. One cannot analytically decompose these two sources of misallocation, and their relative contribution is state-dependent.[14]

2.3 From Theory to Empirics

A key challenge in evaluating the gains from trade is that productivity and welfare are not directly observable. Here we characterize the mapping between these theoretical objects and their empirical counterparts. We focus on firm and aggregate productivity in the differentiated sector, which are the objects of interest in both the single- and two-sector models.

Theoretical vs. measured firm productivity: The theoretical concept of firm productivity is quantity-based, while empirical measures are generally revenue-based. For our purposes, real value added per worker is a valid proxy for effective firm productivity inclusive of any distortions.

Without misallocation, observed value added and employment correspond respectively to total firm revenues, $r_i(\varphi) = \sum_j r_{ij}(\varphi)\mathbf{I}(\varphi \geq \varphi_{ij}^*)$, and total labor hired, $l_i(\varphi) = \sum_j l_{ij}(\varphi)\mathbf{I}(\varphi \geq \varphi_{ij}^*)$. Denoting labor used towards fixed costs as $f_i(\varphi) = \sum_j f_{ij}\mathbf{I}(\varphi \geq \varphi_{ij}^*)$ and normalizing by the price index in the differentiated industry $P_{iQ} = P_i^{1/\beta}$, real value added per worker $\Phi_i(\varphi)$ is:

$$\Phi_i(\varphi) = \frac{r_i(\varphi)}{P_{iQ} l_i(\varphi)} = \frac{w_i}{\alpha P_i^{1/\beta}} \left[1 - \frac{f_i(\varphi)}{l_i(\varphi)}\right]. \tag{2.21}$$

One can show that without distortions, real value added per worker increases monotonically with theoretical firm productivity conditional on export status, $\Phi_i'(\varphi|\varphi < \varphi_{ij}^*) > 0$ and $\Phi_i'(\varphi|\varphi \geq \varphi_{ij}^*) > 0$.[15]

[14] 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.

[15] 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 φ because of economies of scale. Note the measured productivity of firm φ 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 $r_{ii}(\varphi_{ij}^*)/l_{ii}(\varphi_{ij}^*) > r_{ij}(\varphi_{ij}^*)/l_{ij}(\varphi_{ij}^*)$.

In the case of misallocation, real value added per worker reflects firms' effective productive capacity given distortions, and can thus be labeled $\underline{\Phi}_i(\varphi,\eta)$. It is now monotonic in theoretical distorted productivity conditional on export status, $\underline{\Phi}_i'(\varphi\eta|\varphi\eta < \underline{\varphi}_{ij}^*) > 0$ and $\underline{\Phi}_i'(\varphi\eta|\varphi\eta \geq \underline{\varphi}_{ij}^*) > 0$:[16]

$$\underline{\Phi}_i(\varphi,\eta) = \frac{r_i(\varphi,\eta)}{P_{iQ}l_i(\varphi,\eta)} = \frac{w_i}{\alpha P_i^{1/\beta}\eta}\left[1 - \frac{f_i(\varphi,\eta)}{l_i(\varphi,\eta)}\right]. \tag{2.22}$$

Measured aggregate productivity and OP decomposition: Let measured aggregate productivity, $\tilde{\Phi}_i$, be the weighted average of measured firm productivity. Without distortions, $\tilde{\Phi}_i$ is:

$$\tilde{\Phi}_i \equiv \int_{\varphi_{ii}^*}^{\infty} \theta_i(\varphi)\Phi_i(\varphi)\frac{dG_i(\varphi)}{1-G_i(\varphi_{ii}^*)}, \tag{2.23}$$

where $\theta_i(\varphi) \equiv l_i(\varphi)/\left[\int_{\varphi_{ii}^*}^{\infty} l_i(\varphi)\frac{dG_i(\varphi)}{1-G_i(\varphi_{ii}^*)}\right]$ is firm φ's share of aggregate employment.[17]

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

$$\tilde{\Phi}_i = \overline{\Phi}_i + \ddot{\Phi}_i = \int_{\varphi_{ii}^*}^{\infty} \Phi_i(\varphi)\frac{dG_i(\varphi)}{1-G_i(\varphi_{ii}^*)} + \int_{\varphi_{ii}^*}^{\infty} \left[\Phi_i(\varphi) - \overline{\Phi}_i\right]\left[\theta_i(\varphi) - \overline{\theta}_i\right]\frac{dG_i(\varphi)}{1-G_i(\varphi_{ii}^*)}. \tag{2.24}$$

The OP decomposition reveals how adjustments across and within firms shape aggregate measured productivity. Changes in $\overline{\Phi}_i$ reflect two effects of firm selection: exit/entry into production modifies the set of active firms, and exit/entry into production or exporting impacts measured firm productivity. Changes in $\ddot{\Phi}_i$ indicate reallocation of activity across firms with different productivity levels through changes in their share of production resources and implicitly sales. The OP decomposition remains valid in the case of misallocation, when $\underline{\varphi}$, $\underline{\varphi}_{ii}^*$, $\underline{\Phi}_i(\varphi,\eta)$, and $H_i(\varphi,\eta)$ replace φ, φ_{ii}^*, $\Phi_i(\varphi)$, and $G_i(\varphi)$ in (2.24).

Welfare vs. measured 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 can differ, even under allocative efficiency: 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 supplying i, using their activity in i 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 in special cases, such as symmetric countries and bilateral trade costs, 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.[18]

One can express measured aggregate productivity as a function of the real wage, w_i/P_i, and the

[16] Note $\Phi_i(\varphi)$ and $\underline{\Phi}_i(\varphi,\eta)$ depend on the real wage, and implicitly on the (distorted) productivity thresholds.

[17] In the data, the firm weights are defined such that they sum to 1 across firms. Here, $\theta_i(\varphi)$ is defined such that it averages 1 across firms and the residual in the OP decomposition is the covariance of $\Phi_i(\varphi)$ and $\theta_i(\varphi)$.

[18] Also, since $\Phi_i(\varphi)$ is monotonic in φ only conditional on export status, $\tilde{\Phi}_i$ need not be monotonic in $\widetilde{\varphi}_i$.

size-weighted average distortion across firms, $\tilde{\eta}_i$, where $\eta \equiv 1$ and $\tilde{\eta}_i = 1$ without misallocation:

$$\tilde{\Phi}_i = \begin{cases} \frac{\sigma\theta}{\sigma\theta-(\sigma-1)} \frac{w_i}{P_i^{1/\beta}} & \text{without misallocation} \\ \frac{\sigma\theta}{(\sigma-1)\theta\tilde{\eta}_i+\theta-(\sigma-1)} \frac{w_i}{P_i^{1/\beta}} & \text{with misallocation} \end{cases}, \tag{2.25}$$

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

Together, equations (2.19), (2.20) and (2.25) imply 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 $\beta = 1$), the aggregate price index P_i, and the average distortion $\tilde{\eta}_i$. In particular:

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

Lemmas 1 and 2 imply that measured aggregate productivity can be a sufficient statistic for welfare only without misallocation.[19] With 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 (see Section 2.5) to numerically explore their relationship. We assume productivity and distortions are joint log-normal with $\mu_\varphi = \mu_\eta = 1$, $\sigma_\varphi = 1$, and vary the levels of distortion dispersion $\sigma_\eta \in [0, 0.5]$ and 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 the given $\rho(\varphi, \eta)$. At low levels of σ_η, W_i rises as the distortion and productivity draws become more positively correlated, but the opposite holds at sufficiently high levels of σ_η. While measured aggregate productivity behaves similarly under this parametrization in Figure 1B, W_i and $\tilde{\Phi}_i$ need not comove under alternative assumptions (unreported). For completeness, Figure 1C plots measured average productivity $\overline{\Phi}_i$ against the misallocation parameters.

OP covariance vs. 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 φ) but $\ddot{\Phi}_i \gtrless 0$ in the presence of distortions.[20] However, 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 structure, cost structure, market structure, productivity distribution). Even if the optimal covariance $\ddot{\Phi}_i^*$ were known, 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.

[19] 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. With misallocation, the Pareto assumption for distorted productivity gives tractability but no longer guarantees monotonicity.

[20] A sufficient condition for $\ddot{\Phi}_i > 0$ in the frictionless economy is 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.

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 σ_η, higher $\rho(\varphi, \eta)$ tends to imply lower $\ddot{\Phi}_i$; although productive firms get inefficiently large, this counterintuitive pattern reflects distortion-induced measurement error in $\underline{\Phi}_i(\varphi, \eta)$. This measurement error also explains why $\ddot{\Phi}_i$ does not peak at $\rho(\varphi, \eta) = 0$ if $\sigma_\eta > 0$, when misallocation would intuitively be lowest. Alternative parameterizations can also produce non-monotonic patterns for $\ddot{\Phi}_i$ in σ_η and $\rho(\varphi, \eta)$.

Inspecting Figures 1A and 1D, the comparative statics for W_i and $\ddot{\Phi}_i$ are not perfectly aligned, reinforcing the conclusion that $\ddot{\Phi}_i$ does not fully capture the welfare cost of misallocation.[21] One can therefore not unambiguously interpret a rise (fall) in $\ddot{\Phi}_i$ in response to an exogenous shock as an improvement (deterioration) in allocative efficiency.

In sum, we are not able to develop a model-based index of misallocation that would be observable in the data and that would allow one to decompose measured aggregate productivity into potential productivity and distortions. However, this is also not the goal of our exercise: We are interested in the impact of globalization on effective aggregate productivity inclusive of any distortions. As we show below, our theoretical framework allows to predict and contrast this impact in environments with and without misallocation. Indeed, the combined effect of trade shocks on the three OP productivity terms *can* reveal the presence of misallocation.

2.4 Trade Liberalization

We can now examine the impact of trade liberalization on welfare W_i and measured aggregate productivity $\tilde{\Phi}_i$, average productivity $\overline{\Phi}_i$, and productivity covariance $\ddot{\Phi}_i$. We consider three forms of trade liberalization: symmetric bilateral reduction in variable trade costs τ_{ij} and τ_{ji}, unilateral reduction in export costs τ_{ij}, and unilateral reduction in import costs τ_{ji}.

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 τ_{ij} creates more export opportunities for firms in i, as they can charge lower prices in j and benefit from higher export demand. This decreases the productivity cut-off for exporting φ^*_{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 the productivity threshold for survival, φ^*_{ii}, rises. This effect is amplified when wages can flexibly adjust, as export expansion bids up labor demand and wages in i, such that even more low-productivity firms are no longer profitable.

Consider next import liberalization. A decline in τ_{ji} enables foreign firms to sell more cheaply to i. This lowers the productivity cut-off for exporting from j to i, φ^*_{ji}, and induces continuing j exporters to

[21] 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 Bartelsman et al. (2013).

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, φ_{ii}^*. The indirect effect is a higher productivity threshold for survival in j, φ_{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, φ_{ij}^*, and with free entry in i, acts to depress the survival threshold, φ_{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, φ_{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.

From Lemmas 1 and 2, changes in the productivity threshold φ_{ii}^* signal changes in aggregate outcomes. Thus bilateral and unilateral export liberalizations unambiguously increase welfare W_i, as in Melitz (2003), Melitz and Redding (2014), Arkolakis et al. (2012), and Demidova and Rodriguez-Clare (2013). Unilateral import liberalizations raise welfare under flexible wages, but generate welfare losses with fixed wages, as in Demidova (2008) and Bagwell and Lee (2016).[22] We further establish that in the absence of distortions, measured aggregate productivity $\tilde{\Phi}_i$ 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 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 *Under no misallocation and flexible wages ($\beta = 1$), bilateral and unilateral trade liberalizations (i.e. reductions in τ_{ij}, τ_{ji}, or both τ_{ij} and τ_{ji}) increase welfare W_i and measured aggregate productivity $\tilde{\Phi}_i$, but have ambiguous effects on average productivity $\overline{\Phi}_i$ and covariance $\ddot{\Phi}_i$.*

Proposition 2 *Under no misallocation and fixed wages ($\beta < 1$), bilateral and unilateral export liberalizations (i.e. reductions in τ_{ij} or both τ_{ij} and τ_{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 τ_{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 operate in a sub-optimal equilibrium both before and after any trade reforms. Trade liberalization now triggers reallocation across firms based on distorted productivity $\underline{\varphi}$ rather than true productivity φ. While trade does not affect the underlying institutions that generate distortions (i.e. σ_η and $\rho(\varphi, \eta)$), it can in principle improve or worsen allocative efficiency. From the theory of the second best, it is therefore not possible to unambiguously determine the impact of trade

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

reforms on aggregate welfare and productivity: It hinges on initial state variables and model parameters, in particular, the joint distribution $H_i(\varphi, \eta)$.

The effects of trade also need not be monotonic in the distortion parameters σ_η and $\rho(\varphi, \eta)$ or the initial degree of misallocation. In other words, 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. Misallocation would reduce the gains from trade if more productive firms cannot fully respond to growth opportunities, while less productive firms are not forced to exit. For example, trade liberalization could magnify existing distortions if firms with inefficiently abundant access to inputs can expand their activity relatively more than firms with inefficiently constrained resources (e.g. if new loans are extended based on collateralizable tangible assets accumulated with past loans). 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).

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

2.5 Numerical Simulation

We explore the impact of counterfactual trade reforms through numerical simulations, to inform both its sign and magnitude. We consider 20% reductions in trade costs from initial values of $\tau_{ij} = \tau_{ji} = 1.81$ in three scenarios: bilateral liberalization (shocks to both τ_{ij} and τ_{ji}), export liberalization (shock to τ_{ij}), and import liberalization (shock to τ_{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 ($\ln \varphi \sim \mathcal{N}\left(\mu_\varphi, \sigma_\varphi\right)$, $\mu_\varphi = 0$, $\sigma_\varphi = 1$).[23] 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 $\rho \in [-0.5, 0.5]$.[24]

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

[24] In unreported numerical exercises available on request, we consider the case of no distortions in Foreign and varying degrees of misallocation in Home. The impact of trade liberalization in Home on Home's aggregate welfare and productivity are qualitatively similar to the baseline with two distorted economies.

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 liberalization increase welfare and measured 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 3 (Panel C). With flexible wages, the welfare and productivity gains from trade are either smaller or only marginally higher with misallocation than without, and decrease smoothly with the correlation parameter ρ. 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 ρ: 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 ρ is sufficiently positive. As for productivity, trade liberalization generates less negative or higher productivity gains at higher levels of ρ. Once again, misallocation can enlarge, moderate or overturn the productivity gains that obtain in the first best.

Finally, the two components of aggregate productivity $\tilde{\Phi}_i$ - average productivity $\overline{\Phi}_i$ and covariance $\ddot{\Phi}_i$ - move in different directions only under misallocation. With no distortions, changes in $\overline{\Phi}_i$ account 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, we use baseline IV estimates to compute the implied productivity effects of a 20% rise in export demand and import competition in Panel D. 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 in line with the numerical calculations for exports and higher for imports.

2.6 Discussion

Two model features that 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 $\tilde{\Phi}_i$ now depends 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, τ_{ij} and τ_{ji}. The effect of exogenous shocks to foreign demand - such as a rise in foreign market size L_j or aggregate expenditure E_j - would be qualitatively the same as the effect of a fall in export costs, τ_{ij}. Likewise, the effect of exogenous shocks to foreign supply - such as a rise in the measure of foreign firms M_j or a shift in the foreign productivity distribution $G_j(\varphi)$ - would be similar to the effect of a fall in import costs, τ_{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

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

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.[25] Two features of the data make it unprecedented in detail and ideally suited to our analysis. First, it contains not only aggregate measures at the country-sector-year level, but also multiple moments of the underlying firm distribution in each country-sector-year cell. This includes for example means, standard deviations and skewness of various firm characteristics, as well as moments of the joint distribution of several such characteristics. The dataset is built from raw firm-level data that are independently collected in each country and maintained by national statistical agencies and 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.[26]

Second, CompNet includes productivity measures that map exactly to the Olley-Pakes (1996) decomposition in Section 2.3 of aggregate productivity in country i, sector k and year t ($\tilde{\Phi}_i \equiv AggProd_{ikt}$) into unweighted average firm productivity ($\overline{\Phi}_i \equiv AvgProd_{ikt}$) and the covariance of firm productivity and share of economic activity ($\ddot{\Phi}_i \equiv CovProd_{ikt}$). In particular, we examine firms' labor productivity defined as log real value added per worker ($\Phi_i(\varphi)$ or $\underline{\Phi}_i(\varphi, \eta)$), and weight firms by their employment share ($\theta_i(\varphi)$) at the country-sector-year level.[27]In addition to being model-consistent, labor productivity

[25] 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)).

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

[27] The empirical counterpart to the theoretical OP decomposition in equation (2.24) at the country-sector-year level is:

has the added advantage that it is based on directly observable data, rather than on a TFPR residual from production function that is subject to estimation bias.

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 β, $P_{iQ} = P_i^{1/\beta}$. With multiple years and differentiated sectors, this would correspond to $P_{ikt} = P_{it}^{1/\beta_k}$, which is not observed. As standard with productivity and GDP data, CompNet deflates firm value added by the Eurostat value-added producer price index by country-sector-year, $VAPPI_{ikt}$. Compared to P_{ikt}, an advantage of $VAPPI_{ikt}$ is that it is consistent with measured value added being net of producers' input purchases that are absent from our model. On the other hand, the CPI aggregates the prices of both local and imported varieties, while the VAPPI aggregates only domestic producers' prices. In our empirical analysis, we therefore control for country-year fixed effects that absorb P_{it} and sector-year fixed effects that absorb β_k.

Table 2 documents the variation in aggregate productivity across countries, sectors and years in the panel. Additional statistics for the variation across sectors and years within countries 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).[28] While standard trade statistics report gross flows by exporter, importer and traded sector, WIOD exploits country-specific input-output tables to infer bilateral value-added flows by both traded sector and sector of final use. In particular, it provides 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}. 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

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

[28] See Timmer et al. (2015) for details on the data methodology and structure.

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 of the value of i's imports in sector k, less the value of sector k imports used by i in the production of sector k goods. We do not remove sector k imports used in i by producers in other sectors since such imports also compete with locally produced k goods.

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

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 Trade and Aggregate Productivity: OLS Correlation

We empirically assess the aggregate productivity effects of international trade in three steps. In this section, we first provide OLS evidence that countries' observed export and import activity, $ExpDemand_{ikt}$ and $ImpComp_{ikt}$, is systematically correlated with their aggregate productivity. Since observed trade flows capture aggregate supply and demand conditions in general equilibrium, however, $ExpDemand_{ikt}$ confounds exogenous foreign demand for the products of country i with i's endogenous export supply. Analogously, $ImpComp_{ikt}$ reflects both the exogenous supply of foreign products to country i and i's endogenous import demand. In order to identify the causal effects of globalization, in Section 5 we pursue an IV-2SLS estimation strategy to isolate the exogenous components of export demand and import competition. Finally, in Section 6 we perform additional analyses to inform the mechanisms through which export demand and import competition operate.

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 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, ψ_{it}, such that β_{EX} and β_{IM} are identified from the variation across sectors within countries at a given point in time. The ψ_{it} account for macroeconomic supply and demand shocks at the country-year level that affect trade and productivity symmetrically in all sectors, such as movements in aggregate income, labor supply, or exchange rates. Implicitly, 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, ε_{ikt}, by sector-year to accommodate cross-country correlation in sector-specific shocks.

We add several controls Z_{ikt} to alleviate concerns with omitted variable bias and sample selection. First, there may be worldwide sector trends in supply and demand conditions. To capture these, we condition on the average log number of 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. These thresholds 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 country-sector-year observations that are based on data for fewer than 20 firms. We also drop observations with extreme annual growth rates in the top or bottom percentile of the distribution for any of the key variables ($AggProd_{ikt}$, $AvgProd_{ikt}$, $CovProd_{ikt}$, $ExpDemand_{ikt}$, $ImpComp_{ikt}$, $\ln N_{ikt}$). These two corrections filter out 11% of the raw sample.

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 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 both stronger average firm productivity and increased concentration of activity in more productive firms, with the former channel roughly twice the magnitude of the latter. By contrast, deeper import penetration entails higher firm

productivity on average, but a shift in activity towards less productive firms.

The bin scatters in Figure 5 provide 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 fixed effects. The plots indicate that $AggProd_{ikt}$ is strongly positively correlated with both $ExpDemand_{ikt}$ and $ImpComp_{ikt}$ across the distribution.

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

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.[29] 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.

5 Impact of Trade on Aggregate Productivity: IV Causation

5.1 The Endogeneity Problem

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 performance are jointly determined by some omitted variable. Given the country-year fixed effects in the OLS specification, such omitted variable bias would have to vary systematically across sectors within country-years to explain our findings.

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. Trade 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 β_{EX} positively. Analogously, import flows reflect both endogenous demand conditions in the importing country and exogenous supply conditions in the exporting country. Given local demand, 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 β_{IM} negatively. Other mechanisms may generate reverse causality that biases β_{EX} and β_{IM} either upwards or downwards.

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

5.2 IV Strategy

In order to identify the causal effects of trade, we adopt a two-stage least squares (2SLS) estimation strategy. In the first stage, 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 observed exports and imports, $ExpDemand_{ikt}$ and $ImpComp_{ikt}$. In the second stage, we regress aggregate productivity on these predicted exogenous trade values in place of their endogenous counterparts:

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

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

We condition on controls Z_{ikt} and country-year fixed effects, ψ_{it} and ϕ_{it}, as in the OLS baseline. In robustness checks, we further add sector fixed effects, ψ_k and ϕ_k, or sector-year fixed effects, ψ_{kt} and ϕ_{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, ε_{ikt} and ϵ_{ikt}, by sector-year.

The ideal instruments for trade exposure would be relevant by having predictive power in explaining trade flows, and would meet the exclusion restriction by affecting productivity only through the trade channel. In the case of $ExpDemand_{ikt}$, we would therefore like to isolate exogenous foreign demand for ik products in year t from country i's endogenous 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 use Bartik instruments, which we construct 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.[30] 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, or market size in the model. Aggregate supply of sector k goods from origin o at time t can be measured 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 and capture pure import competition induced by o. Note that 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

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

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

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

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

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

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.

5.3 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. Two findings stand out. First, export demand and import competition both significantly increase 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.

Second, Table 5 reveals that the productivity impacts of export and import expansion are mediated through different channels. Export growth both sizeably improves average firm productivity, $AvgProd_{ikt}$, and reallocates activity towards more productive firms, as manifested in higher $CovProd_{ikt}$. The latter contributes 26% of the total productivity benefit 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).

The asymmetric effects of export demand and import competition on allocative efficiency signal that the "right" firms may be able to access relatively more resources than the "wrong" firms during boom times, compared to bust times. This suggests that the root causes of misallocation matter. In the case of financial market frictions, for example, imperfect information may play out in different ways during peaks and troughs. Financiers may have incomplete knowledge of firm fundamentals, and make financing decisions based on expected future profits (which depend on fundamentals) and on past performance and collateralizable assets (which depend on previous distortions in capital allocation). Since expansions in export demand and import competition have opposite effects on firm profits, the results are consistent with lenders being more willing to extend capital based on the net present value of future profits during boom times, and conversely tying funding more closely to collateral during bust times.

5.4 Sensitivity Analysis

We perform extensive sensitivity analysis in Appendix Table 3 to validate the robustness of the baseline results. We record consistently large and significant effects of international trade on all three productivity outcomes, safe for imprecisely estimated effects of $ImpComp_{ikt}$ on $CovProd_{ikt}$ in specifications with country-year and sector-year fixed effects.

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. Panels A and B show that this delivers qualitatively similar results and quantitatively bigger magnitudes for each dimension of globalization.

Panel C 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 can arise through gradual adjustment within and across firms.

Alternative measures 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 D corroborates the main results when we estimate specification (5.1) using $ImpCompRatio_{ikt}$ in place of $ImpComp_{ikt}$ and an analogously

constructed instrument $FSupplyRatio_{ikt}$ in place of $FSupply_{ikt}$.[31]

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.

5.5 Additional Results

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

5.5.1 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 β_{EX} and β_{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. These estimates would reflect the impact of globalization on the average sector across both manufacturing and services, under the assumption that productivity in the average manufacturing sector exhibits the same trade elasticity as the average services sector, even if these elasticities vary across individual sectors.

5.5.2 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 (although growing) wages and productivity.

[31] 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.

We compare the impact of import competition from China, $ChinaImpComp_{ikt}$, and import competition from the rest of the world, $ROWImpComp_{ikt}$, on aggregate productivity in Europe. 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 for $ChinaImpComp_{ikt}$ and $ROWImpComp_{ikt}$, $ChinaSupply_{ikt}$ and $ROWSupply_{ikt}$, which replace $FSupply_{ikt}$ in the IV first stage. 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 importing countries i based on China's initial share in i's imports of k goods at time $t = 0$, $\frac{M_{China \to ik,t=0}}{M_{ik,t=0}}$.

$$ChinaImpComp_{ikt} = \ln\left[\sum_{s \neq k} X_{China \to i,kst}\right], \quad ChinaSupply_{ikt} = \ln\left[\frac{M_{China \to i,k,t=0}}{M_{ik,t=0}} XVA^{final}_{China,kt}\right] \tag{5.6}$$

We present the results in Panel C of Table 6. The findings for the productivity impact of 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.

5.5.3 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. This may arise because firms make endogenous hiring decisions, or because exogenous variation in worker skill or firm-worker match quality is unobserved at the hiring stage. This raises the possibility that measured real value added per worker may confound firm productivity with employee skill, but the two causes for skill dispersion across firms would have different implications for the interpretation of the results: In the latter case it would pose the threat of omitted variable bias, while in the former case it would be merely a manifestation of the underlying productivity heterogeneity.

To be conservative, in Panel D of Table 6 we explicitly control for skill dispersion across firms. In particular, we condition on the 90th-10th interpercentile ratio of average wage across firms within country-sector-years, available from CompNet. The baseline results remain unchanged.

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 practice, such mark-up heterogeneity can introduce measurement error in real value-added per worker at the firm level, which

can, in turn, lead to measurement error in aggregate productivity, average productivity and productivity-size covariance at the sector level.

Panel E of Table 6 provides suggestive evidence that mark-up heterogeneity does not contribute to the estimated effects of globalization on aggregate productivity. These regressions control for the 90th-10th interpercentile ratio of the price-to-cost margin across firms within country-sector-years; this is the best available proxy for mark-up dispersion and comes from CompNet.

6 How Trade Affects Productivity: Mechanisms

Our estimation approach identifies the independent effects of export demand and import competition, which we interpret as the effects of unilateral export and import liberalization through the lens of theory. We now argue that the empirical results are consistent with globalization shaping aggregate productivity by triggering reallocations across heterogeneous firms in the presence of resource misallocation.

We base this conclusion on three pieces of 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 aggregate productivity, counter to model predictions without distortions. Finally, the impact of trade on aggregate productivity depends on countries' measured institutional and market efficiency. Although the consequences of misallocation for the gains from trade are in principle ambiguous, finding that institutional frictions do moderate these gains implies that misallocation plays a role. While the first two arguments for misallocation rely on model-dependent inference, the last one constitutes direct, model-independent evidence.

6.1 Pattern of Trade Effects

The sign pattern for the estimated effects of $ExpDemand_{ikt}$ on $\{AggProd_{ikt}, AvgProd_{ikt}, CovProd_{ikt}\}$ is $\{+,+,+\}$, while that for $ImpComp_{ikt}$ is $\{+,+,-\}$. This suggests that export access generates aggregate productivity gains through the exit of relatively less productive firms and the reallocation of market share towards more productive firms. By contrast, import competition induces cleansing along the extensive margin and worsens allocative efficiency along the intensive margin, for a net positive effect on aggregate productivity. 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).

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 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, regardless of whether wages are fixed or flexible. On the other hand, import liberalization can move these outcomes in different directions in different segments of the parameter space. In particular, with fixed wages, it is possible that $AggProd_{ikt}$ and $AvgProd_{ikt}$ both rise while $CovProd_{ikt}$ declines.

Based on our benchmark IV estimates, the direction and magnitude of the productivity effects of a 20% increase in $ExpDemand_{ikt}$ and $ImpComp_{ikt}$ are thus in line with the numerical simulation for the case of misallocation under fixed wages, intermediate distortion dispersion, and positive productivity-dispersion correlation (see Panel D and the last line of Panel C in Table 1).

6.2 Firm Selection

We next evaluate the impact of trade exposure on firm selection at the bottom end of the productivity distribution. In the absence of misallocation, globalization can affect aggregate productivity $AggProd_{ikt}$ by (i) raising the first-best productivity cut-off φ^*_{ii} and by (ii) reallocating resources across inframarginal firms. Moreover, the change in φ^*_{ii} is a sufficient statistic for the change in $AvgProd_{ikt}$ and $AggProd_{ikt}$, but generally not for the change in $CovProd_{ikt}$ without additional functional form assumptions. The empirical counterpart to φ^*_{ii} is the minimum productivity across firms in a given country-sector-year, $\min Prod_{ikt}$. Therefore, controlling for $\min Prod_{ikt}$ in regression (5.1), any residual impact of international trade on $\{AggProd_{ikt}, AvgProd_{ikt}\}$ would be inconsistent with efficient allocation.

In the presence of misallocation, globalization still affects aggregate productivity via (i) and (ii), but also by (iii) changing the degree of misallocation by shifting resources across firms along the extensive and intensive margins. The observed minimum productivity would now be the empirical counterpart to the distorted productivity threshold $\underline{\varphi}^*_{ii}$, which is no longer a sufficient statistic for $AvgProd_{ikt}$ or $AggProd_{ikt}$. Controlling for $\min Prod_{ikt}$, any residual impact of trade on $\{AggProd_{ikt}, AvgProd_{ikt}\}$ would now be consistent with mechanism (iii) and the presence of misallocation.

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 (5.1) to include $\min Prod_{ikt}$ in the second stage.[32] Higher $\min Prod_{ikt}$ is associated with higher aggregate and average productivity, but lower 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 (Column 6). The point estimates for β_{EX}

[32] 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.

and β_{IM} are also reduced by only 48% and 57% in the regression for $AvgProd_{ikt}$ (Column 3). In the specification for $CovProd_{ikt}$, β_{EX} increases by 20%, while β_{IM} falls by 38% (Column 4).

Through the lens of the model, 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 via channels (i) and (ii). Instead, the patterns are consistent with the presence of distortions, whereby international trade influences aggregate productivity in part by changing the efficiency with which resources are allocated across firms.[33]

6.3 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 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 (5.1) 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

[33] 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 expenditures 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 (5.1) leaves large residual productivity effects of trade.

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 aggregate productivity, average firm productivity and allocative efficiency. The interaction terms are highly statistically and economically significant for all but 2 out of 30 coefficient estimates.[34]

These results indicate the complex interactions between international trade and market frictions in shaping 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 productivity more when markets and institutions are less efficient. This may occur if the "right" productive firms that start out with sub-optimal resources can more effectively scale up production than the "wrong" 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 less productive firms downsize disproportionately more.[35] There may also be less scope for distortionary policy interventions such as heterogeneous subsidies across firms in response to import-induced contraction than in response to export-induced expansion.

6.4 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 likely to fail in realistic economic environments. Under certain assumptions, Hsieh-Klenow (2009) and Gopinath et al. (2015) 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 output-market distortions.

[34] 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.

[35] 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 on allocative efficiency $CovProd_{ikt}$ in Table 5, which capture average effects across countries.

There are several difficulties in interpreting these indicators in terms of allocative efficiency. 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. 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. 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.

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). Were $Dispersion_{ikt}$ and $CovProd_{ikt}$ indicative of misallocation, our conclusion that export access (import penetration) enhances (reduces) allocative efficiency would have been consistent with $Dispersion_{ikt}$ falling (rising) with $ExpDemand_{ikt}$ ($ImpComp_{ikt}$).

7 Conclusion

We examine the impact of international trade on aggregate productivity. Theoretically, we show that bilateral and unilateral export liberalizations increase aggregate productivity, while unilateral import liberalization can either raise or reduce it. However, all three trade reforms have ambiguous effects in the presence of resource misallocation. Using unique new data on 14 European countries and 20 manufacturing industries during 1998-2011, we empirically establish that exogenous shocks to export demand and import competition generate large aggregate productivity gains. Although both trade activities increase average firm productivity, however, export expansion reallocates activity towards more productive firms, while import penetration acts in reverse. Unpacking the mechanisms of transmission, we show that improved firm selection can account for only half of the productivity gains from trade, suggesting a potential role for resource misallocation. Indeed, efficient institutions, factor and product markets amplify the productivity gains from import competition, but dampen those from export expansion.

Our findings have important implications for policy design in developing countries that aspire to promote growth through greater economic integration but suffer from weak institutions and significant frictions in capital, labor and product markets. The analysis suggests that 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. Richer data would make it possible to examine how international trade affects the incentives for technological upgrading across the firm productivity distribution. It would also be valuable to assess the impact of specific frictions in capital, labor and product markets on firm selection, firm innovation, and reallocations across firms. These constitute some steps towards understanding how to design trade policy and coordinate it with structural reforms that remove institutional and market imperfections in order to improve welfare.

8 References

Aghion, P., Bergeaud, A., Lequien, M. and M. Melitz (2018). "The Impact of Exports on Innovation: Theory and Evidence." Harvard University mimeo.

Ahn, J. (2016). "Is the Trade Slowdown Contributing to the Global Productivity Slowdown? New Evidence." IMF World Economic Outlook, Chapter 2.

Alfaro, L. and Chen, M. (2018). "Selection and Market Reallocation: Productivity Gains from Multinational Production." American Economic Journal: Economic Policy, 10(2), 1–38.

Amiti, M. and Khandelwal, A. (2013). "Import Competition and Quality Upgrading." Review of Economics and Statistics, 92(2), 476-490.

Amiti, M. and Konings, J. (2007). "Trade Liberalization, Intermediate Inputs, and Productivity: Evidence from Indonesia." American Economic Review, 97(5), 1611-1638.

Arkolakis, C., Costinot, A., Donaldson, D. and Rodriguez-Clare, A. (2019). "The Elusive Pro-Competitive Effects of Trade." Review of Economic Studies, 86, 46-80.

Arkolakis, C., Costinot, A. and Rodriguez-Clare, A. (2012). "New Trade Models, Same Old Gains?" American Economic Review, 102(1), 94-130.

Atkin, D. and Khandelwal, A. (2019). "How Distortions Alter the Impacts of International Trade in Developing Countries." NBER Working Paper 26230.

Bagwell, K. and S.H. Lee (2015). "Trade Policy under Monopolistic Competition with Firm Selection." Stanford University mimeo.

Bai, Y., Jin, K. and Lu, D. (2019). "Misallocation Under Trade Liberalization." LSE mimeo.

Bajgar, M. (2016). "Gains from Trade in a Distorted Economy." University of Oxford mimeo.

Bartelsman, E., Haltiwanger, J. and Scarpetta, S. (2013). "Cross-Country Differences in Productivity: the Role of Allocation and Selection." American Economic Review, 103(1), 305-334.

Baqee, D. and Farhi, E. (2019). "Productivity and Misallocation in General Equilibrium."

Bems, R. and Johnson, R. (2017). "Demand for Value Added and Value-Added Exchange Rates." American Economic Journal: Macroeconomics, 9(4), 45-90.

Ben Yahmed, S. and Dougherty, S. (2017). "Domestic Regulation, Import Penetration and Firm-level Productivity Growth." Journal of International Trade & Economic Development.

Berman, N., Aghion, P., Askenazy, P., Cette, G. and Eymard, L. (2012) "Credit Constraints and the cyclicality of R&D Investment: Evidence from France." Journal of the European Economic Association, 10(5), 1001-1024.

Berman, N., Berthou, A. and Héricourt, J. (2015). "Export Dynamics and Sales at Home." Journal of International Economics, 96(2), 298-310.

Bernard, A. B., Jensen, J. B. and Schott, P. K. (2006). "Survival of the Best Fit: Exposure to Low-Wage Countries and the (Uneven) Growth of U.S. Manufacturing Plants." Journal of International Economics, 68(1), 219-237.

Bernard, A.B., Redding, S.J. and Schott, P.K. (2011). "Multiproduct Firms and Trade Liberalization." Quaterly Journal of Economics, 126 (3), 1271-1318.

Bloom N., Draca, M. and Van Reenen, J. (2015). "Trade Induced Technical Change: The Impact of Chinese Imports on Innovation, Diffusion and Productivity." Review of Economic Studies, 83, 87-117.

Brandt, L., Tombe, T. and Zhu, X. (2013). "Factor Market Distortions across Time, Space and Sectors in China." Review of Economic Dynamics, 16, 39-58.

Burstein, A. and Cravino, J. (2015). "Measured Aggregate Gains from International Trade." American Economic Journal: Macroeconomics, 7(2), 181-218.

Bustos P. (2011). "Trade Liberalization, Exports, and Technology Upgrading: Evidence on the Impact of MERCOSUR on Argentinian Firms." American Economic Review, 101(1), 304-40.

Caliendo, L., Parro, F. and Tsyvinski, A. (2017). "Distortions and the Structure of the World Economy." NBER Working Paper 23332.

Chen, M.X. and Alfaro, L. (2017). "Selection and Market Reallocation: Productivity Gains from Multinational Production." NBER Working Paper 18207.

Chor, D. and Manova, K. (2012). "Off the cliff and back? Credit Conditions and International Trade during the Global Financial Crisis." Journal of International Economics, 87(1), 117-133.

Chung, J.C. (2018). "Firm Heterogeneity, Misallocation, and Trade". Stanford University mimeo.

Coe, D. and Helpman, E. (1995). "International R&D Spillovers." European Economic Review, 39, 859-87.

Costinot, A. and Rodríguez-Clare A. (2014). "Trade Theory with Numbers: Quantifying the Consequences of Globalization." In Handbook of International Economics, 4:197–261. North-Holland.

De Loecker, J. and Warzynski, F. (2012). "Markups and Firm-Level Export Status." American Economic Review, 102(6), 2437-71.

Demidova, S. (2008). "Productivity Improvements and Falling Trade Costs: Boon or Bane?" International Economic Review, 49(4), 1437-1462.

Demidova, S. and Rodriguez-Clare, A. (2013). "The Simple Analytics of the Melitz Model in a Small Open Economy." Journal of International Economics, 90(2), 266-272.

Dhingra, S. (2013). "Trading Away Wide Brands for Cheap Brands." American Economic Review, 103(6), 2554-2584.

Dhingra, S. and Morrow, J. (2014). "Monopolistic competition and optimum product diversity under firm heterogeneity." Journal of Political Economy (forthcoming).

Ding, S., Jiang, W. and Sun, P. (2016). "Import Competition, Dynamic Resource Allocation and Productivity Dispersion: Micro-Level Evidence from China." Oxford Economic Papers, 68 (4): 994-1015.

Donaldson, D. (2015). "The Gains from MarketIntegration." Annual Review of Economics, 7, 619-47.

Edmond, C., Midrigan, V. and Xu, D. Y. (2015). "Competition, Markups, and the Gains from International Trade." American Economic Review, 105(10), 3183-3221.

Epifani, P. and Gancia, G. (2011). "Trade, markup heterogeneity and misallocations." Journal of International Economics, 83(1), 1-13.

Feenstra, R. and Weinstein, D. (2017). "Globalization, Markups and U.S. Welfare." Journal of Political Economy, 125(4), 1040-74.

Foley, F. and Manova, K. (2015). "International Trade, Multinational Activity, and Corporate Finance." Annual Review of Economics, 7, 119-46.

Foster, L., Grim, C., Haltiwanger, J. and Wolf, Z. (2016). "Firm-Level Dispersion in Productivity: Is the Devil in the Details?" American Economic Review, 106(5), 95-98.

Foster, L., Haltiwanger, J. and Syverson, C. (2008). "Reallocation, Firm Turnover, and Efficiency: Selection on Productivity or Profitability?" American Economic Review, 98(1), 394–425.

Goldberg, P. K.,. Khandelwal, A., Pavcnik, N. and Topalova, P. (2010). "Imported Intermediate Inputs and Domestic Product Growth: Evidence from India." Quarterly Journal of Economics, 125(4), 1727-67.

Gopinath, G., Kalemli-Ozcan, S., Karabarbounis, L. and Villegas-Sanchez, C. (2015) "Capital Allocation and Productivity in South Europe." NBER Working Paper 21453.

Harrison, A., Martin, L. and Nataraj, S. (2013). "Learning versus Stealing: How important are Market-Share Reallocations to India's Productivity Growth?" World Bank Economic Review, 27 (2), 202-28.

Head, K., Mayer, T. and M. Thoenig (2014). "Welfare and Trade without Pareto" American Economic Review: Papers Proceedings, 104(5), 310-16.

Helpman, E., Itskhoki, O. and Redding, S. (2010). "Inequality and Unemployment in a Global Economy." Econometrica, 78 (4), 1239–83.

Hopenhayn (2014). "Firms, Misallocation, and Aggregate Productivity: A Review." Annual Review of Economics, 6, 735-770.

Hornbeck, R. and Rotemberg, M. (2019). "Railroads, Reallocation, and the Rise of American Manufacturing." University of Chicago mimeo.

Hsieh, C.-T. and Klenow, P. (2009). "Misallocation and Manufacturing TFP in China and India." Quarterly Journal of Economics, 124(4), 1403-48.

Hummels, D. and Jørgensen, R. and Munch, J. and Xiang, C. (2014). "The Wage Effects of Offshoring: Evidence from Danish Matched Worker-Firm Data." American Economic Review, 104(6), 1597-1629.

Kaufmann, D., Kraay, A. and M. Mastruzzi (2010). "The Worldwide Governance Indicators: Methodology and Analytical Issues." World Bank Policy Research Working Paper 5430.

Khandelwal, A. and Topalova, P. (2011)."Trade Liberalization and Firm Productivity: The Case of India." Review of Economics and Statistics, 93(3), 995-1009.

Khandelwal, A., Schott, P. and Wei, S.-J. (2013). "Trade Liberalization and Embedded Institutional Reform: Evidence from Chinese Exporters." American Economic Review, 103(6), 2169-95.

Lileeva A. and Trefler D. (2010). "Improved Access to Foreign Markets Raises Plant-Level Productivity... for Some Plants." Quarterly Journal of Economics, 125(3), 1051-99.

Lopez-Garcia, P. and the CompNet Task Force (2015). "Assessing European competitiveness: the new CompNet microbased database." ECB Working Paper 1764.

Manova, K. (2008). "Credit Constraints, Equity Market Liberalizations and International Trade." Journal of International Economics, 76(1), 33-47.

Manova, K. (2013). "Credit Constraints, Heterogeneous Firms, and International Trade." Review of Economic Studies, 80(2), 711-44.

Manova, K., Wei, S.-J., and Zhang, Z. (2015). "Firms Exports and Multinational Activity under Credit Constraints." Review of Economics and Statistics, 97(3), 574-88.

Manova, K. and Yu, Z. (2016). "How firms export: Processing vs. ordinary trade with financial frictions." Journal of International Economics, 100(C), 120-37.

Martin, J. and Méjean, I. (2014). "Low-Wage Countries' Competition, Reallocation Across Firms and the Quality Content of Exports." Journal of International Economics, 93(1), 140-52.

Mayer, T., Melitz, M. and Ottaviano, G. I. P. (2014). "Market Size, Competition, and the Product Mix of Exporters." American Economic Review, 104(2), 495-536.

Melitz, M. (2003). "The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity." Econometrica, 71(6), 1695-725.

Melitz, M. and Cuñat, A. (2012). "Volatility, Labor Market Flexibility, and the Pattern of Comparative Advantage." Journal of the European Economic Association, 10, 225-54.

Melitz, M. and Polanec, S. (2015). "Dynamic Olley-Pakes productivity decomposition with entry and exit." RAND Journal of Economics, 46(2), 362-75.

Melitz, M. and Redding, S. (2014). "Heterogeneous Firms and Trade." In Handbook of International Economics, 4, 1-54. Elsevier.

Midrigan, V. and Xu, D. (2014). "Finance and Misallocation: Evidence from Plant-Level Data." American Economic Review, 104(2), 422-58.

Olley, S. and Pakes, A. (1996). "The Dynamics of Productivity in the Telecommunications Industry." Econometrica, 64(6), 1263-1298.

Pavcnik, N. (2002). "Trade Liberalization, Exit, And Productivity Improvements: Evidence From Chilean Plants." Review of Economic Studies, 69(1), 245-76.

Restuccia, D. and Rogerson, R. (2018). "Policy Distortions and Aggregate Productivity with Heterogeneous Establishments." Review of Economic Dynamics, 11(4), 707-20.

Ruggieri, A. (2018). "Trade and Labor Market Institutions: A Tale of Two Liberalizations". UAB-UPF Barcelona mimeo.

Sandoz, C. (2018). "Input Prices, Allocation of Resources and TFP Growth: Evidence from Chinese Imports in France." PSE mimeo.

Swiecki, T. (2017). "Intersectoral Distortions and the Welfare Gains from Trade." Journal of International Economics, 104, 138-56.

Timmer, M. P., Dietzenbacher, E., Los, B., Stehrer, R. and de Vries, G. J. (2015). "An Illustrated User Guide to the World Input–Output Database: the Case of Global Automotive Production." Review of International Economics, 23, 575-605.

Zi, Y. (2016). "Trade Liberalization and the Great Labor Reallocation." IHEID Working Paper 18-2016.

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 σ_η=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 Institution (it)	**-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*** **
	(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 Institution (it)	**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*** **
	(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 Institution (it)	**-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*** **
	(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 Institution (it)	**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**
	(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 Institution (it)	**-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** **
	(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 Institution (it)	**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***
	(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 ρ(φ,η) varies along the x-axis and the standard deviation of distortions σ_η 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

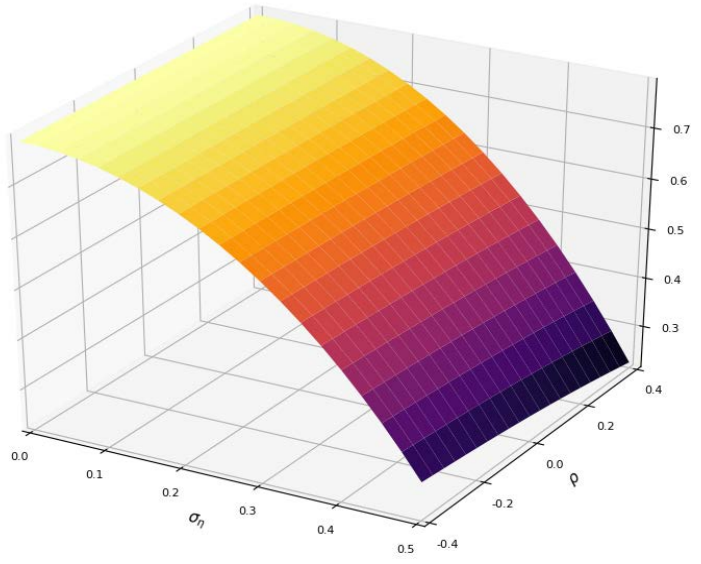


Figure 1B. (log) Aggregate Productivity

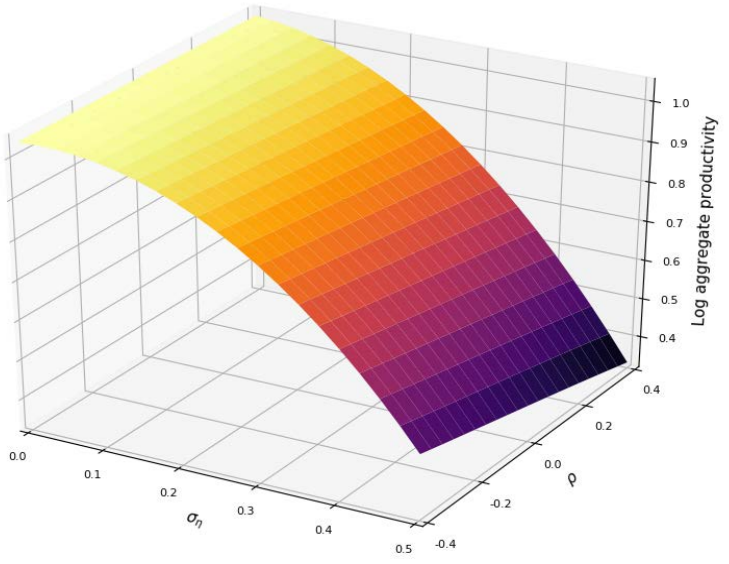


Figure 1C. (log) Average Productivity

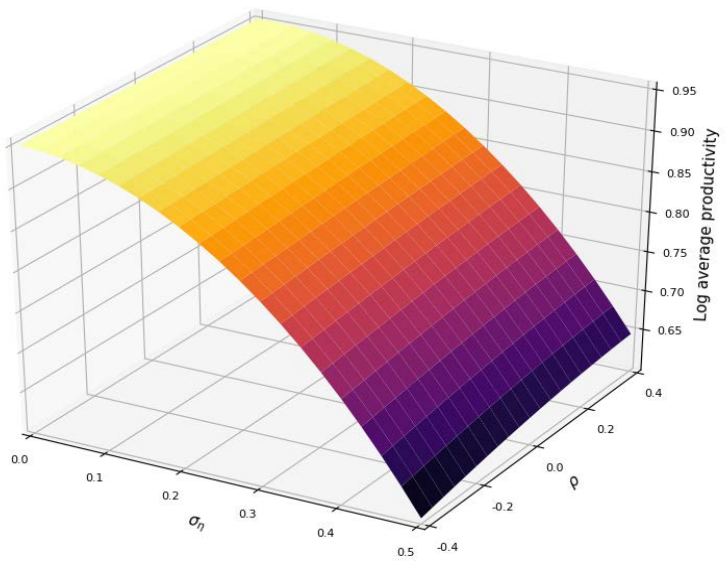


Figure 1D. (log) Productivity-Size Covariance

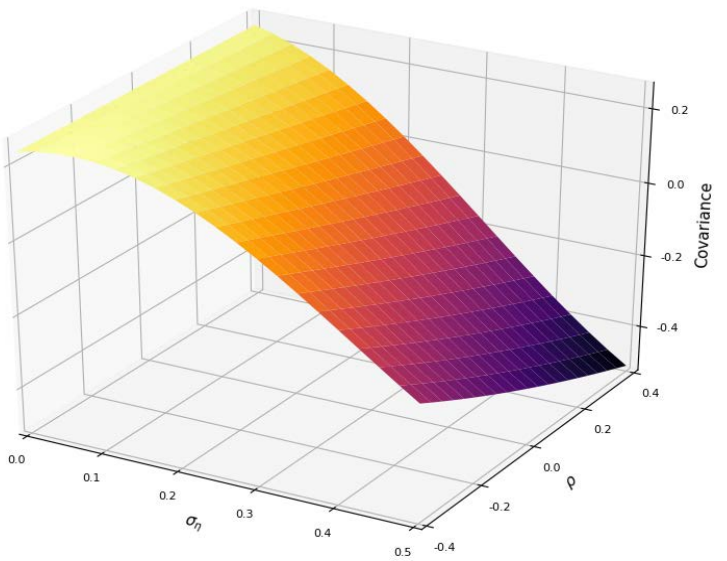
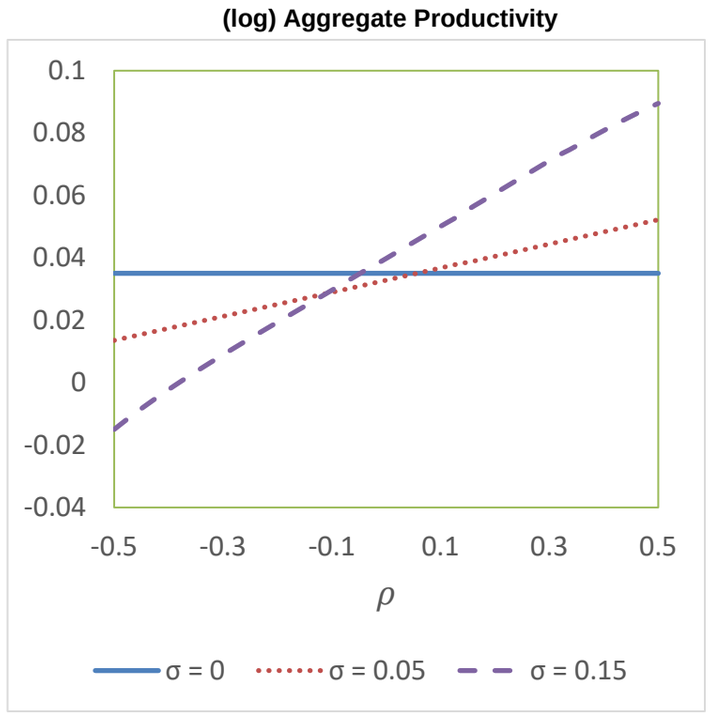
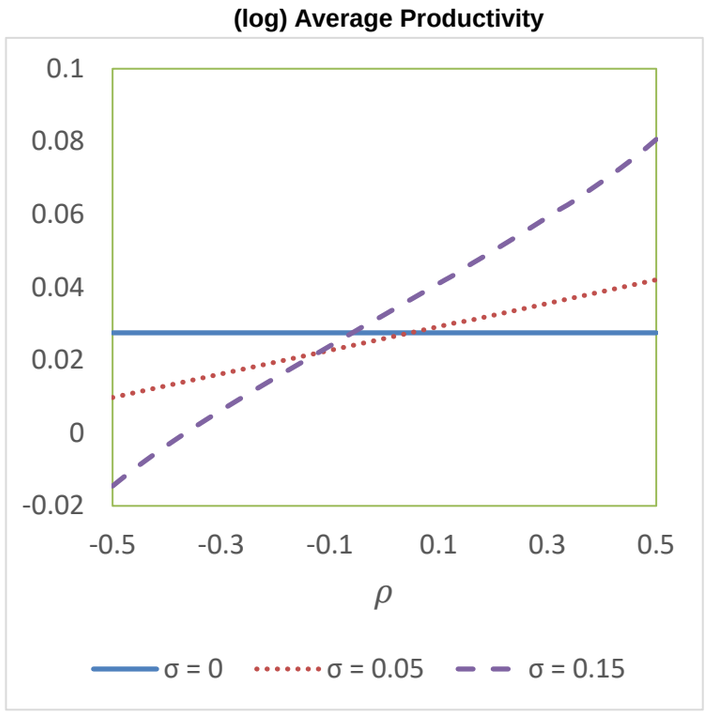


Figure 2. Numerical Simulation: Trade Liberalization

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 $\rho(\varphi,\eta)$ 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





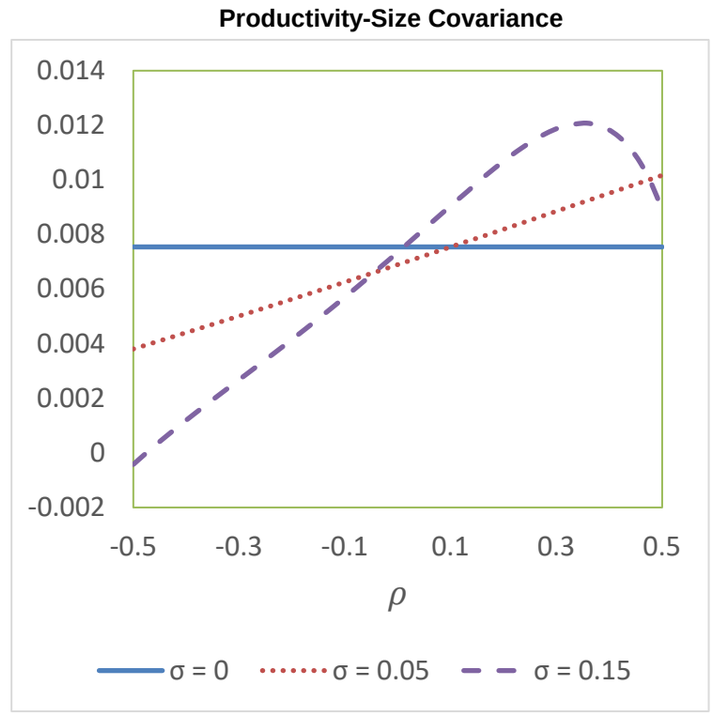


Figure 2. Numerical Simulation: Trade Liberalization (cont.)

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 $\rho(\varphi,\eta)$ 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

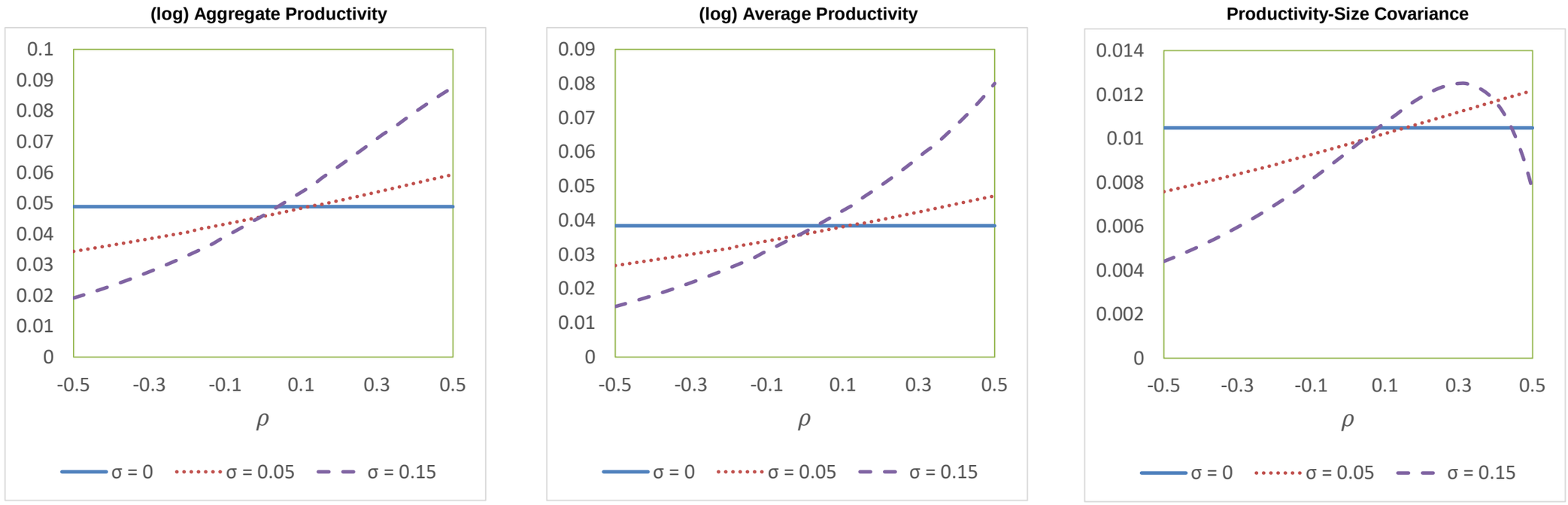


Figure 2C. Unilateral Import Liberalization

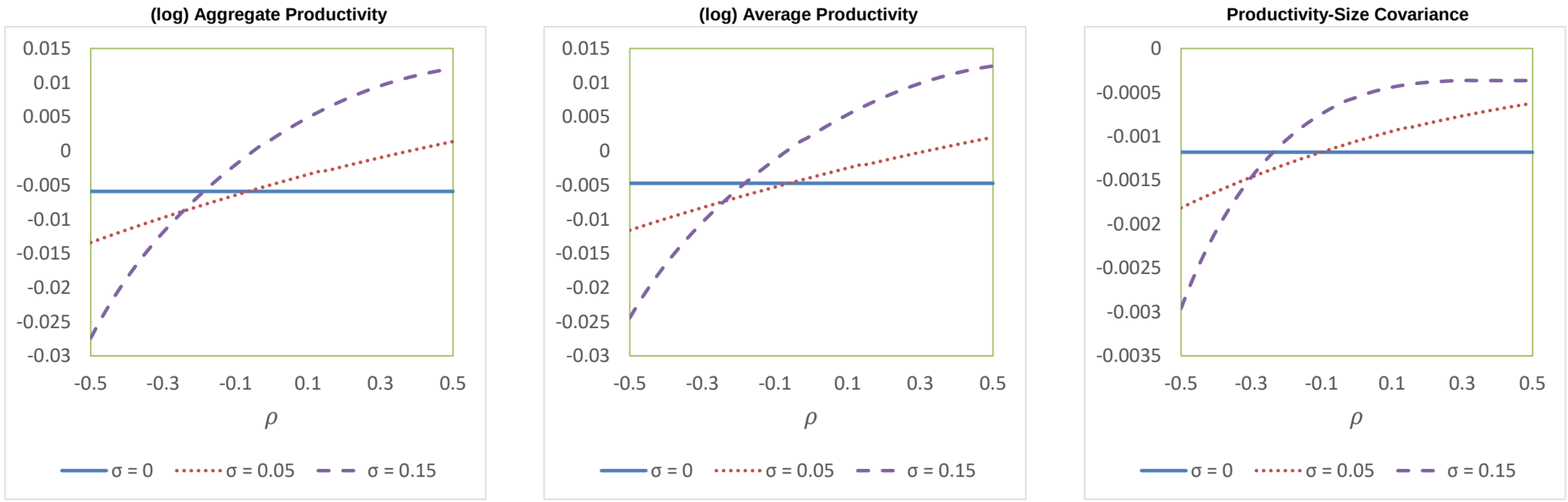


Figure 3. Sources of Productivity Growth

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

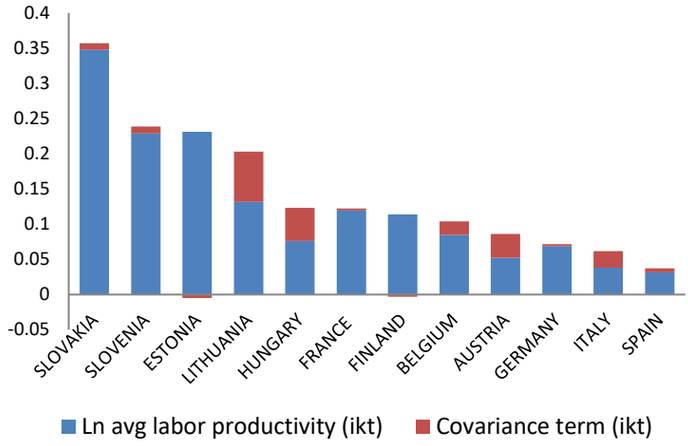


Figure 3B. Growth 2008-2011

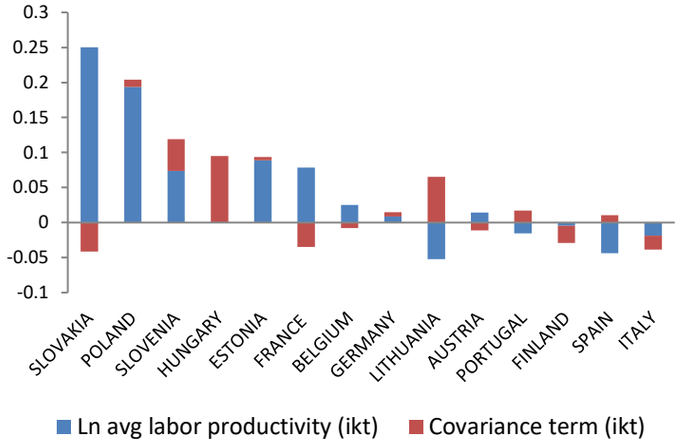


Figure 4. Trade Exposure Over Time

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

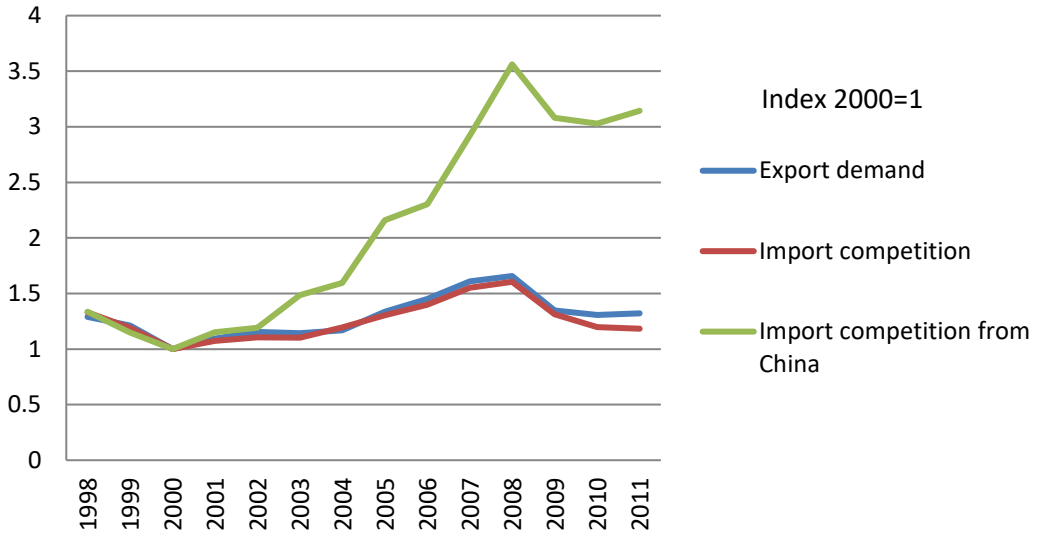


Figure 4B. New Member States

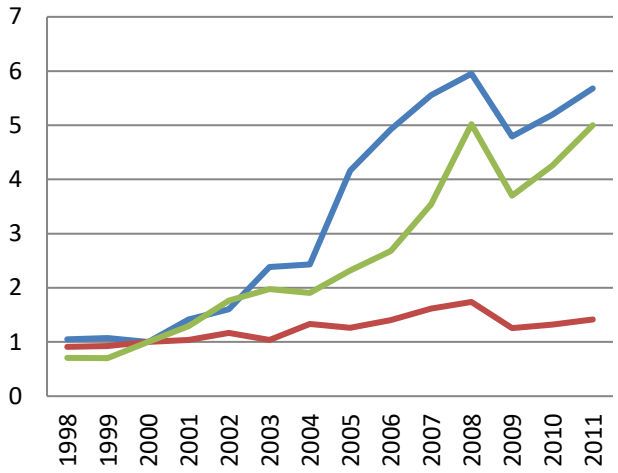


Figure 4C. EU-15 Countries

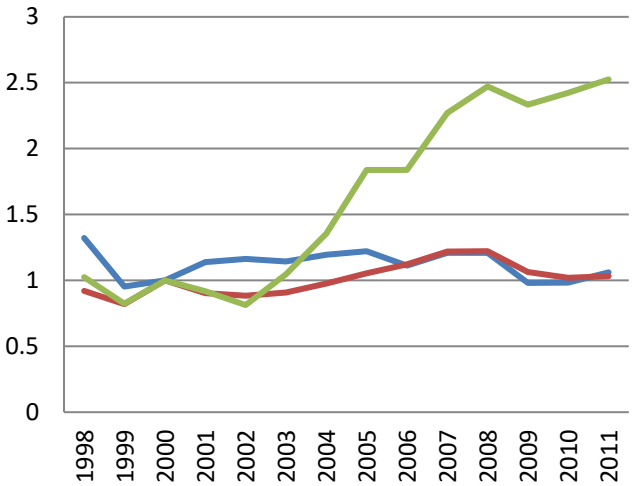
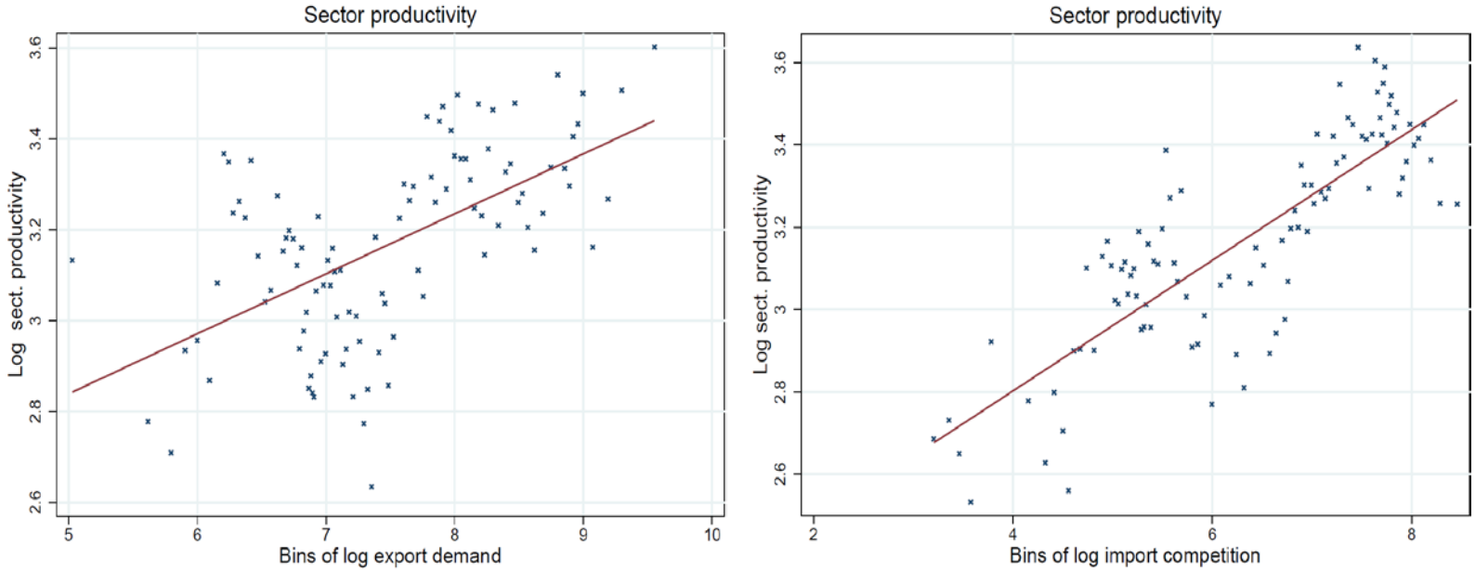


Figure 5. Trade Exposure and Aggregate Productivity

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

Antoine Berthou*
Banque de France and *CEPII*

John Jong-Hyun Chung
Auburn

Kalina Manova
UCL and *CEPR*

Charlotte Sandoz Dit Bragard
IMF

December 10, 2019

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.

*Antoine Berthou: antoine.berthou@banque-france.fr. John Jong-Hyun Chung: jhc0054@auburn.edu. Kalina Manova (corresponding author): k.manova@ucl.ac.uk. Charlote Sandoz Dit Bragard: charl.sandoz@gmail.com.

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 Ω_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 φ 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 φ 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 φ 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:

$$E_j = P_jQ_j = w_jL_j. \tag{1.10}$$

Note that this condition implies balanced international trade. To see this, let X_{ij} denote aggregate sales from i to j. Then $X_{ij} = \frac{\sigma\theta}{\theta-(\sigma-1)}M_iw_if_{ij}\left(\frac{\varphi_i^m}{\varphi_{ij}^*}\right)^\theta$, so that $\sum_j X_{ij} = \frac{\sigma\theta}{\theta-(\sigma-1)}M_iw_i(\varphi_i^m)^\theta\sum_j f_{ij}(\varphi_{ij}^*)^{-\theta} = w_iL_i = E_i$, 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:

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

where the first equality follows from the CES aggregation $E_i = Q_iP_i$, 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 φ_{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 λ_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 βE_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 φ_{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 τ_{21} and thus increases a_{21} will decrease φ_{11} and depress welfare in country 1. On the other hand, a unilateral export liberalization in country 1 that increases a_{12} will raise φ_{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 λ_k^M and decreases the mass of domestic entrants M_k will necessarily decrease the domestic cutoff φ_{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 θ, 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 η 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 φ and subsidy η 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 (φ, η) 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 φ 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 χ_i depend on the joint distribution of (φ, η), 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 (φ, η). 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* χ_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 φ. 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 φ 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 φ. 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 φ.

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 η to true firm productivity φ. 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 φ 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 φ_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,* $\frac{d\tilde{\Phi}_i}{d\varphi_{ii}^*} \gtrless 0$.

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 τ_{ij}, τ_{ji}, or both τ_{ij} and τ_{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 τ_{12} or in the import cost τ_{21} increases the domestic productivity cut-off φ_{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), φ_{ii} can be expressed as a function of φ_{ij}, denoted $\varphi_{ii} = h_{ii}(\varphi_{ij})$. From the zero cut-off profit conditions (3.1) and (3.2), φ_{ij} can in turn be written as a function of φ_{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, φ_{12}^* and w_1.

Equation (3.2) implies a positive relationship between φ_{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 φ_{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 φ_{21}^* because $\theta > \sigma - 1$ and $\sigma > 1$ by assumption. The right hand side is decreasing in φ_{12}^*, since the free entry condition (3.5) implies that φ_{11}^* and φ_{12}^* move in opposite directions. Therefore, φ_{12}^* and φ_{21}^* move in the same direction. Condition (3.1) then implies that w_1 and φ_{12}^* move in opposite directions: If w_1 rises, $\varphi_{21}^*/\varphi_{11}^*$ must fall. Since φ_{11}^* and φ_{12}^* move in opposite directions but φ_{12}^* and φ_{21}^* move in the same direction, this can only occur when φ_{21}^* and φ_{12}^* decrease while φ_{11}^* increases.

Therefore, equations (3.2) and (3.7) determine the unique equilibrium (φ_{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 τ_{21} decreases φ_{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, φ_{11}^* and φ_{12}^*, move in opposite directions. An import reform that reduces the export cut-off φ_{12}^* would thus increase productivity cut-off φ_{11}^*.

From the perspective of country 2, a fall in τ_{21} corresponds to an export liberalization. If φ_{12}^* decreases in response, so would φ_{21}^*, since φ_{12}^* and φ_{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 φ_{22}^*.

We illustrate the effect of a reduction in τ_{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 φ_{12}^* fixed, free entry (3.5) implies that φ_{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 τ_{21} falls, φ_{22}^* must increase and φ_{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 φ_{12}^* would decrease if τ_{21} falls. Since φ_{12}^* and φ_{21}^* move in the same direction, it is sufficient to show that φ_{21}^* must fall. By way of contradiction, suppose φ_{21}^* were to increase. Then (3.1) implies that φ_{11}^* would rise as well. In turn, (3.5) implies that φ_{12}^* would decrease. But then φ_{21}^* would have to fall as well, contradicting the initial assumption.

Since both curves shift down with a reduction in τ_{21}, the wage w_1 must fall. One can further establish that φ_{12}^* must also fall. Suppose by way of contradiction that φ_{12}^* were to rise. Then from (3.2), φ_{22}^* would have to increase, and from (3.6) φ_{21}^* would in turn have to fall. This would, however, violate the result above that φ_{12}^* and φ_{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 φ_{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 θ and σ 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 τ_{ij} or both τ_{ij} and τ_{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 τ_{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 τ_{12} or in bilateral trade costs τ_{12} and τ_{21} increases the domestic productivity cut-off φ_{11}^*, while a reduction in the import cost τ_{21} decreases φ_{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 φ_{jj}^* and φ_{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 openmness in that it is decreasing in f_{ij} and τ_{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 φ_{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 τ_{21} and thus increases a_{21} will decrease the domestic productivity cut-off φ_{11}^*.

Conversely, a unilateral export liberalization in country 1 that reduces τ_{12} and thus increases a_{12} will likewise raise φ_{11}^*. Taking the derivative of φ_{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 τ.■

Equation (2.20) in the paper shows that welfare W_i is proportional to the domestic productivity cut-off φ_{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 τ_{ij}, τ_{ji}, or both τ_{ij} and τ_{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 τ_{ij} and τ_{ji} only through their effect on the distorted productivity cut-off for domestic production $\underline{\varphi}_{ii}^*$ and the share of disposable income χ_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 ϕ to $\phi - \varepsilon$ can generate a discrete rise in T_i when $\bar{\eta}$ is sufficiently large relative to ε. 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 χ_i but a marginal rise in $\underline{\varphi}_{ii}^*$, leading to a fall in aggregate welfare W_i.

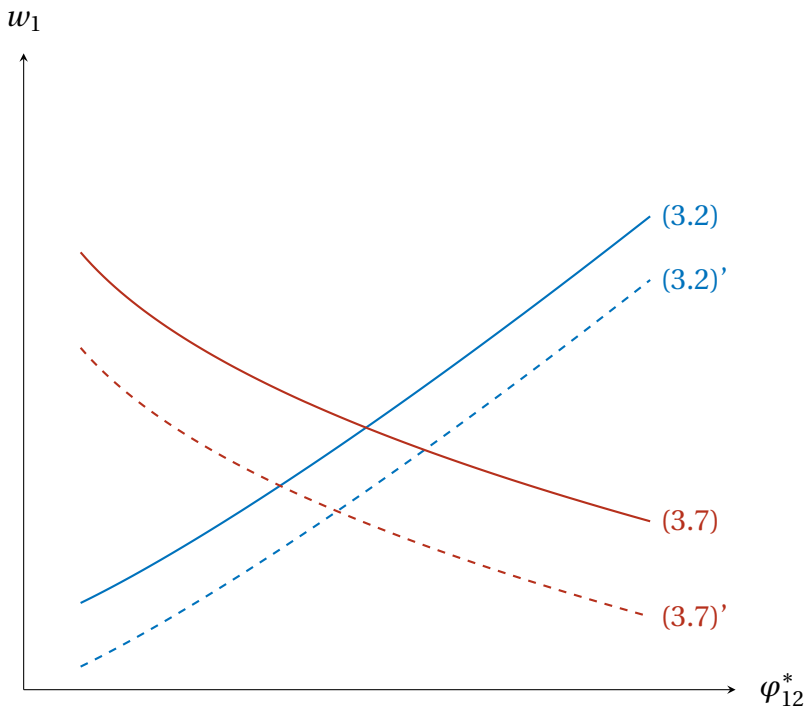
Intuitively, this sample economy subsidizes a small set of firms, that become larger than socially optimal while all other firms remain smaller than optimal due to general equilibrium forces. Trade liberalization can exacerbate this misallocation when it allows firms that are already too large to become 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 φ_{12}^* as given by zero cutoff profit condition (3.2) and the balanced trade condition (3.7). The equilibrium level of (w_1, φ_{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 τ_{21}, which reduces the equilibrium wage w_1 and the export cutoff φ_{12}^*.

CENTRE FOR ECONOMIC PERFORMANCE
Recent Discussion Papers

1667	Holger Breinlich Elsa Leromain Dennis Novy Thomas Sampson	Exchange Rates and Consumer Prices: Evidence from Brexit
1666	Fabrice Defever Michele Imbruno Richard Kneller	Trade Liberalization, Input Intermediaries and Firm Productivity: Evidence from China
1665	Philippe Aghion Antonin Bergeaud Richard Blundell Rachel Griffith	The Innovation Premium to Soft Skills in Low-Skilled Occupations
1664	Filip Gesiarz Jan-Emmanuel De Neve Tali Sharot	The Motivational Cost of Inequality: Pay Gaps Reduce the Willingness to Pursue Rewards
1663	Felix Koenig	Technical Change and Superstar Effects: Evidence From the Roll-Out of Television
1662	Enrico Moretti Claudia Steinwender John Van Reenen	The Intellectual Spoils of War? Defense R&D, Productivity and International Spillovers
1661	Decio Coviello Andrea Ichino Nicola Persico	Measuring the Gains from Labor Specialization
1660	Nicolás González-Pampillón	Spillover Effects from New Housing Supply
1659	Walter Bossert Andrew E. Clark Conchita D'Ambrosio Anthony Lepinteur	Economic Insecurity and the Rise of the Right

1658	Paul Frijters Andrew E. Clark Christian Krekel Richard Layard	A Happy Choice: Wellbeing as the Goal of Government
1657	Philippe Aghion Antonin Bergeaud Matthieu Lequien Marc Melitz	The Heterogeneous Impact of Market Size on Innovation: Evidence from French Firm-Level Exports
1656	Clare Leaver Renata Lemos Daniela Scur	Measuring and Explaining Management in Schools: New Approaches Using Public Data
1655	Clément S. Bellet Jan-Emmanuel De Neve George Ward	Does Employee Happiness Have an Impact on Productivity?
1654	Matej Bajgar Giuseppe Berlingieri Sara Calligaris Chiara Criscuolo Jonathan Timmis	Industry Concentration in Europe and North America
1653	Andrés Barrios Fernandez	Should I Stay of Should I Go? Neighbors' Effects on University Enrollment
1652	Emanuel Ornelas Laura Puccio	Reopening Pandora's Box in Search of a WTO-Compatible Industrial Policy? The Brazil – Taxation Dispute
1651	Giulia Giupponi	When Income Effects are Large: Labor Supply Responses and the Value of Welfare Transfers
1650	Jonas Jessen Sophia Schmitz Sevrin Waights	Understanding Day Care Enrolment Gaps